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Hazards assessment of St. Charles County - earthquakes and floods

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HAZARDS ASSESSMENT OF ST. CHARLES COUNTY –

EARTHQUAKES AND FLOODS

by

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ABSTRACT

Located on the northernmost limits of the St. Louis metropolitan area, St. Charles County has been, and continues to be, one of the fastest-growing counties in the country. The county consists of several major cities featuring extensive industry, retail, and agriculture. Bounded by the Missouri River on the south and the Mississippi River on the north and east, St. Charles County is predominantly flat, low-lying terrain at great risk to periodic flooding. The county is also well within the area of influence for several local seismic zones, increasing the susceptibility to earthquake damage. Given the apparent risk to both flood and earthquake, this study applied the latest version of the GIS driven software program: HAZUS-MH, to assess both hazards for St. Charles County in terms of damages, social impact, and economic losses. With this technology, it is not only possible to compare the extent of damage or losses between various scenarios but also between the different hazards. Specifically, HAZUS-MH was initially developed for FEMA to produce comprehensive, risk-based loss estimates intended to further advance planning at all levels for risk mitigation, emergency preparedness, response, and recovery. While HAZUS-MH provides individuals, businesses, and communities with the information and tools necessary to assesses potential losses due to natural hazards, few are utilizing this powerful program to aid in planning, construction practices, and disaster preparedness. However, St. Charles County is committed to proactive planning to mitigate hazards and prevent losses resulting from disasters, as indicated by the collaborative support offered during this research effort. It is the intent of this research to assess the possible consequences associated with each hazard scenario as well as determine which natural hazard is of most concern. It is also anticipated that this study will eventually lead to other jurisdictions considering multiple hazard loss estimation in order to become familiar with natural hazards, reduce the susceptibility to such hazards, and estimate economic losses.

ACKNOWLEDGMENTS

This is perhaps the easiest and hardest chapter that I have to write. It will be simple to name all the people that contributed in one way or another and ultimately made this thesis possible; but it will be tough to thank them enough. Nonetheless, I will try…

Foremost, I would like to express my sincere thanks and appreciation to my advisor, Dr. Ronaldo Luna, for his continuous support and skillful guidance which enabled me to finish this work successfully. I would also like to thank my committee members, Dr. Jeffrey Cawlfield and David Hoffman, whose thoughtful advice often served to give me a sense of direction during my studies. Their discussions, encouragement, and critiques were essential to the progress of this work.

I am forever grateful to the University of Missouri – Rolla and the CArE department for the financial support in the form of the Chancellor's Fellowship and graduate assistantships.

I am tempted to individually thank all of my friends which, from my childhood until graduate school, have joined me in the discovery of what is life all about and how to make the best of it. However, because the list will certainly be too long and by fear of leaving someone out, I will simply say thank you very much to you all.

I cannot finish without thanking my family for supporting and encouraging me to pursue this degree. Particular thanks, of course, to my parents, Neil and Glenda Krauch, who taught me the value of hard work by their example. Without their loving support and understanding I would never have completed my present work. I must also thank my fiancé, Thomas Morris Jr., for the unwavering support he provided throughout my research work even when his patience was tested to the utmost by a long period of separation. Our wedding date served as a constant motivator for the completion of this thesis. To them I dedicate this work.

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1. INTRODUCTION

1.1. BACKGROUND AND PURPOSE

Natural hazards are naturally occurring events that threaten lives, property, and other assets, and include earthquake, flood, tornado, hurricane among many other weather-related processes. In the past, much of the research on natural disasters was based on developing an understanding of the hazard – the location, size, frequency, and failure mechanisms – instead of the risk associated with the hazard including factors such as population, infrastructure, and dollar exposure. Because policy, development, and land use decisions at the Federal, state, and local levels are indeed risk-based, new standardized technologies have been developed to analyze the susceptibility of a region to various hazards. Specifically, the Hazards United States – Multiple Hazard (HAZUS-MH) program was initially developed for the Federal Emergency Management Agency (FEMA) to produce comprehensive, risk-based loss estimates intended to further advance planning at all levels for risk mitigation, emergency preparedness, response, and recovery. Specifically, the latest version of the program provides loss estimation techniques for three natural hazards: earthquake, flood, and hurricane. However, other wind hazard models such as thunderstorm, hail, and tornado are being developed for future releases.

While HAZUS-MH provides individuals, businesses, and communities with the information and tools necessary to assesses potential losses due to natural hazards, few are utilizing this powerful program to aid in planning, construction practices, and disaster preparedness. However, St. Charles County is committed to proactive planning to mitigate hazards and prevent losses resulting from disasters, but is not currently using HAZUS-MH.

Bounded by the Missouri River on the south and the Mississippi River on the north and east, St. Charles County is predominantly flat, low-lying terrain at great risk to periodic flooding. The county is also well within the area of influence for several local seismic zones, increasing the susceptibility to earthquake damage. Given the apparent risk to both flooding and earthquake, this study will apply the latest HAZUS-MH edition to assess both hazards for St. Charles County. With this technology it is possible to compare the extent of damage or losses between various scenarios or between different hazards.

It is the intent of this research to inform St. Charles County of the possible losses, direct and indirect, associated with each hazard scenario. Also, it is important to determine which hazard is of most concern so that the county officials may then pursue the appropriate recourse. Expectantly, this study will eventually lead to other jurisdictions considering multiple hazard loss estimation.

1.2. OBJECTIVES

The goal of this thesis is to assess the vulnerability of St. Charles County, Missouri to earthquake and flood hazards. This was ultimately accomplished through several sequential objectives such as:

- Develop an understanding of the HAZUS-MH methodology
- Obtain collaborative support of St. Charles County Government's Community Development Division (Appendix A)
- Determine which earthquake and flood scenarios to investigate
- Perform Level 1 HAZUS-MH analyses for both hazards and each scenario
- Evaluate and compare the results, both between scenarios and between hazards
- Improve the Level 1 earthquake analyses with the addition of local seismic hazard maps
- Compare these hazard maps with the results of a site-specific SHAKE 2000 analysis
- Conclude which hazard poses the greatest threat to St. Charles County
- Provide recommendations for improvements and possible future research

1.3. THESIS ORGANIZATION

This thesis, "Hazards Assessment of St. Charles County – Earthquakes and Floods", is organized into nine chapters, including this introduction, plus a series of appendices. Chapter 2 provides an extensive profile of St. Charles County including a brief summary of the area's historical significance, development, demographics, geology, topography, hydrology, environmental concerns, and current community plans. Chapter 3 introduces previous HAZUS-MH studies performed for the St. Louis metropolitan area, indicating the dire need for further research within this region. Chapter 4 defines both the earthquake and flood hazards focusing on how these hazards have affected St. Charles County in the past and what efforts have been made to reduce the overall risk. Chapters 5 and 6 identify the various methodologies utilized for this study and the specific procedures followed during the analysis, respectively. Chapter 7 introduces the various earthquake and flood scenarios selected. Chapter 8 contains the major findings of each scenario and appropriate comparisons. Chapter 9 summarizes the risk of each hazard and the potential threat posed to St. Charles County as well as offers recommendations for possible future research. A series of technical appendices, included in the provided CD, contain the complete results of each scenario evaluated, for each analysis.

2. ST. CHARLES COUNTY PROFILE

2.1. HISTORY

Prior to European settlement, St. Charles County was inhabited by several Native American tribes such as the Missourian, Osage, Sioux, Iowa, Oto, Winnebago, Sac and Fox tribes. In 1769, Louis Blanchette, a French explorer, colonized St. Charles under the authority of the Spanish government and served as the area's civil and military leader until his death in 1793. Although the settlement was under Spanish jurisdiction, the settlers themselves remained primarily French citizens. The first American settlers migrated from the Kentucky region in hopes of establishing land farther west. One such settler, Colonel Daniel Boone, the famed pioneer, settled in St. Charles County with much of his extended family in 1799. Boone was appointed syndic and commander of the Femme Osage district; and as such, he resided in the county until his death in 1820.

In 1804, the area became part of the United States due to the Louisiana Purchase. In that same year, the Lewis & Clark Expedition departed from St. Charles City on the historic journey to the Pacific. For much of the era of westward expansion, the city served as the easternmost station for the stagecoach and supply trains that transported settlers and supplies to the trailheads. As a result, the district of St. Charles was first established on October 1, 1812 by Governor William Clark and named for Italian Cardinal St. Charles Borromeo. Following the admission of Missouri into the Union in 1821, the City of St. Charles served as the first capitol of the new state until 1826 when the state capitol was relocated to Jefferson City. Given the area's extensive settlement and significant role in westward expansion, St. Charles County was established as one of the five original counties in Missouri. At this time, the county comprised a much larger portion of the state. However, the area was steadily reduced to its current boundaries as other areas of Missouri were established and communities formed (Figure 2.1).

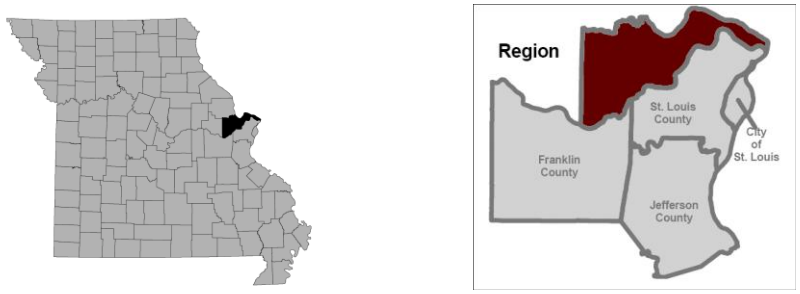


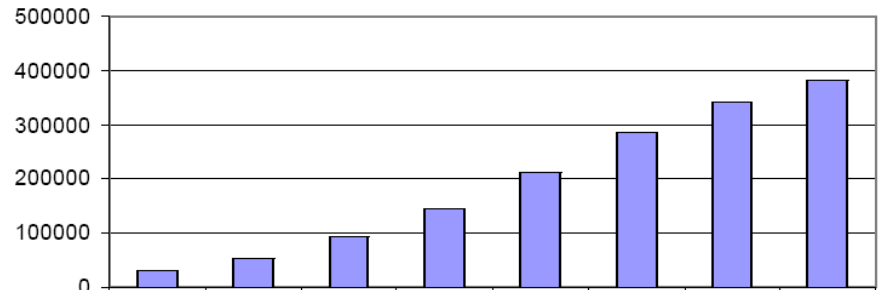
Figure 2.1. Location of St. Charles County

It is clearly evident that St. Charles County is one of the most historically significant places in the United States. The area saw its population and economic base increase as a result of the western expansion and a later wave of German immigration. Also, the strategic location of St. Charles County at the confluence of the Mississippi and Missouri Rivers has greatly enriched its history. Yet, the inclusion of railway and bridge building networks has facilitated further development. Today, St. Charles County is a rapidly developing modern community offering several attractions to its visitors as well as residents including shopping centers, casinos, wineries, recreational complexes, nature preserves, and historical districts. (East-West Gateway 2004)

2.2. DEVELOPMENT

2.2.1. Population. St. Charles County is located in the east-central portion of Missouri, approximately 18 miles northwest of the City of St. Louis. Neighboring counties include Lincoln, Warren, Franklin, and St. Louis in Missouri, and Calhoun, Jersey, and Madison in Illinois. St. Charles County represents the current northernmost limits of the ever-expanding St. Louis metropolitan area. With a recent estimated population of 338,719, St. Charles County is the fastest growing county in Missouri and continues to be one of the top 100 in the nation. Specifically, there has been an average population growth of 9,000 new residents annually over the past five years, making the area the third largest jurisdiction in the St. Louis region. (St. Charles County Government 2006) While the St. Louis metro area population increased by only

8 percent between the 1990 and 2000 Census, St. Charles County's population increased 33.3 percent during the same 10 year time period. (St. Charles County Council 2003) Figure 2.2 illustrates the population trends for St. Charles County since 1950 and estimates the projected population for 2010 and even 2020 based on these growth patterns.



	1950	1960	1970	1980	1990	2000	2010	2020
Population	29834	52297	92954	144107	212907	283883	343100	382300

Figure 2.2. Population Trend of St. Charles County
(Source: Adapted from St. Charles County Council, 2003, page iii)

There are seventeen incorporated communities within St. Charles County which vary in population. The major cities include Dardenne Prairie, Lake St. Louis, O'Fallon, St. Charles, St. Peters, Weldon Spring, and Wentzville. Moreover, three of these communities are ranked in the top fifteen for population throughout the state: St. Charles, eighth; St. Peters, ninth; and, O'Fallon, thirteenth. In fact, the City of St. Charles remains the second largest city in the St. Louis metropolitan area, surpassed only by the City of St. Louis. Also, the City of O'Fallon iscurrently the fastest growing city in the entire state. (St. Charles County Council 2003) The County consists of several small towns such as Augusta, Cottleville, Flint Hill, Foristell, Josephville, New Melle, Portage Des Sioux, St. Paul, Weldon Spring Heights, and West Alton. These small towns are often a desirable place to live as proven by the rapid growth and urban sprawl in these areas. Still, approximately 33% of the total population resides in unincorporated areas. These communities currently include Defiance, Harvester, Matson, and Orchard Farm.

Table 2.1 below presents the individual populations of the cities located in St. Charles County. It is important to note that these numbers are based on the 2000 Census, and as such have grown tremendously since then. However, more recent data was not available for every city. (East-West Gateway 2004)

Table 2.1. St. Charles County City Populations

City	Population	Percent of County
Augusta	218	0.08
Cottleville	1,928	0.68
Dardenne Prairie	4,384	1.54
Flint Hill	379	0.13
Foristell	297	0.10
Josephville	270	0.10
Lake St. Louis	10,169	3.58
New Melle	124	0.04
O'Fallon	46,169	16.26
Portage Des Sioux	351	0.12
St. Charles	60,321	21.25
St. Paul	1,634	0.58
St. Peters	51,381	18.10
Weldon Spring	5,270	1.86
Weldon Spring Heights	79	0.03
Wentzville	6,896	2.43
West Alton	573	0.20
Unincorporated Communities*	93,440	32.91
Total Population	**283,883**	**100.00**

** Includes communities such as Defiance, Harvester, Matson, and Orchard Farm*
(Source: Adapted from East-West Gateway, 2004, Section 1, pages 77-86)

2.2.2. Employment. A clear indication of this unprecedented growth is the steady increase in the county workforce. In St. Charles County, the number of full and part time employees has increased by 43 percent from 1990 to 2000, with a total of 37,763 jobs being established. (St. Charles County Council 2003) In fact, there are more than 7,800 businesses located within county boundaries offering over 117,000 positions. (St. Charles County Government 2006)

St. Charles County consists of several major cities featuring extensive industry, retail, and agriculture. (East-West Gateway 2004) Specifically, business and industry are rapidly developing, with a special emphasis on home building. Despite the rapid loss of agricultural land to urban development, agriculture remains a vital industry in the County. (Tummons 1982) Once dominated by the manufacturing of automotive and aerospace, St. Charles County has since expanded its employer base to include internationally leading technology companies in the service industry. (St. Charles County Council 2003) Based on the 2000 Census data, Table 2.2 illustrates the County's employment distributed by industry.

Table 2.2. St. Charles County Employment by Industry

Industry	**Employment (%)**
Accommodations & Food Services	5.8
Administrative, Support & Waste Management Service	3.2
Agriculture, Forestry, Fishing & Hunting	0.4
Arts, Entertainment, & Recreation	1.7
Construction	7.7
Educational Services	7.1
Finance & Insurance	5.8
Health Care & Social Assistance	9.6
Information	3.7
Management of Companies & Enterprises	0.2
Manufacturing	16.2
Mining	0.1
Other Services (except Public Administration)	4.7
Professional, Scientific & Technical Services	5.6
Public Administration	3.2
Real Estate, Rental & Leasing	1.7
Retail Trade	13.2
Transportation & Warehousing	0.6
Utilities	3.9

(Source: Adapted from St. Louis Regional Chamber & Growth Association 2004, page 1)

Some of the largest for-profit employers in the county include, but are not limited to, Citigroup, General Motors Corp., Ameristar Casino, Master Card Global Technology, MCI, and various school districts. (St. Charles County Government 2005) Please refer to Table 2.3 for a complete listing of St. Charles County's largest employers.

Table 2.3. St. Charles County Largest Employers

Company	**Industry**	**Employment**
Citigroup	Financial Services	5,000
General Motors Corp.	Manufacturing	2,800
Francis Howell School District	Education	2,249
Fort Zumwalt School District	Education	2,234
SSM St. Joseph Medical Center	Health Care	2,036
Ameristar Casino	Leisure & Hospitality	1,900
Master Card Global Technology	Financial Services	1,752
MCI	Telecommunications	1,498
Wentzville School District	Education	1,498
MEMC	Manufacturing	1,270
CenturyTel	Telecommunications	1,200

(Source: Adapted from St. Louis Regional Chamber & Growth Association 2004, page 1)

Unemployment rates have remained fairly steady over the past ten years even as the number of laborers has increased dramatically. The only exceptions were in 1992, when the unemployment rate was 4.9 percent and in 1993 when it was a staggering 5.2 percent. In 2001, the local unemployment rate had declined to 3.3 percent. Please refer to the chart below. (St. Charles County Council 2003) Currently, St. Charles County has announced an unemployment rate of 3.8%, much lower than the current national average and consistently lower than the St. Louis metropolitan average. (St. Charles County Government 2006)

Table 2.4. St. Charles County Workforce Trends

Year	Workforce	Employment	Unemployment	Unemployment Rate
1992	128,323	122,061	6,262	4.9
1993	130,349	123,523	6,826	5.2
1994	134,256	129,342	4,914	3.7
1995	144,137	139,362	4,775	3.3
1996	150,954	146,562	4,392	2.9
1997	150,822	146,824	3,998	2.7
1998	153,653	149,338	4,315	2.8
1999	156,788	153,486	3,302	2.1
2000	162,824	159,270	3,554	2.2
2001	163,310	157,870	5,440	3.3

(Source: Adapted from St. Charles County Master Plan, page 7)

According to the 2000 Census, only 65,512 residents worked within the boundaries of St. Charles County while 139,730 residents worked elsewhere. Since then, the number of residents working in the County has steadily increased as more employment opportunities have been created. (East-West Gateway 2004)

2.2.3. Land Use. With a total area of approximately 375,040 acres, St. Charles County consists of 35,753 acres of residential land, 5,031 acres of commercial land, 2,979 acres of industrial land, 19,303 acres of recreational land, 10,724 acres of public land, and 303,137 acres of undeveloped/agriculture land. (East-West Gateway 2004)

Approximately 45 percent of St. Charles County meets the soil requirements for prime farmland. Prime farmland, as defined by the U.S. Department of Agriculture, is the best land for producing food, feed, fiber, forage, and oilseed crops. This land has the soil quality, growing season, and moisture supply necessary to economically produce a sustained high yield of crops when it is managed with acceptable farming methods. Providing both the Nation's short and long term needs, prime farmland produces the highest yields with minimal inputs of energy and economic resources, resulting in the least damage to the environment. While these regions are scattered throughout the county, most are in the northern half. Prime farmland may be used for crops, pastures, and woodland, but once designated, may not be used for urban, built-up land, or water areas. Specifically, it must be used for producing food or fiber or at least be available for such uses. A continued trend throughout the county has been the loss of prime farmlands to urban, suburban, and industrial uses. (Tummons 1982)

Corn, soybeans, and wheat are the primary cash crops, while beef cattle, dairy cattle, and hogs are the principal livestock. (Tummons 1982)

2.2.4. Transportation. St. Charles County is served by a variety of transportation routes including interstates; state highways; county, local, and arterial roadways; and streets maintained by the Missouri Department of Transportation, St. Charles County Highway Department, and local community municipalities. The major thoroughfares throughout the County are Interstate 70, Interstate 64 (U.S. Highway 40-61), U.S. Highway 61, U.S. Highway 67, State Highway 370, State Highway 94, and State Highway 79. (St. Charles County Council 2003)

Two studies commissioned by the St. Charles County Economic Department Center analyzed the commuting trends of the county resident workforce within the metropolitan area. Conducted in 1996, the first study performed by Paragon Decision Resources determined that nearly 70 percent of the county workforce commuted elsewhere in the metropolitan area for employment. By 2000, a similar study by the Public Policy Department at Saint Louis University estimated that the number of residents working outside St. Charles County dropped to 55 percent. (St. Charles County Council 2003) Just as many St. Charles County residents work outside of the community, several metropolitan area residents commute to St. Charles County for employment. The St. Louis Regional Chamber & Growth Association also performed a study to determine where the St. Charles County labor force commuted from. The results are listed in the following table.

Table 2.5. Labor Force Commuters to St. Charles County

County of Residence	Number of Employees	Percent of Commuters
MISSOURI		
St. Charles County	70,058	71.00
St. Louis County	12,859	13.03
Lincoln County	5,529	5.68
Warren County	2,967	3.01
St. Louis City	1,439	1.46
Jefferson County	1,291	1.31
Franklin County	766	0.78
Montgomery County	362	0.37
ILLINOIS		
St. Clair County	1,051	1.07
Madison County	640	0.65

(Data Source: St. Louis Regional Chamber & Growth Association 2004)

The average travel time for the St. Charles County residents to reach work varies depending not only on distance but also traffic flow. Generally, approximately 34% of the working population has a commute time of less than 15 minutes, 39% travel on average 15 to 30 minutes, 25% traverse 30 to 60 minutes, and only 2% commute more than 60 minutes. The vast majority of the County workforce commutes to work at least five days per week. (St. Charles County Council 2003)

Table 2.6 illustrates the means of transportation that St. Charles County residents use to commute to work compared between the 1990 Census and the 2000 Census. As shown, nearly all workers continue to use their personal vehicle to commute to and from work. However, despite obvious advantages, the number of people utilizing public transportation has barely increased over this ten year time period. Also, fewer people are walking or riding bicycles to work most likely due to length of travel. (East-West Gateway 2004)

Table 2.6. St. Charles County Modes of Transportation

Year	Workforce 16 & Over	Work from Home	Personal Vehicle	Carpool / Public	Walk	Other
1990	111,051	3,114	93,349	12,504	1,382	702
2000	149,111	4,546	129,937	12,576	1,184	868

(Source: Adapted from East-West Gateway, 2004, Section 1, page 12)

Establishing a good system of roads and bridges has been one of the top priorities facing St. Charles County throughout the last decade. In 1985, residents first approved a ½-cent sales tax for transportation projects involving the upgrade and expansion of various roadways. Since then several improvements have been made to accommodate growth, preserve and maintain current systems, and facilitate the safe flow of traffic. (St. Charles County Council 2003) Also, St. Charles County transportation department created a Thoroughfare Plan as well as a travel demand model to assist in evaluating proposed construction projects. The county-wide Thoroughfare Plan is a long-range conceptual road plan that outlines the strategic roadways vital for efficient traffic flow as well as those necessary to accommodate additional residential, commercial, and retail development. The travel demand model is used to assess the effectiveness of proposed road improvement projects and to insure that these projects accomplish the goals intended. The model is also being utilized to better understand the impact of proposed subdivisions and retail centers on existing local roads and estimate how driving patterns will change. (St. Charles County Missouri website 2007)

2.3. DEMOGRAPHICS

2.3.1. Age. The data on the age of the County's residents indicates that the area has a primarily youthful population when compared to both the surrounding metropolitan area and the state as a whole. (St. Charles County Council 2003) As of 2006, the median age throughout the county is 35.4. (St. Charles County Government 2006) However, the senior citizen population, 55 years of age and older, has grown to 16.8% of the total population compared to 13.3% in 1990.

(St. Charles County Council 2003) Refer to Table 2.7 below to determine the percentage of the population various age groups constitute.

Table 2.7. St. Charles County Age Groups

Age	Amount	Percent
Under 18	82,128	28.9
18 to 64	176,990	62.3
Over 65	24,789	8.7

(Source: Adapted from East-West Gateway, 2004, Section 1, page 9)

2.3.2. Diversity. While St. Charles County has remained predominantly Caucasian since its establishment, some diversity in the population has been introduced due to various ethnic influxes. According to 2005 Census estimates, the County's population can be categorized as follows: 93.5 percent Caucasian, 3.5 percent African American, 2.0 percent Hispanic/Latino, 1.5 percent Asian, 0.2 percent Native American, and no native Hawiians or other Pacific Islander. Approximately 1.2 percent of the population surveyed reported two or more races. Table 2.8 shows the exact amount of the total population that each race contributes.

Table 2.8. St. Charles County Diversity

Ethnic Race	Amount	Percent
Caucasian	316,703	93.5
African American	11,856	3.5
Hispanic / Latino	6,775	2.0
Asian	5,081	1.5
Native American	678	0.2
Native Hawaiian / Other Pacific Islander	0	0.0
Two or More Races	4,065	1.2

(Data Source: U.S. Census Bureau 2007)

2.3.3. Education. The St. Charles County government strongly advocates the advancement of education. The county hosts six public school districts, 27 private schools, a major university, a community college, and several satellite campuses. Thus, 30.6% of its residents over the age of 25 have earned a Bachelors degree or even higher. (St. Charles County Government 2006)

As Table 2.9 illustrates, the number of residents without a high school education has drastically dropped between the 1990 census and the 2000 census. However, the number of residents with some high school education but still no diploma has actually slightly risen during that 10 year time frame. Even still, the amount of people completing advanced degrees, such as an associate, bachelors, or graduate degree, has substantially increased during the same time period and has continued to do so since then.

Table 2.9. St. Charles County Educational Attainment

Year	No High School Education	Some High School Education - No Diploma	Associate Degree	Bachelor Degree	Graduate Degree
1990	9,156	12,593	8,298	20,002	7,545
2000	6,412	12,979	12,763	33,022	13,140

(Source: Adapted from East-West Gateway, 2004, Section 1, page 10)

2.3.4. Income. The average per capita income for St. Charles County was $34,088 and the median family income was greater than $73,600 in 2005; and both have steadily increased since then. (St. Charles County Community Development Department 2006) Nearly half of all households in the county consist of two or more steady incomes, allowing for higher standard of living. In fact, St. Charles County has 30 percent more two or more income households compared to the entire St. Louis metropolitan area. Table 2.10 illustrates the distribution of income across St. Charles County family households. The number of households with combined incomes greater than $50,000 increased 117 percent between the 1990 census and 2000 census, while the number of families with household incomes less than $50,000 has declined 26 percent during the same ten year time period. Moreover, the number of families with household incomes greater than $75,000 has increased from constituting 12.1 percent of all families in 1990 to 37.7

percent of all families in 2000, just another indicator of the extensive economic development in the area. (St. Charles County Community Development Department 2006)

Table 2.10. Family Household Income Ranges in 1990 & 2000

Income Range	1990		2000	
	Amount	Percent	Amount	Percent
Under $10,000	1,919	3.3	1,276	1.6
$10,000 - $14,999	2,034	3.5	1,279	1.7
$15,000 - $24,999	6,272	10.8	3,865	5.0
$25,000 - $34,999	8,581	14.7	6,468	8.4
$35,000 - $49,999	15,286	26.3	12,279	15.9
Total Under $50,000	34,092	58.6	25,167	32.6
$50,000 - $74,999	17,036	29.3	23,003	29.7
$75,000 - $99,999	4,938	8.5	15,133	19.5
$100,000 - $149,999	1,758	3.0	10,515	13.6
$150,000 +	384	0.6	3,635	4.6
Total Above $50,000	24,116	41.4	52,286	67.4

	1990	2000
Total Family Households	58,208	77,453
Median Family Income	$44,634	$64,415

Source: Adapted from St. Charles County Community Development Department, 2006, page 3

Additionally, only 2.8 percent of St. Charles County residents currently live below the national poverty level. That ranks the County as lowest in the nation for counties with populations of 200,000 or more. (St. Charles County Council 2003)

2.4. GEOLOGY

2.4.1. Surficial Materials. Bounded by the Missouri River on the south and the Mississippi River on the north and east, St. Charles County is a roughly triangular area dissected by numerous inland streams and tributaries. Thus, approximately half of the land area is categorized as floodplain where alluvial fill materials are generally very thick. (Missouri Geological Survey 1977) Specifically, the alluvium consists of silt, sand, and gravel and can reach thicknesses up to 150 feet near the river banks. (East-West Gateway 2004) Dominant in the northeast and southern portion of the county, the floodplain regions have relatively low relief and often a very high water table making much of the county subject to periodic flooding.

Large quantities of wind-blown silt have been transported out of these river and stream valleys onto the upland hills bordering the river plains in the eastern portion of the county. (Missouri Geological Survey 1977) This loess material uniformly grades from a thin soil cover on the inlands to very thick sections, up to 100 feet thick, near the river boundaries. (East-West Gateway 2004) While some of this silt material has eroded away, exposing bedrock in various drainage systems, most of the material remains, masking the bedrock throughout this region of the county. (Missouri Geological Survey 1977)

The northwest portion of the county was densely covered with glaciers during the Pleistocene era. (Missouri Geological Survey 1977) The southernmost limit of this glaciation runs in an east-west line through the center of the county. (East-West Gateway 2004) Thus, the land in this area is covered with unstratified, densely compacted, and moderately thick glacial till comprised of nearly equal amounts of clay, silt and sand, with some boulders. (Missouri Geological Survey 1977) These glacial deposits can reach up to 300 feet in thickness. (East-West Gateway 2004)

In the southwestern portion of the county, surficial materials resulting from the in-situ weathering of the parent rock vary in thickness, but typically not in excess of 10 feet. (East-West Gateway 2004) This residuum is most prominent in regions where streams have carved deep into the underlying bedrock. (Missouri Geological Survey 1977)

Provided by the Missouri Department of Natural Resources, the map in Figure 2.3 delineates the average thicknesses of surficial materials across St. Charles County.

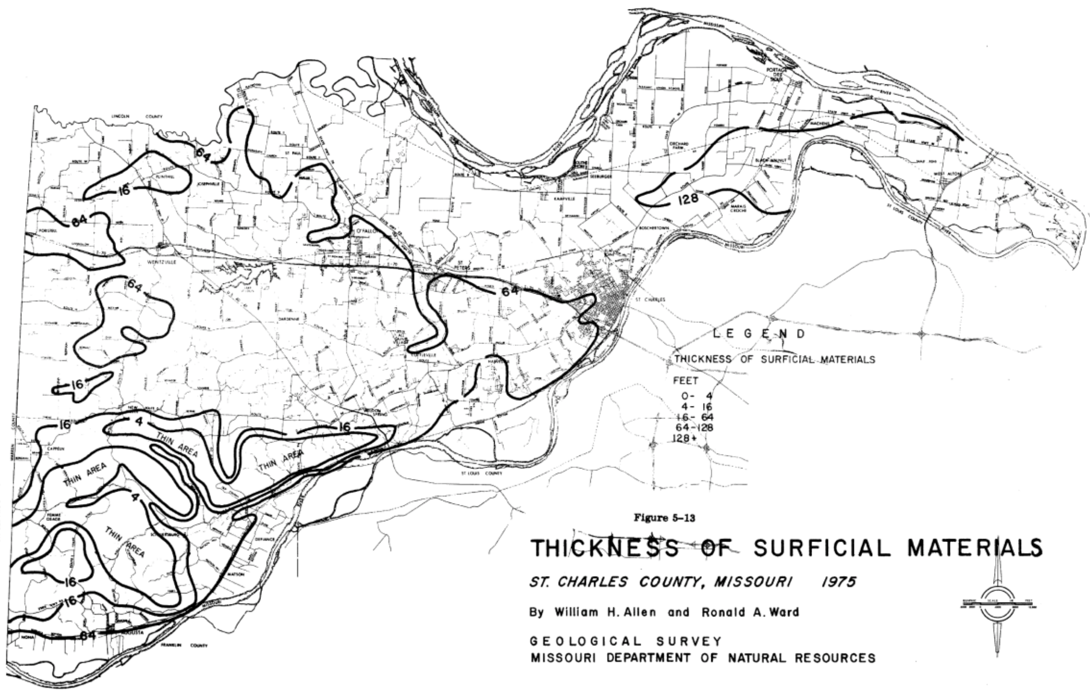


Figure 2.3. Thickness of Surficial Materials in St. Charles County
(Source: Missouri Geological Survey 1977, pages 135-136)

2.4.2. Bedrock Formations. The thickness of surficial materials in St. Charles County varies anywhere from no overburden to an excess of 300 feet. The bedrock underlying this soil cover consists primarily of dolomite, limestone, shale, and sandstone. From oldest to youngest, the bedrock in the west-central portion of the county is composed of Mississippian aged strata that includes the Fern Glen Formation, Keokuk and Burlington Limestones, Warsaw and Salem Formations, St. Louis Limestone and the Ste. Genevieve Limestone. Confined to the southwestern corner of the county, Ordovician aged strata lies directly beneath these strata and includes the St. Peter Sandstone and Cotter Dolomite. Small outcrops of the Cherokee Group from the Pennsylvanian era are located in the west, southwest, and southeast regions of the county. (East-West Gateway 2004) Specifically, St. Charles County contains 15 distinct geologic formations, for which similar formations were grouped by the Missouri Department of Natural Resources into six lithologic units: cherty dolomite, quartz sandstone, dolomite, limestone, cherty limestone, and shale, as displayed in Figure 2.4. (Missouri Geological Survey 1977)

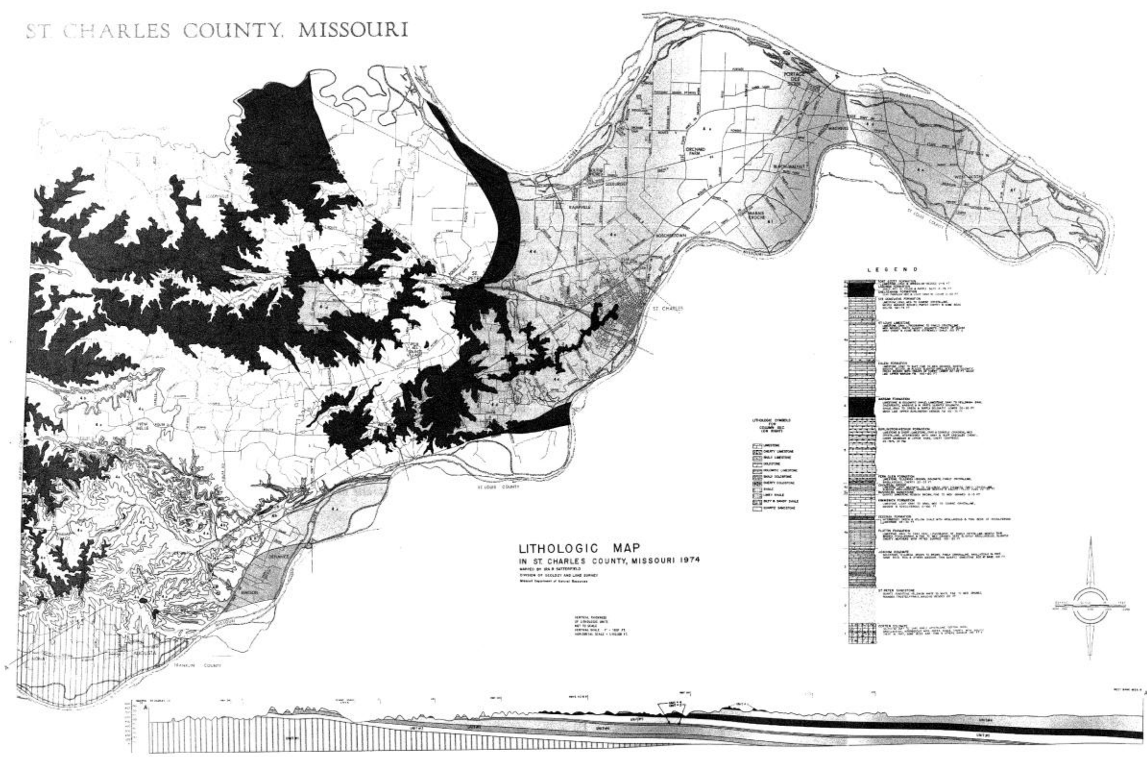


Figure 2.4. St. Charles County Lithologic Map
(Source: Missouri Geologic Survey 1977, pages 149-150)

Cherty Dolomite – Unit 1

Consisting of alternating beds of chert and dolomite, this lithologic unit is actually the Cotter Dolomite formation which has a typical thickness in excess of 100 feet. This formation is predominantly a fine-grained, thin-bedded dolomite that varies from white to beige or gray in color. Occurring both as thin layers and rounded nodules, the intermittent oolitic chert ranges in thickness from a few inches up to one foot and are grayish-white to beige in color. Very thin shale and sandstone layers can also be found intermingled within this entity but have no great extent. This cherty dolomite unit is located at the surface in the extreme southwestern corner of the county, where it has been quarried as rip rap. (Missouri Geological Survey 1977)

Quartz Sandstone – Unit 2

This unit consists of two quartz sandstone formations, the St. Peter Sandstone and the Bushberg Sandstone. Confined to the southwestern part of the county, outcrops of the St. Peter Sandstone, the lower zone, are yellowish white to white in color, pure, and relatively weak rocks that have been mined for glass sand. This sandstone formation is uniform and approximately 100 feet thick. The upper sandstone zone, the Bushberg Sandstone, is nearly 300 feet stratigraphically above the lower sandstone zone and is primarily confined to the west-central portion of the county. Reddish brown in color, this formation ranges from 0 to 15 feet in thickness and resides between two limestone zones to be discussed later. (Missouri Geological Survey 1977)

Dolomite – Unit 3

This dolomite unit varies throughout the county as either massive or extremely thin beds with an average thickness of 100 feet. This formation, comprised almost entirely of the Joachim Dolomite formation, is yellowish brown to beige in color. With the exception of a thin chert layer near the top, little chert is present. On occasion, the dolomite grades into poorly consolidated siltstone. Commonly, there is a three to five foot thick quartz sandstone layer near the base of the unit, where it comes into contact with the underlying St. Peter Sandstone. (Missouri Geological Survey 1977)

Limestone – Unit 4

With a composite thickness of approximately 500 feet, this lithologic unit is the predominant surface rock covering St. Charles County. Still, there are two distinct outcrop regions in the county, one primarily in the eastern section, and the other in the southwestern to west-central vicinity. The limestone unit in the eastern portion of St. Charles County consists of the Salem Formation, St. Louis Limestone, Ste. Genevieve Formation, and the Fort Scott Limestone. Comprising 275 to 350 feet of the total stratum, this unit is gray to beige in color, fine to coarsely grained, medium to massively bedded, and slightly dolomitic in the upper region with minimal chert present. Commonly, siltstone and several shale layers are cross bedded in the lower third of the entity. The limestone unit in the southwestern and west-central portions of the county is comprised of the Plattin Formation, Decorah Formation, Kimmswick Formation and the Chouteau Group. While the Chouteau Group is actually separated from the other underlying formations by the thinly bedded Bushberg Sandstone, it is still considered part of the limestone unit. Typically, these limestone formations are gray to white in color, dense, fine-grained, medium to massively bedded, and often weathered. At many exposures, this unit is dolomitic and has a yellowish hue. Small amounts of nodular chert is irregularly scattered throughout the unit. Also, thin, fissile shales are often present in the upper portion of the entity. (Missouri Geological Survey 1977)

Cherty Limestone – Unit 5

Comprised of interbedded limestone and chert, this unit is approximately 250 feet thick. The chert layers are relatively thin, varying from a few inches to more than a foot in thickness. While the chert is yellow to off-white with a slight bluish hue, the limestone is a standard light gray. The Fern Glen Formation, Burlington-Keokuk Limestone, and the lower 20 to 30 feet of the Warsaw Formation make up this unit. These formations are typically gray to yellowish-brown, fine to medium grained, and thin to massively bedded with significant chert present. (Missouri Geological Survey 1977)

Shale – Unit 6

This unit is comprised of three different shale formations having a composite thickness that ranges from 75 to 150 feet. Consisting of the upper portion of the Warsaw Formation, the lower shale is typically beige to green in color, very calcarious, and slightly dolomitic. At various intervals, the shale is interbedded with thin limestone, especially near the lower strata of the Warsaw Formation. The upper shale includes the Cheltenham Formation in the western and southwestern regions of the county, and the Lagonda Formation in the eastern vicinity. The Cheltenham Formation is clay, usually a maroon or light gray, with a thickness varying anywhere from 0 to 50 feet. The Lagonda Formation is a red, partly silty shale with a thickness ranging from 0 to 75 feet. (Missouri Geological Survey 1977)

Overall, these rock formations lie practically horizontal with a slight dip of approximately one to two degrees to the northeast. Typically, the limestone formations have a high permeability (10^{-4} cm/s), making them prone to dissolution and karstic features. In fact, the majority of the joints and cracks in the carbonate bedrock have been enlarged by water seepage. Also, a known stretch of sinkholes, several miles in length, exists along the Missouri River bluffs southwest of St. Charles City. Although carbonate bedrock, the dolomite formations in the southwestern portion of the county are thinly bedded and do not exhibit the same solution features that are present throughout most of the massively bedded limestone bedrock. That is, some horizontal permeability may exist, but the vertical movement of water is hindered by the lack of vertical joints or cracks. While the permeability of the shale bedrock is low, it is still susceptible to swell. (Missouri Geological Survey 1977)

2.4.3. Soils. St. Charles County has a total of seven soil associations: (1) Armster-Mexico-Hatton association; (2) Menfro-Harvester-Weller association; (3) Portage-Carlow-Kampville association; (4) Haynie-Blake-Waldron association; (5) Goss-Crider-Gatewood association; (6) Dockery-Haymond-Sensabaugh association; and (7) Lomax-Blase association. Figure 2.5, a general soil map provided within the U.S. Department of Agriculture's soil survey, illustrates the distribution of these soil associations across St. Charles County. (Tummons 1982) Most of these soil associations are covered by organic topsoil which is not considered in the type designations. (Missouri Geological Survey 1977) A soil association typically consists of one or more major soils as well as some minor soils. However, the association is named only for the major soils. Also, it is important to note that the soils making up one association can occur in other associations but in a different pattern. Each association has a distinct pattern, relief, drainage, and natural landscape; all to be discussed in further detail. Nonetheless, the soils that comprise an association often vary across locations in depth, slope, and drainage. (Tummons 1982)

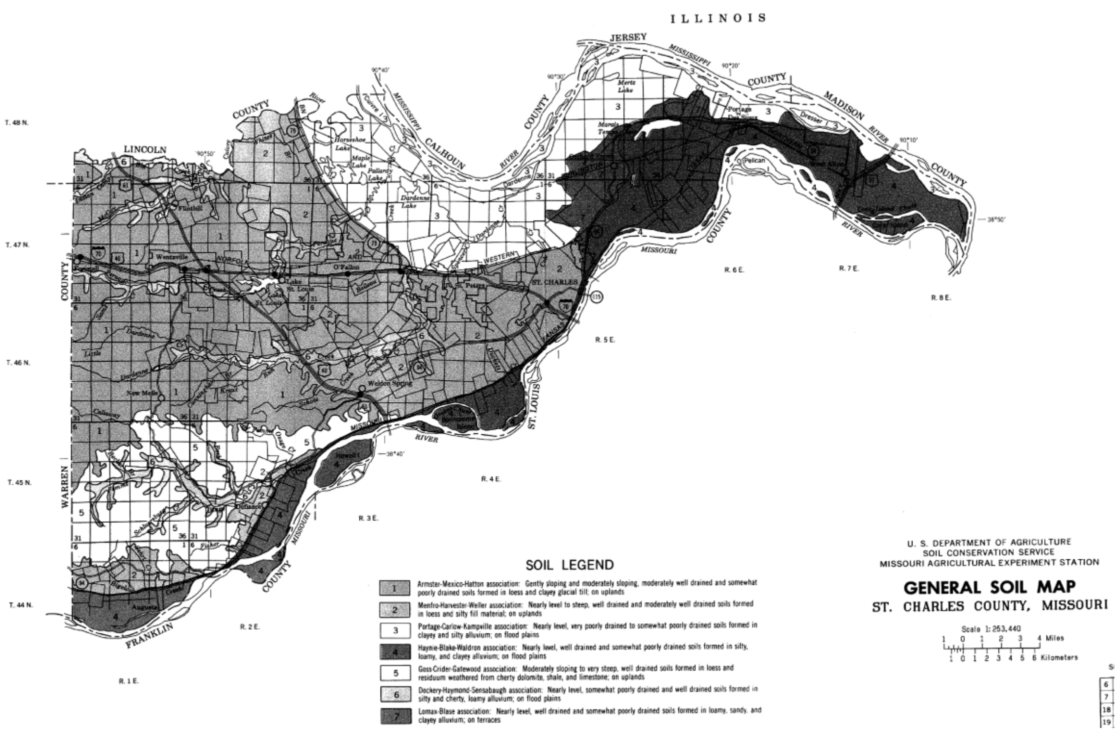


Figure 2.5. St. Charles County General Soil Map
(Source: Tummons 1982, page 158)

Armster-Mexico-Hatton association (1):

This soil association is gently to moderately sloping, moderately well to poorly drained soils formed in loess and clayey glacial till. Covering approximately 21 percent of St. Charles County, this association is primarily located on the upland regions, narrow ridges, and the adjacent side slopes. The association is comprised of 28 percent Armster soils, 18 percent Mexico soils, and 16 percent Hatton soils with the remainder being minor soils. Water erosion and the high shrink-swell potential are the major concerns associated with this soil group. (Tummons 1982)

Menfro-Harvester-Weller association (2):

This association includes nearly level to steep, well to moderately well drained soils formed in loess and silty fill materials located in the deeply dissected upland regions adjacent to the flood plains of the Mississippi and Missouri Rivers. This association occupies nearly 22 percent of the county and consist of approximately 44 percent Menfro soils, 23 percent Harvester soils, 23 percent Weller soils, and the remaining 10 percent is minor soils. The main management concerns for this association are the susceptibility to erosion and moderate to high shrink-swell potential of the subsoil. (Tummons 1982)

Portage-Carlow-Kampville association (3):

This soil unit consists of nearly level, poorly drained soils formed in clayey and silty alluvium. Covering approximately 15 percent of St. Charles County, this association consists of soils on the Mississippi River flood plains. While differences in elevation are slight, the landscape gradually inclines from the lowest areas along the river channel toward the surrounding uplands. This association is comprised of nearly 32 percent Portage soils, 31 percent Carlow soils, and 9 percent Kampville soils with the remainder being minor soils. Differences among the soils are largely a result of the texture of the materials from which they formed. The main limitations for this soil association are extreme saturation, frequent flooding, and high clay content. (Tummons 1982)

Haynie-Blake-Waldron association (4):

Covering approximately 15 percent of St. Charles County, this soil association contains nearly level, well to poorly drained soils formed in silty, loamy, and clayey alluvium located in the Missouri River flood plain. Although changes in elevation are slight, the silty soils are typically the highest positions on the landscape and the clayey soils are the lowest positions. This soil group consists of about 26 percent Haynie soils, 26 percent Blake soils, 16 percent Waldron soils, and 32 percent minor soils. Slight differences in the soils are largely a result of the texture of the material in which they formed. Main management concerns include the extreme wetness and the hazard of flooding. (Tummons 1982)

Goss-Crider-Gatewood association (5):

This soil association consists of moderately to steeply sloping, well drained soils formed in loess and residuum weathered from cherty dolomite, shale, and limestone located on the hillsides, ridge tops, and foot slopes of the upland regions. Differences in elevation in excess of 250 feet within a quarter mile are quite common in this locale. Occupying nearly 14 percent of the county, this soil group consists of nearly equal amounts of the major soils. Specifically, it is nearly 28 percent Goss soils, 27 percent Crider soils, and 25 percent Gatewood soils with the remainder being minor soils. Steep slopes, hazard of erosion, depth to bedrock, and excessive chert in the soils are the main limitations of this soil unit. (Tummons 1982)

Dockery-Haymond-Sensabaugh association (6):

Covering only 9 percent of St. Charles County, this soil association consists of nearly level, poorly to well drained soils formed in silty and cherty, loamy alluvium located on the flood plains along the interior creeks, tributaries, and small drainage ways. The soil group is approximately 44 percent Dockery soils, 16 percent Haymond soils, 13 percent Sensabaugh soils, and 27 percent minor soils. Flooding and excessive saturation are the management issues related with this association. (Tummons 1982)

Lomax-Blase association (7):

This soil group consists of nearly level, well and poorly drained soils formed in loamy, sandy, and clayey alluvium positioned on the high terrace between the Missouri and Mississippi River flood plains. This terrace abruptly rises to its highest elevation along the Missouri River flood plain and gradually slopes toward the Mississippi River flood plain. Occupying only 4 percent of the county, the soil association is approximately 40 percent Lomax soils, 29 percent Blase soils, and 31 percent minor soils. There are no major limitations with this soil unit. (Tummons 1982)

2.4.4. Structures. There is no evidence of major structural features; however, a minor fault trending northwest to southeast is centrally located in the county. (East-West Gateway 2004)

2.5. TOPOGRAPHY

The floodplain region has relatively low relief. Outside of the flat-lying floodplain regions, the majority of St. Charles County consists of gently rolling topography, with the exception of the southwestern corner of the county and along the Missouri River bluff line, where it is highly dissected. This drastic change in topography nearly parallels the boundaries of glaciation. (Missouri Geological Survey 1977)

Around the major drainage areas, slopes are relatively gentle, ranging from 0-5.9 percent. Steeper slopes ranging from 6-13 percent are located in the central and western regions of the county. The greatest relief is positioned in the southwestern portion of the county at 14 percent or greater. Elevations range from approximately 400 feet above seal level at the confluence of the Mississippi and Missouri Rivers to approximately 900 feet above sea level in the south-central portion of the county. (East-West Gateway 2004)

2.6. HYDROLOGY

Bounded by the Missouri River on the south and the Mississippi River on the north and east, St. Charles County is a roughly triangular area dissected by numerous inland streams and tributaries. Specifically, the Cuivre River, Peruque Creek, and Dardenne Creek, all tributaries to the Mississippi River, greatly contribute to the broad floodplains dominating the county topography. These surface waters have the potential to supply water for many towns and industries and to provide navigable routes for commerce and recreation. (Missouri Geological Survey 1977) Due to the close proximity of several large rivers, St. Charles County has an extensive history of flooding, which will be covered in detail as part of Chapter 4.

In addition to the previously described surface water sources, a large amount of fresh water is available within the bedrock and alluvium underlying the area. (Missouri Geological Survey 1977)

2.7. ENVIRONMENTAL CONCERNS

As St. Charles County continues its rapid growth promoted by good transportation routes, available housing, and economic opportunities, environmental challenges will undoubtedly follow.

2.7.1. Waste Management.

2.7.1.1 Storm Water. The most common cause of water pollution, storm water runoff is generated by precipitation that is unable to infiltrate land and impervious areas such as streets, parking lots, rooftops, etc. Precipitation can pick up oil, fertilizers, pesticides, dirt, and many other pollutants along the pathway to down gradient creeks, streams, rivers, and lakes. (St. Charles County 2007a) The impacts of storm water runoff are of considerable concern. As more homes are built and more commercial sites are developed, proactive planning measures must be taken to protect water quality in the watersheds and to reduce storm water damage to property and human life. (St. Charles County Council 2003) Several long-term watershed studies have been conducted throughout the County to determine the effects of storm water discharge. Most recently, St. Charles County has partnered with the U.S. Army Corps of Engineers to perform a three-year comprehensive study of the Dardenne watershed. (St. Charles County – Division of Environmental Services)

The St. Charles County Government is required to follow a five-year Storm Water Management Plan as required under the EPA mandated Clean Water Act. As such, the County Government recently submitted a draft of the new 2008-2013 Storm Water Management Plan to the Missouri Clean Water Commission. This plan outlines extensive control measures, monitoring procedures, detection levels, and incident reports. Also, this plan covers the unincorporated areas of the County where there is no significant interlocking storm sewer system. Individual municipalities manage storm water issues within their specific boundaries as a part of this County Storm Water Management Plan. (St. Charles County Government 2007)

2.7.1.2 Sanitary Sewers and Waste Water Treatment Facilities. St. Charles County Government requires that all residential structures, commercial and industrial buildings, public facilities, and other uses of land maintaining occupants including the unincorporated regions must be equipped with an adequate, safe, and sanitary disposal system for human, domestic, and industrial wastes. (St. Charles County Government 1999) Most of the County has access to the extensive sanitary sewer system underlying the ground framework and existing nearby waste water treatment facilities. However, where access to sanitary sewer systems is not available, either package waste water treatment facilities or septic systems must be utilized. Traditional package waste water treatment plants use a biological treatment methodology. However, more advanced package waste water treatment plant systems may include a combination of biology and filters and/or membranes. Where the use of these package waste water treatment plants is not feasible, septic systems then must be utilized. (St. Charles County Council 2003)

2.7.1.3 Solid Waste. The responsibility for municipal solid waste management falls on a variety of agencies including federal, state, county, and city governments, private firms and residents themselves. (St. Charles County Council 2003) The provisions within the solid waste management code of St. Charles County are to be followed throughout the County including all the unincorporated areas. This code covers policy on general operations, interjurisdictional cooperation, enforcement, and penalties. (St. Charles County 2007b) The County's Environmental Services Department is responsible for regulating the management, storage, collection, transportation, processing, disposal, and recycling of solid waste for the unincorporated areas. The current system of laws, regulations, and private sector management is relatively efficient and protective of public health and the environment. (St. Charles County Council 2003)

2.7.1.4 Hazardous Waste. St. Charles County has had to deal with potentially dangerous waste sites and leaks/spills that have resulted in contamination in the past and may do so again in the future. These threats must be monitored to protect human health, the environment, and natural resources. (St. Charles County Council 2003)

The St. Charles County Division of Environmental Services actively monitors the progress of two massive remediation projects to ensure the protection of public health and the environment. Both of these projects have been completed within the past five years but still require continued monitoring. Administered by the Department of Energy, the Weldon Spring

Site Remediation Action Project (WSSRAP) manages low-level radioactive waste residues resulting from years of explosive production and uranium processing. (EVS 1999) Managed by the Army Corps of Engineers, the Weldon Spring Ordinance Works Project (WSOW) removes and treats the chemical contaminants from decades of explosive production, specifically TNT and DNT. (USACE 2004)

Other hazardous waste facilities located in St. Charles County include the Boeing site in Hazelwood, the Findett and Safely Kleen sites in St. Charles, and the General Motors assembly plant in Wentzville. These facilities simply produce hazardous waste as a by-product of their manufacturing and properly manage and dispose of the material following all necessary protocol. Restrictions concerning hazardous waste storage, treatment, and disposal are based on the most recent federal and state regulations. Existing codes and regulations require additional mitigation measures such as site plan review of soil, slope, drainage, flood hazard, and street connectivity issues prior to the handling of any hazardous substances. (East-West Gateway 2004)

2.7.2. Air Quality. St. Charles County and the entire St. Louis metropolitan area struggles to meet federal ambient air regulations. While the area was declared to be in attainment of the one-hour standard for ozone pollution levels, it was also designated as a non-attainment area for the eight-hour standard. There are two air quality monitoring sites located within the County to measure these levels as well as other pollutants. Specifically, these sites, near Orchard Farm and West Alton observe ozone, nitrogen dioxide, and particulates. Better industrial pollution controls, the enhanced vehicle maintenance program, and the gasoline vapor recovery program have all been implemented in an effort to protect human health and the environment. (St. Charles County Council 2003)

2.7.3. Climate. St. Charles County consistently has cold winters and long, hot summers. In the winter months, the average temperature is 33° F with an average daily minimum temperature of 24° F. In 1963, the lowest temperature was recorded at -11° F. Conversely, in the summer months, the average temperature is 77° F with an average daily maximum temperature of 87° F. In 1954, the highest temperature was recorded at 115° F. (East-West Gateway 2004)

Heavy rainfall mainly occurs in the spring and early summer months, when moist air from the Gulf of Mexico combines with drier continental air. (Tummons 1982) The total annual precipitation is 33.81 inches, of which approximately 20 inches falls between April through September. On average, two out of every ten years the rainfall during April through September is less than 16 inches. The heaviest single day rainfall was recorded at Lambert Airport in 1957 at 3.95 inches. Typically, thunderstorms occur on nearly 50 days of every year, mostly in the summer months. (East-West Gateway 2004)

The average annual snowfall is 18 inches. On an average of nine days, a minimum of one inch of snow is on the ground. The greatest snow depth at any one time was recorded at 12 inches. (East-West Gateway 2004)

The average relative humidity during the mid-afternoon is approximately 60 percent. The humidity escalates during the night, resulting in an average humidity of 80 percent at dawn. The sun shines 70 percent of the time during the summer and 50 percent of the time in the winter. Prevailing from the south, the wind reaches its highest speed during March at 12 miles per hour. (Tummons 1982)

2.8. FORM OF GOVERNMENT

St. Charles County is a first-class county with a charter form of government. Executive power of the County is vested in the County Executive, which is a full-time salaried position. The current county executive is Steve Ehlmann, who was elected on November 7, 2006. Elected by the general population, the County Executive's serves a four year term along with seven County Council members. One Council member is elected by the voters in each of the seven Council districts. Council member terms are also four years with terms for even- and odd-numbered districts staggered. After their election, the County Council elects a Chair and Vice-Chair to govern the Council. All legislative powers for St. Charles County are vested in the County Council. Other elected county officials include the County Sheriff, Recorder of the Deeds, Collector, Assessor, Prosecuting Attorney and the Election Authority. (East-West Gateway 2004)

The seat of County Government is located in the City of St. Charles. There are 21 municipalities within St. Charles County. The County government is organized into several different departments and divisions that support and carry out the directives of the elected officials while providing governmental services to the citizens in the unincorporated areas of the County. Other governmental services are supplied by various departments including, but not limited to, building inspection, circuit clerk, corrections court/judge, dispatch/alarm, finance, information systems, parks and recreation, planning/zoning, transportation, and workforce development. (East-West Gateway 2004)

2.9. COMMUNITY PLANS

Designated by state and federal agencies as the planning organization for the bi-state metropolitan area, East-West Gateway has partnered with local governments, including St. Charles County, to facilitate community-driven planning processes. St. Charles County has taken a proactive approach for long range planning to deal with the issues common to most communities located within the outer limits of metropolitan areas, where recent growth pressures are greatest. Other concerns need to be addressed such as land use, urban expansion, and transportation strategies. Recent policies prepared include the Year 2010 Plan for St. Charles County, St. Charles County Master Plan Target 2015: Prosperity Through Planning, Unified Development Ordinance, St. Charles County Transportation Plan 2015, and the St. Charles County Transportation Plan 2030.

The Year 2010 Plan serves as the current framework that directs growth and development within the County and guides staff and elected officials in their decisions of land use issues such as rezoning requests or subdivision approval. (East-West Gateway 2004) However, the 2015

Master Plan is the updated St. Charles County Master Plan used to address the needs and priorities of the County through the year 2015. The primary goal of this Plan is to balance the competing issues and interests which affect future growth and development patterns within the County. Specifically, the Master Plan sets policies, identifies and evaluates community goals and concerns, and presents recommendations for improvement and advancement. (St. Charles County Council 2003) Completed in 1999, the Unified Development Ordinance provides rules and regulations regarding zoning and subdivision development requirements. (East-West Gateway 2004)

Released in 1997, the St. Charles County Transportation Plan 2015 forecasts the travel demands for the street and highway systems. Deficient roadway sections are identified and necessary transportation improvements along with funding options available for such improvements are presented. Also, this plan examines safety issues, pedestrian and bicycle activity, public transportation including transit and paratransit service, railroad, aviation, pipeline and barge movements. The 2030 Transportation Plan has recently been created in response to the continued rapid growth of St. Charles County. Since the release of the preceding transportation plan, extensive commercial, industrial, and residential development has occurred. While many of the previously suggested roadway improvements have been made with more expected in the near future, development has greatly impacted the existing or newly improved roadway system as well as unincorporated areas in ways that were not anticipated. Thus, St. Charles County officials require this updated transportation plan. (East-West Gateway 2007)

3. PREVIOUS HAZUS LOSS ESTIMATION STUDIES IN THE MIDWEST

While earthquake loss estimation methodologies have been available for some time and their application has increased uniformly with technological advances, these advanced tools are seldom utilized, especially when the perceived risk is low. (Luna et al. 2008) In 2004, the Federal Emergency Management Agency (FEMA) conducted an extensive market study and tracked distribution of the HAZUS application software to better characterize overall utilization. It is important to note that the resulting usage statistics are only applicable for the initial versions of HAZUS, as the first multi-hazard edition had just been released immediately before this study. According to the HAZUS Strategic Plan, the number of users at that time of the study was greater than originally anticipated. In fact, the number of HAZUS users nearly tripled from an estimated 1,300 in 2000 to nearly 4,200 in 2004. Table 3.1 illustrates this increase as well as the projected number of users for the current year. While more recent data is currently not available, it is doubtful that the application software has reached this much of the marketplace. (FEMA 2005)

Table 3.1. Number of HAZUS Users

Number of HAZUS Users		
Year	**Number**	**Basis**
2000	1,300	Estimated
2002	1,500	Estimated
2003	1,750	Estimated
2004	4,200	Actual
2008	19,600	Predicted Potential

(Source: FEMA 2005, page 11)

By analyzing orders placed for HAZUS, FEMA was also able to quantify the primary users of the software. As seen in Figure 3.1, HAZUS software is being utilized in all aspects of the potential market, albeit to varying degrees. (FEMA 2005)

HAZUS-MH Distribution Summary by Number of Orders		
March through September 2004		
Orders	**Number**	**Percent**
Local	826	39%
Private Industry	503	23%
Universities	271	13%
Federal	180	8%
State	162	8%
Other	158	7%
Organizations	26	1%
Military	17	1%
Total	**2143**	**100%**

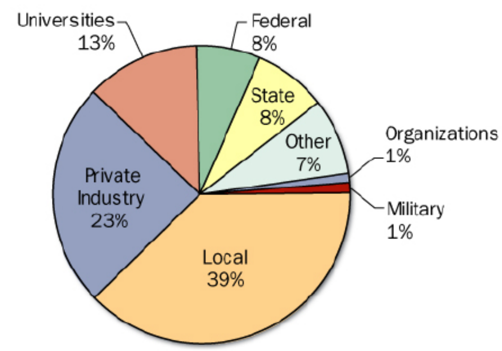


Figure 3.1. 2004 HAZUS-MH Distribution

(Source: FEMA 2005, page 12)

The initial success of HAZUS can be attributed, at least in part, to Project Impact, a FEMA initiative designed to build disaster resistant communities through partnerships with state and local governments. The City of Cape Girardeau was designated as the only Missouri community to join in Project Impact. (Tibbs 1998) In total, nearly 200 communities and over 1,000 business associates participated in this initiative, undoubtedly comprising the majority of early HAZUS users. Although successful, Project Impact ended when the Bush Administration took office. With federal funding no longer available, the number of communities actively planning with the aid of HAZUS has slowly diminished. (USGAO 2002)

Prior to the development of HAZUS, several loss estimation projects approximated the expected consequences of a large magnitude earthquake upon the St. Louis metropolitan area through various well-received relationships/estimations. (FEMA 1990) Since then, a few of these previous loss estimation projects have been re-analyzed to incorporate HAZUS-MH. Specifically, the Central United States Earthquake Consortium (CUSEC) was first to analyze the apparent risk and subsequent losses of six cities within the zone of influence of the New Madrid Seismic Zone (NMSZ) in 1985. This project has been consistently improved with the implementation of HAZUS-MH and the acknowledgement of other seismic zones. However, St. Louis is not one of the original six cities analyzed. Rather, Memphis, Tennessee; Little Rock, Arkansas; Carbondale, Illinois; Evansville, Indiana; Paducah, Kentucky; and Poplar Bluff, Missouri were evaluated. (CUSEC 2003)

Given the unparalleled capacity of the NMSZ to create catastrophic destruction, the research focus has spread to a much larger region. As such, CUSEC, FEMA, and the USGS partnered in 2005 to create scenarios for all three faults (northeast, central, and southwest) within the NMSZ. This study was designed to simply illustrate both the type and extent of damage that can be expected from a large magnitude (M 7.7) earthquake originating at any of these faults. For this particular analysis, a study region was created, including a total of 230 counties across eight Midwestern states, making it difficult to compare results to a much more concise analysis, similar to this. (CUSEC 2005) However, several state officials requested that the same scenario be presented on an individual state-by-state basis to serve as the starting point for emergency planning. These individual results are available for download on CUSEC's website. It is important to note that the seismic hazard maps utilized in this study are the same as those imported for the NMSZ scenarios in this report. (CUSEC 2008)

The primary planning organization for the St. Louis metropolitan area, East-West Gateway has compiled this readily available information for the bi-state area. Specifically, the study region includes all counties within their jurisdiction, the majority of which are located in southeast Missouri and southern Illinois. Thus, St. Charles County was considered as part of this analysis. Once again, this analysis evaluated a M7.7 earthquake originating from the NMSZ, the results of which can be seen in Figure 3.2. According to these results, the total losses for St. Charles County are estimated to be approximately 66 million dollars. (Mook 2007)

While CUSEC was originally at the forefront of this research, several universities are beginning to investigate further. Specifically, the researchers at the Mid-America Earthquake (MAE) Center at the University of Illinois at Urbana – Champaign are developing and validating seismic retrofitting methods of essential facilities in the Midwest. To prioritize mitigation efforts, the expected losses had to be estimated using HAZUS-MH based on a series of earthquake scenarios. The regional study included seven Mid-American states and focused primarily on the impact of the NMSZ on densely populated cities such as St. Louis and Memphis (Wilmot 2000) and Carbondale and Sikeston (Olshansky et al 2003). Once again, this is a larger study region than the one presented in this thesis.

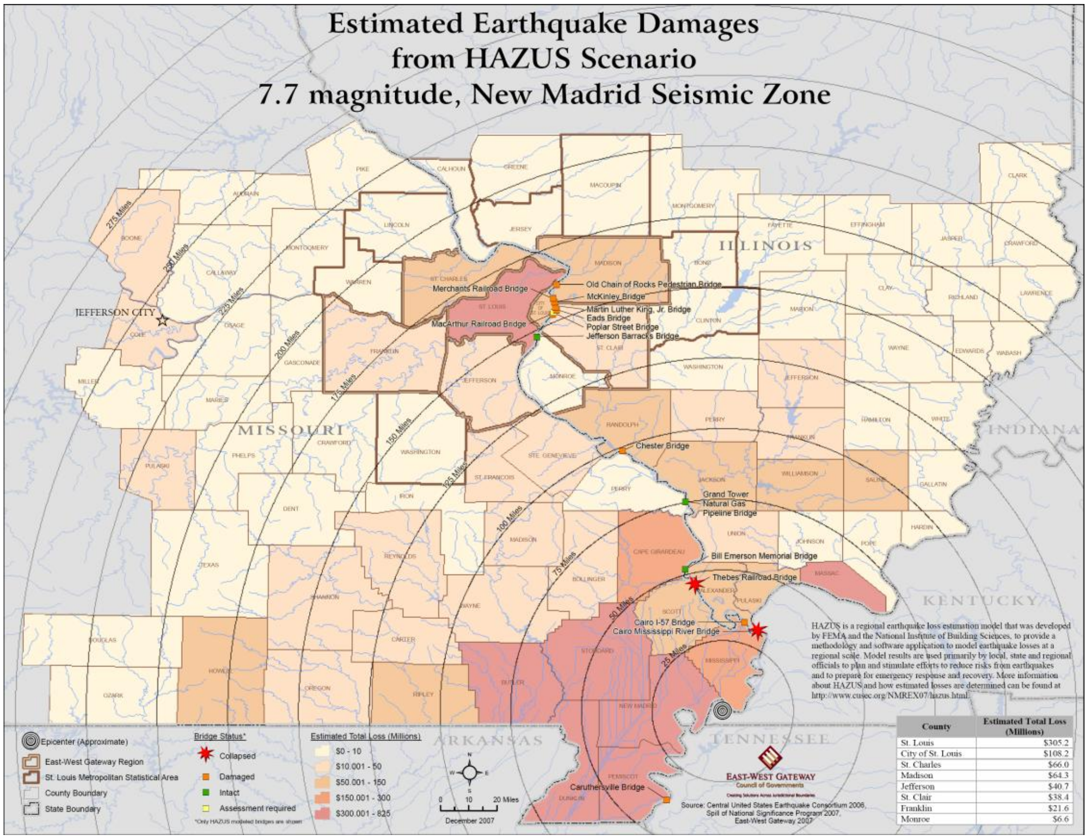


Figure 3.2. East-West Gateway HAZUS-MH Study Results

(Source: East-West Gateway 2008, http://www.ewgateway.org/pdffiles/maplibrary/hazus.pdf)

Given its extensive history with HAZUS-MH, the MAE Center is now looking to build upon the work that has already been completed using HAZUS loss estimation methodology and improving the models and data that go into an earthquake loss assessment study. In fact, the MAE Center has developed its own loss assessment and visualization tool, known as MAEViz, which is still being evaluated. Their most current study includes assessing the vulnerability of central and eastern U.S., a total of four FEMA regions, to earthquake events in the NMSZ and the

Wabash Valley Seismic Zone (WVSZ). Currently under way, Phase I of the project will involve conducting an advanced and comprehensive earthquake loss estimation with the help of HAZUS-MH. However, Phase II will evaluate selected regions with a prototyped MAEViz. (Kubetz 2007)

The University of Illinois is not the only institution currently researching the impacts of natural hazards on urban regions through means of HAZUS-MH. Funded by the FHWA, a study was performed by the University of Missouri – Rolla to estimate earthquake losses specifically associated with bridge damage in the St. Louis metropolitan area for a series of earthquake scenarios. HAZUS-MH was used to estimate the direct losses and a separate transportation model was used to approximate various indirect losses. Similar to this research, earthquake scenarios were selected to compare high impact/low probability and low impact/high probability events and include epicenters in St. Louis, Missouri (M 7.0), Germantown, Illinois (M 7.0), and New Madrid, Missouri (M 7.7). The losses to the bridge infrastructure were estimated to range anywhere from 70 to 800 million dollars, demonstrating the significance of this research. (Luna et al. 2008)

There is only one known HAZUS-MH flood study for the major rivers within the Midwest. Specifically, a pilot study was performed for Livingston Parish, Louisiana which is situated along the Mississippi River. However, this level one analysis began immediately following the initial release of the multi-hazard version of software and experienced several difficulties with the newly developed software. (Meyer 2004)

The state of Missouri has attempted to promote HAZUS-MH to its constituent counties by example. Specifically, Missouri utilized the software while preparing the state's Enhanced Multi-Hazard Mitigation Plan and joined the Heartland HAZUS Users Group. (FEMA 2005) However, there are no known county or city level hazard mitigation plans developed through the utilization of HAZUS-MH; that is, until now. St. Charles County is committed to proactive planning to mitigate hazards and prevent losses resulting from disasters; and as such, is awaiting the results of this thesis to further develop their natural hazard mitigation plan.

Obviously, there is still much more research to be performed in this area. In fact, FEMA just ranked the St. Louis metropolitan area among the top 40 high-loss potential urban areas in the country. (FEMA 2001) Thus, it is time that the public officials, private sector, and general public not only acknowledge the apparent risk to natural disasters, but actively develop and implement preparedness and mitigation plans/actions.

4. EARTHQUAKE AND FLOOD HAZARDS

4.1. EARTHQUAKE HAZARD

4.1.1. Definition of Hazard. An earthquake is defined as the vibration of the Earth produced by the sudden release of energy. Typically, earthquakes are a direct result of the collision or shifting of crustal plates but can also result from the fracture of stressed rock formations within the crust or even be associated with volcanic activity, landslides, and underground explosive detonation. (Tarbuck and Lutgens 2002)

According to the plate tectonics theory, the Earth's crust consists of several plates, platelets, and microplates that constantly interact with each other. There are three distinct types of plate boundaries: spreading ridge boundaries, subduction zone boundaries, and transform fault boundaries. In spreading ridge boundaries, the plates separate from each other and molten rock from the underlying mantle rises to the surface where it becomes part of the plates. Since the size of the earth remains constant, the addition of new plate material at spreading rifts must be balanced by the consumption of plate material at other locations, specifically at subduction zones. Here the relative movement of two plates is toward each other and one plate plunges beneath the other at the point of contact. Transform fault boundaries occur where plates move past each other without creating new crust or consuming old crust. Locally, movement between two portions of the crust occurs along offsets in the geologic stratum known as faults.

As relative movement of the Earth's plates occurs, elastic strain energy is stored in the materials near the boundary. When the induced shear stresses exceed the shear strength of the rock along the fault, the rock fails and the accumulated strain energy is released, as explained by the elastic rebound theory. The effects of the failure depend upon the quality of the rock withstanding the strain. If it is weak and ductile, the small amount of strain that can be stored will be released relatively slowly and the movement will occur without being noticed. On the other hand, if the rock is strong and brittle, the failure will be sudden and result in relatively violent movement.

Although uncommon, a foreshock can occur prior to a larger earthquake as stress begins to increase. However, foreshocks should not be used as an attempt to predict a larger earthquake. Once an earthquake has occurred, aftershocks can follow due to remaining stress in localized areas and will continue until a new equilibrium has been reached. Aftershocks are often mapped to define the total area of the fault.

The energy released radiates in all directions from the source in the form of waves. There are several different types of waves, and they all travel in different ways. Specifically, the two main varieties of waves are body waves and surface waves. Body waves can travel through the interior of the earth, but surface waves can only move along the surface. As such, body waves arrive before the emitted surface waves and are of a higher frequency. Body waves include p-waves and s-waves. P-waves, also known as primary, longitudinal, or compressional waves, advance through successive compression and rarefaction of the earth materials through which they pass, both solids and fluids. Subjected to a p-wave, particles move parallel to the direction of wave propagation. On the other hand, s-waves, also known as secondary, transverse, or shear waves, produce shearing deformations as they travel only through the Earth's solid material, as any fluid medium cannot sustain this shearing deformation. S-waves move individual particles perpendicular to the direction of wave propagation. The speed at which body waves travel varies depending upon the stiffness of the earth materials through which they travel. Since geologic materials are stiffest in compression, p-waves travel faster than all other seismic waves and are first to arrive at a given location.

Resulting from the interaction between body waves and the surficial layers of the earth, surface waves include Rayleigh waves and Love waves. Rayleigh waves result from the interaction of p-waves and the vertical component of the s-waves with the earth's surface. Thus, Rayleigh waves are comprised of both vertical and horizontal particle motions. Faster than

Rayleigh waves, Love waves are produced by the interaction of the horizontal component of the s-wave with a soft surficial layer, and therefore, have no vertical component of particle motion. Due to the nature of the interactions required to produce them along with the lower frequency, surface waves are much more prominent at distances farther from the source of the earthquake. Though they arrive after body waves, the surface waves are almost entirely responsible for the damage and destruction associated with earthquakes. In fact, most of the shaking felt from an earthquake is due to the Rayleigh wave, which is typically much larger than the other waves. The strength of the surface waves and the subsequent damage are reduced the deeper the source of the earthquake. (Kramer 1996)

The precise location of an earthquake can be described by various definitions. While most ruptures can extend several kilometers along a fault plane, the point at which the rupture first originates is termed the focus, or hypocenter of the earthquake, described in three dimensions: latitude, longitude, and depth. Typically, earthquake depths are classified as shallow (0 to 70 km), intermediate (70 to 300 km), and deep (greater than 300 km). The majority of earthquakes that occur are shallow with the fault rupture reaching the ground surface. (Tarbuck and Lutgens 2002) The point on the ground surface directly above the focus is the epicenter, only given in degrees of latitude and longitude. The distance on the ground surface between any given site location and the epicenter is known as the epicentral distance, and the distance between the same site and the focus is called the focal or hypocentral distance (Figure 4.1).

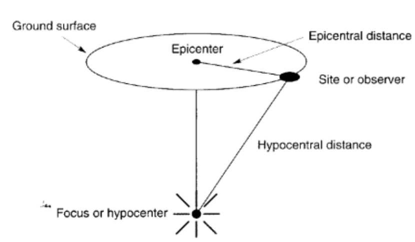


Figure 4.1. Earthquake Terminology
(Source: Kramer 1996, page 43)

The size of an earthquake is another important parameter that can be measured by various means. Earthquake intensity is a qualitative description of the effects of the earthquake at a given location as evidenced by both observed damage and human reaction. Earthquake intensity can be related to historical earthquake accounts to estimate not only the location and size of earthquakes that occurred prior to the development of modern seismic instrumentation but also recurrence rates for the probability of seismic hazards. Intensities can also be utilized to estimate strong ground motion levels for earthquake loss estimation. There are several intensity scales including the Japanese Meteorological Agency (JMA), Medvedev-Spoonheuer-Karnik (MSK), Rossi-Forel (RF), and modified Mercalli intensity (MMI). The MMI scale of intensity is the most common version and the qualitative descriptions of each level are available for review in the Figure 4.2 below. As suspected, the intensity is greatest near the epicenter of the earthquake and dissipates radially.

Modern seismographs have allowed for the measurement of earthquake magnitude to be quantified. There are several magnitude scales available based on some measured characteristic of ground shaking. The most common of which is the Richter local magnitude, defined as the logarithm (base 10) of the maximum trace amplitude recorded on the seismometer located 100 km (62 miles) from the epicenter of the earthquake. This means that at the same distance from the earthquake, the shaking will be 10 times as large during a magnitude 6 earthquake as it would during a magnitude 5 earthquake. Because the Richter local magnitude scale does not distinguish between different types of waves, other magnitude scales are based on the amplitude of a particular wave, such as surface waves or body waves.

The practice of geotechnical engineering involves the identification and mitigation of seismic hazards such as ground shaking, liquefaction, landslides, structural hazards, lifeline hazards, and retaining structure failures. (Kramer 1996)

MODIFIED MERCALLI INTENSITY SCALE	
I	Not felt except by a very few under especially favorable circumstances.
II	Felt by only a few persons at rest, especially on upper floors of buildings; delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake; standing motor cars may rock slightly; vibration like passing of truck; duration estimated.
IV	During the day felt indoors by many, outdoors by few; at night some awakened; dishes, windows, doors disturbed; walls make cracking sound; sensation like heavy truck striking building; standing motor cars rocked noticeably.
V	Felt by nearly everyone, many awakened; some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned; disturbances of trees, piles, and other tall objects sometimes noticed; pendulum clocks may stop.
VI	Felt by all, many frightened and run outdoors; some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; damage slight.
VII	Everybody runs outdoors; damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, considerable in poorly built or badly designed structures; some chimneys broken; noticed by persons driving motor cars.
VIII	Damage slight in specially designed structures, considerable in ordinary substantial buildings, with partial collapse, great in poorly built structures; panel walls thrown out of frame structures; fall of chimneys, factory stacks, columns, monuments, walls; heavy furniture overturned; sand and mud ejected in small amounts; changes in well water; persons driving motor cars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse; buildings shifted off foundations; ground cracking conspicuously; underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked; rails bent; landslides considerable from river banks and steep slopes; shifted sand and mud; water splashed over banks.
XI	Few, if any (masonry) structures remain standing; bridges destroyed; broad fissures in ground; underground pipelines completely out of service; earth slumps and land slips in soft ground; rails bent greatly.
XII	Damage total; practically all works of construction are damaged greatly or destroyed; waves seen on ground surface; lines of sight and level are distorted; objects thrown into the air.

Figure 4.2. Modified Mercalli Intensity Scale of 1931

(Source: Adapted from Kramer 1996, page 46)

4.1.2. History of Hazard As It Affects St. Charles County. St. Charles County has experienced earthquake damage of varying degrees from at least 12 earthquakes in the past 200 years. (USGS 2007) While this may seem insignificant, it is actually quite substantial given the location of seismic activity on the interior of a crustal plate, as opposed to interacting boundaries where most earthquakes occur. (Smith 2007) Midwest earthquakes are much less frequent but much more lethal than earthquakes occurring along the west coast due to less damping of seismic energy. (Karadeniz 2007) Figure 4.3 shows the vast area affected by a Midwestern earthquake contrasted to the much smaller zone of influence resulting from an earthquake along the west coast. Similarly, Figure 4.4 compares earthquake intensity versus distance for both regions. As illustrated, the earthquake intensity uniformly decreases with distance along the west coast, but levels off at a much higher intensity within the Midwest.

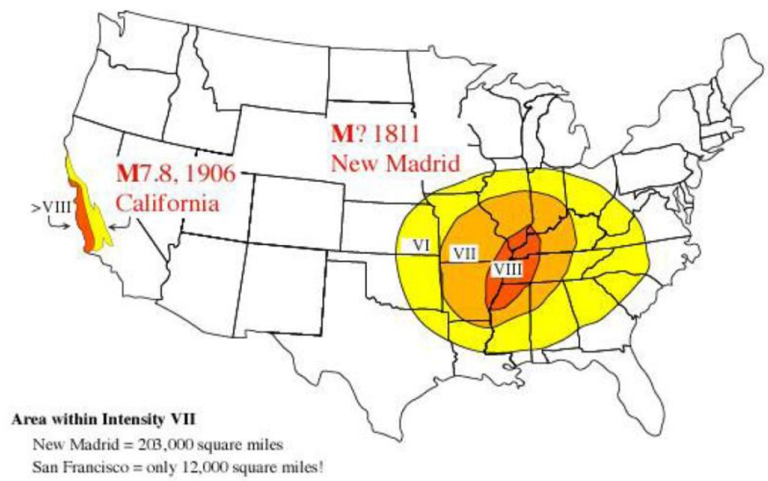


Figure 4.3. Comparison of Earthquake Influence Across the Country

Source: Rogers 2008

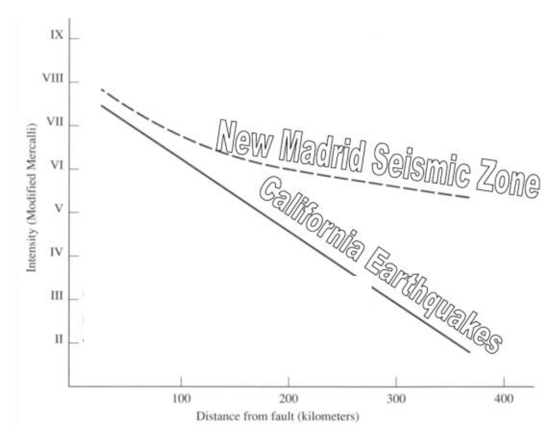


Figure 4.4. Comparison of Earthquake Intensity vs. Distance

(Source: Adapted from Rogers 2008)

There are several active seismic zones in the Midwest. Specifically, Figure 4.5 clearly delineates the three, widely-accepted seismic zones: the New Madrid Seismic Zone, the WabashValley Seismic Zone, and the South Central Illinois Seismic Zone. (Karadeniz 2007)

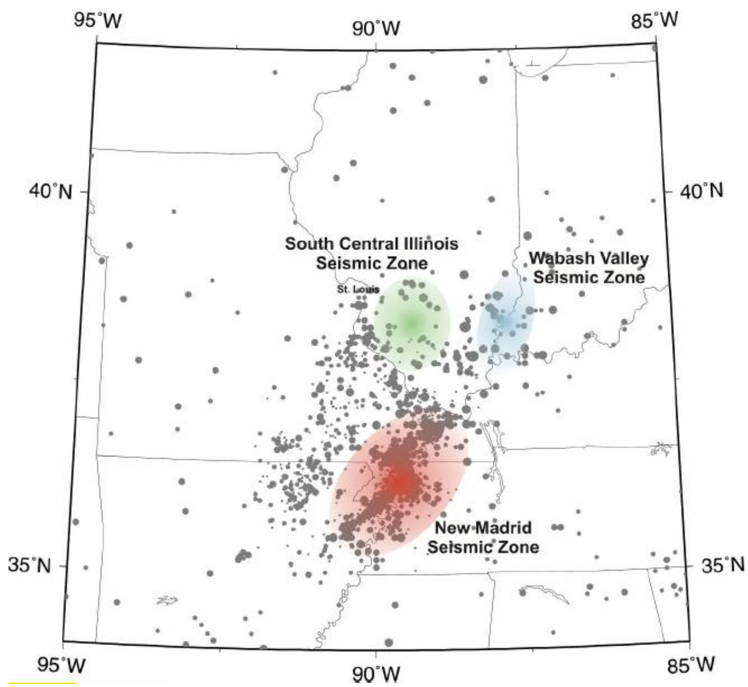


Figure 4.5. Active Midwest Seismic Zones
Source: Rogers 2008

Most notably, the New Madrid Seismic Zone (NMSZ) lies within the upper Mississippi Embayment and extends from northeast Arkansas through southeast Missouri, western Tennessee, western Kentucky, and southern Illinois. The NMSZ is positioned within a 70km-wide, 200km-long, SW-NE trending graben, known as the Reelfoot Rift, which formed as a result of failed continental rifting during the late Cambrian era when the North American continent almost split. (Karadeniz 2007) The northeastern, central, and southwestern portions of the seismic zone are generally characterized by narrow strike-slip faults flanking a single thrust fault, while the exact interactions are highly complex. The NMSZ is the site of the largest earthquakes in the history of the contiguous United States and is the most seismically active region in the Midwest. (Hopper 1985) This region is most famous for the disastrous series of earthquakes during the winter of 1811-1812. While it is estimated that an excess of 2000 earthquakes occurred that winter, three catastrophic events stand out above the rest and are summarized in Table 4.1 below. Since these earthquakes occurred prior to the development of seismographs, the exact magnitudes of each are highly controversial. Most likely, there will never be a definitive magnitude since the accounts of witnesses are questionable at best. (Smith 2007) It is important to note that paleoseismic features within the NMSZ provide convincing physical evidence that at least three other similar size earthquake series have occurred in the past 2000 years, to be further discussed in Chapter 7. (Karadeniz 2007)

Table 4.1. Summary of 1811-1812 NMSZ Earthquake Series

Date	Local Time	Estimated Magnitude	Estimated Epicenter	
			Lat (N)	Long (W)
Dec. 16 1811	2:15 a.m.	7.6	35.8°	90.3°
Jan. 23 1812	9:00 a.m.	7.5	36.2°	89.8°
Feb. 7, 1812	3:45 a.m.	7.8	36.5°	89.6°

(Data Source: Hopper 1985 and Karadeniz 2007)

The Wabash Valley Seismic Zone (WVSZ) is situated along the southern border of Indiana and Illinois. Several westward dipping thrust faults have been identified in this region through various seismic reflection profiles. Recent data suggests that this fault zone is capable of producing large magnitude earthquakes, ranging anywhere from M 7.0 to M 7.8. Specifically, geologists recently discovered liquefaction sites and sand blows, providing evidence of prehistoric earthquakes (summarized in Table 4.2). (Karadeniz 2007) Current research is still uncovering new evidence of additional historical earthquakes within this seismic zone. More recently, a 5.2 magnitude earthquake arose near Bellmont, Illinois, resulting in minor damage and providing a warning to residents. (CUSEC 2008)

Table 4.2. Summary of WVSZ Historical Earthquakes

Event Name	Approximate Date (BP)	Estimated Magnitude
Vincennes – Bridgeport	6,011 ± 200 yr	7.5 to 7.8
Skelton - Mt. Carmel	12,000 ± 1000 yr	7.1 to 7.3

(Data Source: Karadeniz 2005)

The South Central Illinois Seismic Zone (SCISZ) includes a small portion of the St. Louis metropolitan area, and thus poses a severe threat to St. Charles County and surrounding areas. Again, paleoliquefaction data indicates that this region is capable of generating earthquakes with a maximum moment magnitude of 7.5. Recent paleoliquefaction studies have identified two strong mid-Holocene events, known as the Springfield and Shoal Creek earthquakes. There is also documented evidence of an earthquake exceeding M 6.0 having occurred in southwest Illinois as a result of the previously mentioned Shoal Creek earthquake. The area has generated one moderately-sized earthquake (M 6.2 to M 6.8) and a successive smaller earthquake (M 5.5) approximately between 5,900 and 7,400 years before present time. The SCISZ also created several earthquakes with a magnitude greater than 5.0 in 1838, 1857, 1891, (Karadeniz 2007) and most recently in 1968. (Hopper 1985)

Many believe that the St. Louis metropolitan area is overdue for an earthquake. In addition to history of disasters, there is current evidence of seismic activity; each of which could be the precursor for the next catastrophe. The most likely earthquake to impact the St. Louis metropolitan area would be between magnitudes 6.0 and 6.6 (Figure 4.6). Similarly, Table 4.3 shows the recurrence intervals for various magnitudes, based on existing data but is always subject to revision. (Karadeniz 2007) The extent of damage resulting from an earthquake of this magnitude is still unknown at this point in time.

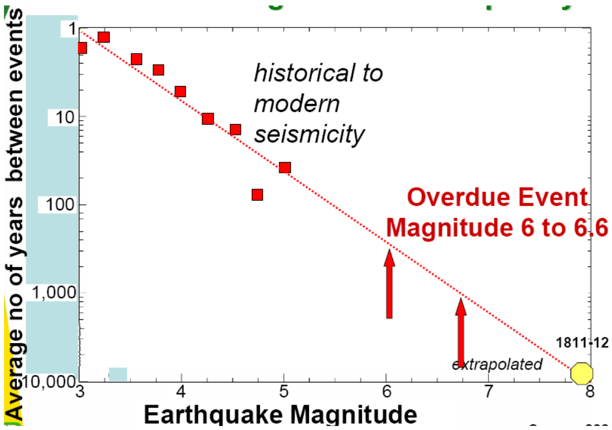


Figure 4.6. Earthquake Magnitude vs. Frequency

(Source: Rogers 2008)

Table 4.3. Earthquake Recurrence Intervals

Magnitude	Recurrence Interval
4.0	14 Months
5.0	10 – 12 Years
6.0	70 – 90 Years
7.0	254 – 500 Years
8.0	550 – 1200 Years

(Source: Rogers 2008)

4.1.3. Earthquake Damage Prevention.

4.1.3.1 Seismic Hazard Mapping. Seismic hazard maps are designed to reflect the expected ground shaking resulting from earthquakes. They illustrate expected future locations and probabilities of ground shaking and ground failure from earthquakes. (Olshansky 1992b)

Since the creation of the National Earthquake Hazards Reduction Program in 1977, the USGS has taken the forefront in developing national seismic hazard maps. However, these maps show the strength of ground shaking at a much broader scale, and thus do not take into account local and regional geologic structures and materials, which may have strong amplifying or damping effects. (Olshansky 1992b) Understanding the limitations of this national data set, the

USGS is now engaged in developing more detailed maps for vulnerable urban areas. (USGS 2006) A set of hazard maps is already available for Memphis and local experts are currently constructing a similar set for the St. Louis metropolitan area. Specifically, the St. Louis Area Earthquake Hazards Mapping Project will produce digital maps that can be customized by the user, all the while illustrating the variability of seismic hazards within the region. The project is being led by representatives from USGS, Central U.S. Earthquake Consortium (CUSEC), the DNR - Division of Geology, Land, and Survey, Illinois State Geological Survey, and the Missouri University of Science and Technology Natural Hazards Institute. (USGS 2007)

4.1.3.2 Design Codes. Building codes contain requirements regarding both building construction and use. Codes are performance standards that regulate structural integrity, construction materials, and seismic resistance, among many other things. In the past, Missouri building codes were enforced locally and only existed in larger communities, with a population greater than 10,000. The St. Louis metropolitan area followed the Building Officials and Code Administrators (BOCA) building code which either had limited or no seismic requirements, depending upon the edition used. (Olshansky 1992a) However, in 2006, St. Charles County, along with many other counties within St. Louis metropolitan area, adopted the 2003 International Building Code (IBC). This code includes the 2000 NEHRP provisions, incorporating soil profile type to estimate ground motion loads necessary for earthquake resistant building design. (Chung 2007)

4.1.3.3 Local Earthquake Hazard Reduction Plan. Currently, there is no published earthquake hazard reduction plan for the St. Louis metropolitan area. However, many communities, including St. Charles County, have already performed some of the necessary actions in developing a plan. Plans can vary depending on local conditions, but should address each of the following:

- Gather Hazard Information
- Use Hazard Information to Improve Current Programs
- Institute New Programs (Olshansky 1997)

4.2. FLOOD HAZARD

4.2.1. Definition of Hazard. Flooding is a natural and reoccurring event most often resulting from heavy or continuous rainfall exceeding the absorptive capacity of soil and the flow capacity of rivers and streams. This causes a watercourse to overflow its banks onto adjacent lands, more commonly referred to as floodplains. (Tarbuck and Lutgens 2002) The National Flood Insurance Program (NFIP) specifically defines flooding as a temporary condition of partial or complete inundation of two or more acres of normally dry land or of two or more properties by overflow of inland or tidal waters, unusual and rapid accumulation or runoff of surface waters from any source, or a mudflow. The two categories of flooding most likely to affect St Charles County are riverine flooding and flash flooding. Riverine flooding occurs when the flow of rainwater runoff is greater than the carrying capacities of the natural drainage system. While riverine flooding is typically slow developing, flash flooding can occur within hours of extensive rainfall. A variety of factors affect the type and severity of flooding including rainfall intensity and duration, urban development, vegetation, soil type, and topography. (East-West Gateway 2004)

Typically, floods are described by their statistical frequency. A 100-year flood, also known as a base flood, is defined as an event or an area subject to a one in one hundred or one percent probability of a certain size flood occurring in any given year. Similarly, any other statistical frequency of a flood event may be chosen depending on the degree of risk that is selected for hazard assessment. The primary use for these terms is for the determination of flood insurance rates. The 100-year flood was chosen as the current standard for the NFIP to provide a higher level of protection while not imposing overly stringent requirements or the burden of excessive costs on property owners. This concept does not mean that such floods will occur only once in one hundred years. Whether or not they occur within a given year has no bearing on the fact that there will still be the same probability of occurrence in the following year. Although unlikely, it is plausible for more than one 100-year floods to occur within a few years or even months of each other. In fact, statistics show that a 100-year flood has a 25 percent chance of occurring throughout the life of a 30-year mortgage. (East-West Gateway 2004) Floods can also be described by flood stage, which is a gage height at which a watercourse overtops its banks causing damage to any portion of the defined reach. Both the duration and the frequency of inundation depend on primarily the climate but also factors such as the size of the river or stream, material comprising the banks, and the channel slopes. (Tarbuck and Lutgens 2002)

Floodplains, in general, are those lands most subject to recurring floods and can be defined from several different perspectives. As a topographic category, floodplains are relatively flat and situated adjacent to rivers and streams. Geomorphologically, floodplains are landforms composed primarily of unconsolidated depositional material derived from the sediments transported by the related river or stream. Also, floodplains are best defined hydrologically as a landform subject to periodic flooding by a parent river or stream. Floodplains are quite dynamic systems, in that they can be rapidly eroded by high velocity flows, elevated through the deposition of new material, or dissected as the water body changes course.

4.2.2. History of Hazard As It Affects St. Charles County. St. Charles County has a history of severe property damage due to flooding considering its location at the confluence of two major rivers, the Missouri River to the south and the Mississippi River to the north. The region is also impacted by the Illinois River which flows into the Mississippi River near Grafton and the Cuiver River along the Lincoln County border. Specifically, flood frequency averages once every other year, with a major flood episode occurring once every six years on average. Thus far, the most severe flood on record was the Great Flood of 1993. (Fulcher et al 1995)

The Flood of 1993 was a record breaker in terms of both flood levels and duration. Of the nine Midwestern states affected, Missouri was undoubtedly the hardest hit with an estimated three billion dollars in total damages and 37,000 families requiring some form of federal assistance. (ASFPM 2000) The conditions that produced the flood began as early as the summer of 1992. Those summer and fall months precipitation levels were much higher than normal in the Upper Mississippi River Basin. While winter precipitation was nearly average, a very wet spring followed. Specifically, April to June of 1993 experienced the wettest season observed in the upper basin over the last 99 years. As a result of all of this, soils were saturated and many streams were flowing well above normal levels by the time summer rains began. During the following summer months, major flooding resulted primarily from a series of heavy rainfall events over the Upper Mississippi Basin which were unprecedented for the Midwest. In fact, rainfall during the June to August period surpassed 24 inches in the St. Louis metropolitan area. (Lovelace and Strauser 1995)

In St. Charles County alone, the combined costs of the Great Flood of 1993 totaled in excess of 160 million dollars. (ASFPM 2000) The following events provide a specific account of St. Charles County locations and areas that were affected by the flood. On July 7, the river overtopped a levee near West Alton flooding the bottomland between the Mississippi and Missouri Rivers. At that time, evacuation warnings were alarmed for the mobile home parks within the vicinity. At 25.0 feet, the Missouri River reached flood stage and minor flooding began on the right downstream bankside. On July 16, the Missouri River overtopped levees protecting Maryland Heights and just outside of St. Charles. At 30.0 feet flood stage, moderate flooding began and Highway 94 at Matson, upstream from St. Charles, was closed to traffic due to high velocity floodwaters. Then, Highway 94 flooded downstream from St. Charles at 33.5 feet flood stage shortly thereafter. At 33.9 feet flood level, the MK&T Railroad tracks flooded halting all railway transportation. Terry Road flooded at 34.0 feet flood stage and Greens Bottom at 34.5 feet. The levee adjacent to Highway 370 Bridge was overtopped when the Missouri River reached 35.0 stage level. Once 36 feet flood stage was reached, major flooding began along the St. Charles riverfront business area and residents north of St. Charles were isolated due to surrounding floodwaters. On August 2, 1993, a record flood level was reached at 40 feet. The Mississippi River was above flood stage for over 180 days along the northeastern St. Charles County border and the Missouri River was above flood stage for over 95 days along the southeastern portion of the county. (East-West Gateway 2004) Figure 4.7 shows a few photographs illustrating how St. Charles County residents were directly affected by the flooding. Also, Figure 4.8 has two satellite images comparing the extent of inundation experienced in 1993 as opposed to a typical summer flood stage in 1991 during the same August month. As illustrated, over 35 percent of St. Charles County was inundated at the peak of the Great Flood. (Fulcher et al 1995)

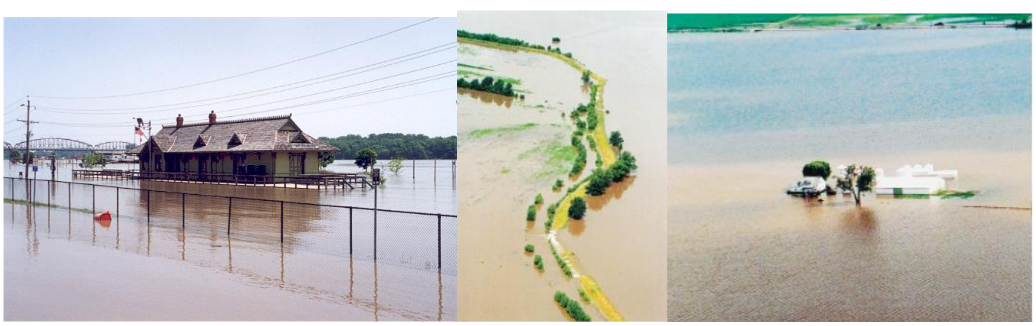


Figure 4.7. Photographs from the St. Charles County area during the Great Flood of 1993
(Source: Theiling 1999)

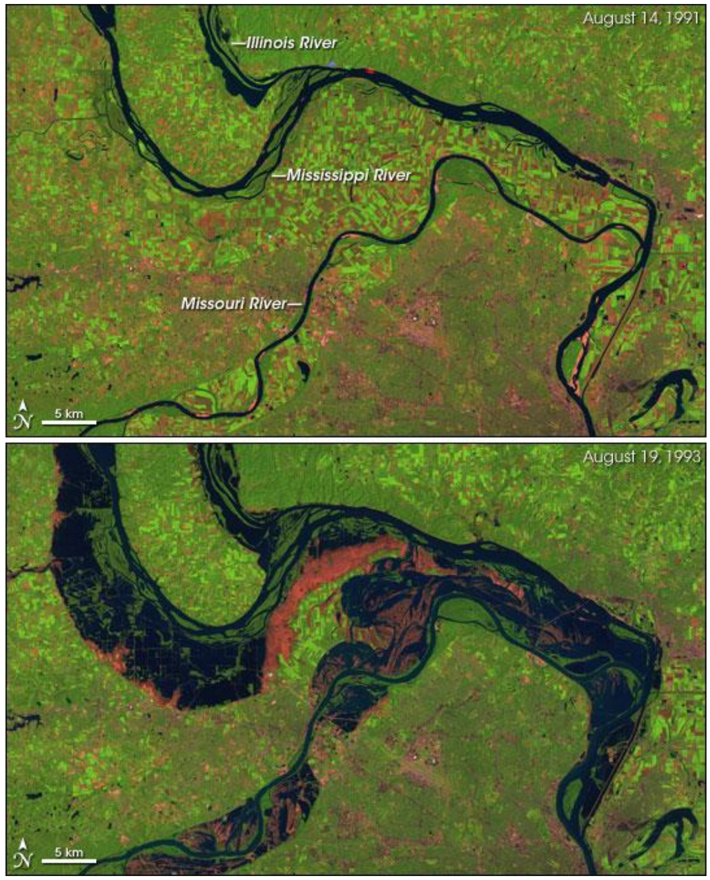


Figure 4.8. Satellite Images of the Great Flood of 1993 Compared to Typical Water Levels
(Source: Dartmouth Flood Observatory http://earthobservatory.nasa.gov/Study/HighWater/high_water2.html)

4.2.3. Flood Damage Prevention.

4.2.3.1 Buyout Program. Formal reviews of the national flood control policy, both before and after the Great Flood of 1993, concluded that the optimum strategy for reducing flood related losses is to limit and even reduce infrastructure in the floodplains. Thus, emphases on flood damage prevention included the widely publicized Missouri Buyout Program. (Pinter 2005) Proactive and cost-effective, this voluntary program provided residents with a practical solution by relocating their homes outside of the floodplain. This would alleviate future problems for homeowners, emergency managers, and taxpayers alike. Also, the newly acquired public property could then be used for open space purposes more consistent with the threat of repeat flooding. (ASFPM 2000)

In St. Charles County, a total of 1,374 parcels of property residing within the 100-year floodplain were purchased under the Missouri Buyout Program. This included over 560 single family residences and three mobile home parks with approximately 814 pads. The occupancy rate in those parks was estimated to be 84 percent during the 1993 flood. The residents in these repeatedly flooded parks required the most disaster assistance from both public and private sources. Table 4.4 summarizes the purchase statistics for the 1, 374 parcels of property purchased in St. Charles County during the Buyout Program. (ASFPM 2000)

Table 4.4. St. Charles County Buyout Program Facts and Figures

Total Fair Market Value	$20,525,624
Actual Purchase Price	$10,146,810
Administrative Costs	$3,554,000
Duplication of Benefits (SBA Loans, NFIP Proceeds, Disaster Benefits) Subtracted From the Sale Price	$10,538,437
Cost Per Property - 1374 Parcels (includes all mobile home lots)	$9,971
Cost Per Unit Purchased – 640	$21,408

Source: Adapted from ASFPM, 2000, page 55

When the 1995 spring rains fell, causing the third worst flood of record, 1,000 fewer families consisting of approximately 2,500 people were out of harm's way as a result of the buyout program. The floodwaters in 1995 affected nearly all of the same 1,374 properties purchased after the 1993 flood albeit to a lesser extent and a shorter period of time. Nonetheless, it is reasonable to assume that more applicants would have requested disaster assistance and/or submitted flood insurance claims had it not been for the buyout program. Table 4.5 compares disaster assistance claims following both the 1993 and 1995 flood events. (ASFPM 2000)

Table 4.5. Flood Disaster Assistance in St. Charles County

Flood	Number of Applicants	Disaster Housing	Individual/Family Grants	Small Business Loans
1993	4,277	$8,359,550	$5,818,167	$11,898,600
1995	333	$204,493	$11,601	$67,000

Source: Adapted from ASFPM, 2000, page 55

Unfortunately, these buyouts are being massively counterbalanced by the new development of the floodplains. For instance, the Lakeside 370 Business Park near St. Peters is currently under construction. This commercial area will encompass approximately 1,600 acres of Mississippi River floodplain including offices, hotels, warehousing, light industrial, retail and dining, a public park, protected wetlands and green space all protected by a newly developed levee. (Saeland 2006)

4.2.3.2 Levee Development. As previously mentioned, St. Charles County has experienced extensive growth since the Great Flood of 1993, resulting in a dramatic increase in infrastructure developments throughout the county. Most of the County's upland has either been urbanized or has been acquired for the purpose of future development, leaving behind little room for further expansion. In fact, commercial and industrial developments are pouring into floodplain regions that were inundated during the Great flood. Since 1993, projects now complete, under construction, or still in planning have placed or will place much of the Mississippi and Missouri Rivers behind new levees, enlarged levees, or floodplain regions elevated above the 100-year and 500-year protection levels. Most of these projects have been financed or substantially subsidized by the local government. Also, the Army Corps of Engineers has expended a large amount of money working on the levee district in the area. Figure 4.9 below illustrates the extensive levee development since the Great Flood of 1993. (Pinter 2005)

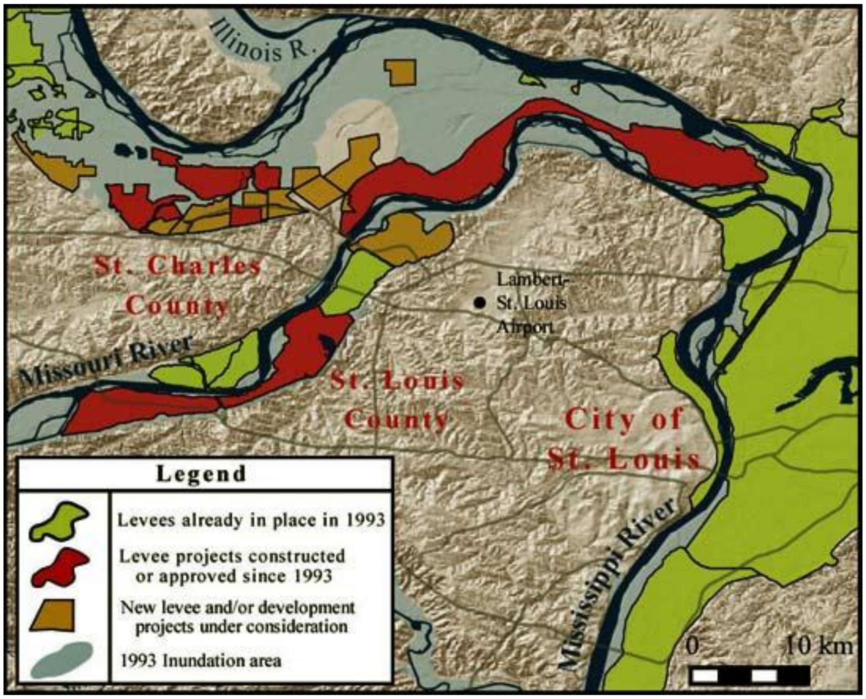


Figure 4.9. Levee Development in St. Charles County

(Source: Pinter 2005)

The largest criticism of flood-control through levees is that development in these levee-enclosed areas promotes the false security that flood risk is reduced to zero. Actually, FEMA entirely removes all floodplains protected by 100-year designated levees from the national flood-hazard maps. (Pinter 2005)

Also, any proposals to elevate or protect areas of a floodplain by use of levees must demonstrate that the project will not unduly impact the public interest, including adversely affecting flood hazard. However, permits for levee construction have been continuously granted despite long standing research documenting the adverse effects of levees, including the contribution to increased flood levels. Specifically, both the Missouri and Mississippi Rivers flood levels have increased nine to twelve feet during the past century. The failure to recognize flood magnification due to levees can be contributed to the fact that incremental levee expansion projects are evaluated individually, even when numerous projects are proposed for a given reach of river. Thus, uncertainties in modeling assert that the incremental increase in flood levels will be negligible, not considering the cumulative effects of such a large encroachment. (Pinter 2005)

Currently, the Missouri floodplain laws are among the weakest in the United States. For example, although NFIP guidelines state that no floodplain construction should result in more than a one foot increase in flood level, other states further specify even more stringent thresholds. However, Missouri has actually passed legislation that prohibits any county government from setting any threshold more rigorous that that already specified by the NFIP. (Pinter 2005)

5. METHODOLOGY

5.1. EVALUATION OF GIS AS A TOOL

A Geographic Information System (GIS) is an organized collection of computer hardware, software, and geographic data designed for the capturing, storing, managing, analyzing, and displaying of all forms of geographically referenced information. (ASTM 1992)

GIS arose from the need to incorporate both graphical and textual information into a single system. In the late 1960s, community planner Dr. Ian McHarg created a system where separate data – such as zoning, slope, and drainage – could be combined into a cohesive plan to aid in community development. Early software systems required that graphics and textual elements by analyzed separately. However, in the late 1970s the emergence of software with the capability of converging graphics and textual data into a single system completely changed thematic mapping. Environmental Systems Research Institute (ESRI) led the forefront of research and development in the GIS field. ESRI's ARC/INFO software, initially released in 1982, quickly became the leading GIS software. Still, the advancement of GIS in the early 1980s was hampered by expensive computer equipment, limited computing power, immature software algorithms, and the lack of a user-friendly model. Since the late 1980s, technological breakthroughs resulting in powerful yet affordable personal computers have led to a new era of Windows-based software providing countless users with the power to perform analyses in a timely manner. (Hutchinson and Daniel 2000)

Previously, the expense to customize spatial data through digitizing hard copy maps had limited GIS implementation to government agencies, utilities, and other large institutions with the resources to initiate a long-term conversion program. Along with the 1990 Census came the release of Topographically Integrated Geographically Encoded Reference (TIGER) files which included an extensive amount of street and demographic data unparalleled in comprehensiveness and format. From TIGER, several hundreds of derivative products were created, thus allowing smaller companies and private users to implement GIS in a cost-effective manner. With its ArcView software, ESRI has now targeted the desktop mapping market with a GIS product specifically designed for the layperson. (Hutchinson and Daniel 2000)

Since its creation, the GIS industry has experienced remarkable growth and this trend will most likely continue well into the future. Specifically, GIS is a $3 billion-per-year industry, with an annual growth rate projected at 20 percent. Given that an estimated 80 percent of all data has a spatial component, mapping has become a mainstream application utilized by many. (Hutchinson and Daniel 2000)

A GIS map consists of several layers, or collections of similar geographic objects. Each geographic object in a layer (city, river, highway, etc.) is called a spatial feature. These geographic objects have an endless variety of shapes. However, all of them can be represented as one of three geometrical forms – a polygon, line, or point. Polygons represent objects large enough to have boundaries such as countries, states, and lakes. Lines symbolize objects too narrow to be polygons including rivers, roads, and pipelines. Points characterize objects too small to be polygons such as cities, schools, and trees. The same object may be represented by a polygon in one layer and a in a line or point in another layer depending on the scale it is presented. Polygons, lines and points are collectively known as vector data. (Ormsby et al. 2004)

Not all layers contain features, but rather a geographic expanse known as a surface. For example, the oceans layer is not a collection of geographic objects but a single continuous expanse that changes from one location to another according to depth of water. Surfaces such as elevation, slope, temperature, rainfall, and wind speed have no distinct shape. Instead, these surfaces have measurable values for any given location. Thus, these surfaces are represented as a raster rather than a feature class. A raster is a matrix of identically sized square cells where each cell represents a unit of surface area and contains a measured or estimated value for that location. It is important to note that many geographically referenced objects can be either features or surfaces depending on the purpose. (Ormsby et al. 2004)

The scale at which these features are presented is a very important aspect of GIS. Scale, most commonly expressed as a ratio, is the relationship between the size of the features on a map and the size of the corresponding features in the world. For example, if the scale of a map is 1:500,000, it indicates that the features on the map are 500,000 times smaller than their true size. While zooming in provides a closer view of features within a smaller area, the amount of detail in the features does not change. (Ormsby et al. 2004) It is important to note that all GIS data has limitations, denoted through scale, that result from collection methods, reporting accuracy, measurement errors and many other factors. The appropriate use of the data and an understanding of its limitations are the responsibility of the user. (Missouri Geological Survey 2003)

Typically, the information pertaining to the various geographically referenced spatial features is stored as attributes in tabular files linked to the feature. (ASTM 1992) The table has a record (row) for each feature in the layer file as well as several fields (columns) for each category of information available, more commonly known as attributes. The link between features and their attributes allows for the user to identify properties, create queries, perform analysis, and produce thematic maps. (Ormsby et al. 2004)

5.2. HAZUS-MH

In 1992, the Hazards United States – Multiple Hazard (HAZUS-MH) program was initially developed for the Federal Emergency Management Agency (FEMA) under cooperation with the National Institute of Building Sciences (NIBS), to produce comprehensive, risk-based loss estimates intended to further advance planning for risk mitigation, emergency preparedness, response, and recovery. This program assesses potential losses to aid in improving planning, construction practices, and disaster preparedness. The main objective of the software is to ultimately reduce the loss of life and property from natural hazards. (FEMA 2004)

This software operates with the latest version of ESRI's Geographic Information System (GIS) software, currently Arcview 9.2 SP1, to map and display hazard data, results of damage and economic loss estimates, and effects on various populations. The initial software development, HAZUS 97, and subsequent releases (1999, 2000, 2001, and 2002) only provided loss estimation analyses for earthquake hazards. Then, the 2004 version 1.0 of HAZUS-MH provided loss estimation techniques for three hazards: earthquake, flood, and hurricane. (Luna et al. 2008) HAZUS-MH MR2, the second maintenance release of the multi-hazard software program, is the version originally utilized for this comprehensive analysis as it is the latest available version at the time the study began. However, once the updated version, HAZUS-MR3, became available to the public in December of 2007, this research had to be refocused around this new software. This version will include various improvements based on consumer feedback and necessary debugging, as FEMA always acknowledges that the program is a continuous work in progress. (NIBS 2007) Other wind hazard models such as thunderstorm, hail, and tornado will be developed for future releases. (FEMA 2004)

HAZUS-MH has separate models for earthquakes, floods, and hurricane winds. The earthquake model accounts for ground motion and ground failure; the flood model accounts for flood frequency, depth, and discharge velocity. The hurricane model accounts for wind pressure, missile damage, and rain.

The HAZUS-MH earthquake model provides estimates of potential damage and loss for buildings, essential facilities, transportation lifelines, utilities, and population based on historic, user-defined, or probabilistic earthquake scenarios. The model estimates resultant debris, damage, casualties and even shelter requirements. Direct economic losses are predicted based on physical damage to structures, contents, and inventory. Advanced capabilities of the software include the addition of custom building types as well as the option to import USGS Shake maps. Also, the Advanced Engineering Building Module (AEBM) may be utilized for specified single or group building mitigation analysis. (NIBS 2007)

Used to assess both riverside and coastal flooding, the HAZUS-MH flood model estimates potential damage to buildings, essential facilities, transportation lifelines, utilities, vehicles, and agricultural crops. The model also takes flood warnings and flow velocity effects into account during the analysis. Direct losses are projected based upon physical damage to structures and known inventory. This hazard model contains the capacity to link to a third party model FLDWAV, a daylight dam break model. (NIBS 2007)

Specifically for the Atlantic and Gulf Coast regions, The HAZUS-MH hurricane model analyzes potential damage and loss to residential, commercial, and industrial buildings. It also estimates direct economic loss, building and tree debris quantities, and shelter requirements. Advanced capabilities of the software include the assessment of specific structural changes to strengthen buildings as a mitigation effort and the ability to define hurricane scenarios using National Weather Service forecasts and advisories. (NIBS 2007) This hazard model also has the ability to link to a third party model ALOHA, aerial locations of hazardous atmospheres. (FEMA 2004)

Data input to HAZUS-MH is supported by the Inventory Collection Tool (InCAST), the Building Inventory Tool (BIT), and the Flood Information Tool (FIT). InCAST is a database that is designed to support the management of local building data necessary for advanced analyses. BIT supports the importation of building data from large files (i.e. records from a tax assessor data file). FIT allows users to transform flood data to the HAZUS-MH flood model's required format. (FEMA 2004) Also, this multiple hazard software is capable of combining annualized loss analyses from the various hazard models and providing integrated reports and graphs. (NIBS 2007)

The HAZUS-MH hazard models operate at several levels depending on the nature of data available to users. At Level 1, all data used for the analysis is provided by national data sets included within the software. This method provides crude results as the national databases tend to be limited in both scope and detail. For instance, the soils database map provided with the software uses a single soil class to map the entire nation, thus overlooking important variations in earthquake soil amplification during ground motion evaluation. At Level 2, the national databases may be refined with local data and hazard maps can be included to produce more accurate estimates. (Luna et al. 2008) At Level 3, users may supply their own techniques through the previously discussed third party models available to analyze special conditions such as a dam break and tsunami. Most often, engineering and other expertise is necessary at this level. (NIBS 2007) As expected, the total effort required as well as the degree of sophistication increases with the levels of analysis as shown below. (FEMA 2004)

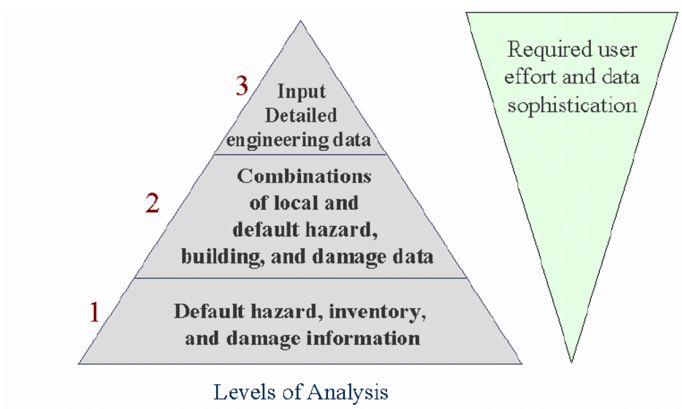


Figure 5.1. HAZUS-MH Levels of Analysis
(*Source: FEMA 2003d, page 27)*

General knowledge of the HAZUS-MH program may be obtained by attending various training sessions periodically offered through FEMA or other qualified organizations, joining online user groups, and studying the technical user's manual provided with the software.

5.3. CUSTOM DATA LAYERS

For the earthquake analyses, the attenuation functions, both magnitude and distance dependent, included within the HAZUS-MH software were not applicable for the majority of the chosen scenarios, to be further discussed in Chapter 7. In fact, the standard HAZUS-MH software computes these attenuation functions to an average distance of only 200 km (125 mi) from the selected earthquake epicenter. To ensure that a source earthquake originating for a far-field location, such as the NMSZ or the WVSZ, would reach St. Charles County, the HAZUS-MH SQL database for attenuation functions had to be modified to extend beyond this prescribed distance. However, not all attenuation functions are applicable to distances greater than 200 km (125 mi). Specifically, the Frankel et al. (1996) attenuation relationship is the only one relevant for greater distances (Luna et al 2008) Thus, the attenuation tables were expanded to a hypocentral distance of 350 km (218 mi) so that the function could be utilized for any significant far-field earthquake scenarios. With the help of the HAZUS-MH developers, this was achieved by creating a SQL database link to the HAZUS-MH Frankel et al. attenuation tables (Escalona 2008) and inserting published values for peak acceleration and spectral accelerations for distances between 200 km (125 mi) and 350 km (218 mi). (Lawrence 2008) After all of this, several far-field scenarios were analyzed using this newly updated attenuation relationship, resulting in absolutely no damages. Besides the obvious, this also suggests that there was an error in the analysis, most likely due to sparse ground motion values beyond the default ones. Thus, an alternative means of evaluating far-field conditions had to be employed.

As previously mentioned, the USGS had partnered with local experts to develop detailed maps for Midwestern regions vulnerable to strong ground shaking. For this study, members of this collaborative group have supplied various seismic hazard maps for use within HAZUS-MH to compute the impact of the same far-field earthquake scenarios as before. (Bausch 2008) Detailed in Chapter 8, these scenario maps resulted in much more realistic damages, and therefore, are the focus of this thesis. While these hazard maps were specifically created for the Memphis metropolitan area, they are regional in nature and complement the national seismic hazard maps. (Cramer et al 2004) However, these maps include the effects of soil conditions within the ground motion estimates. (Cramer 2008)

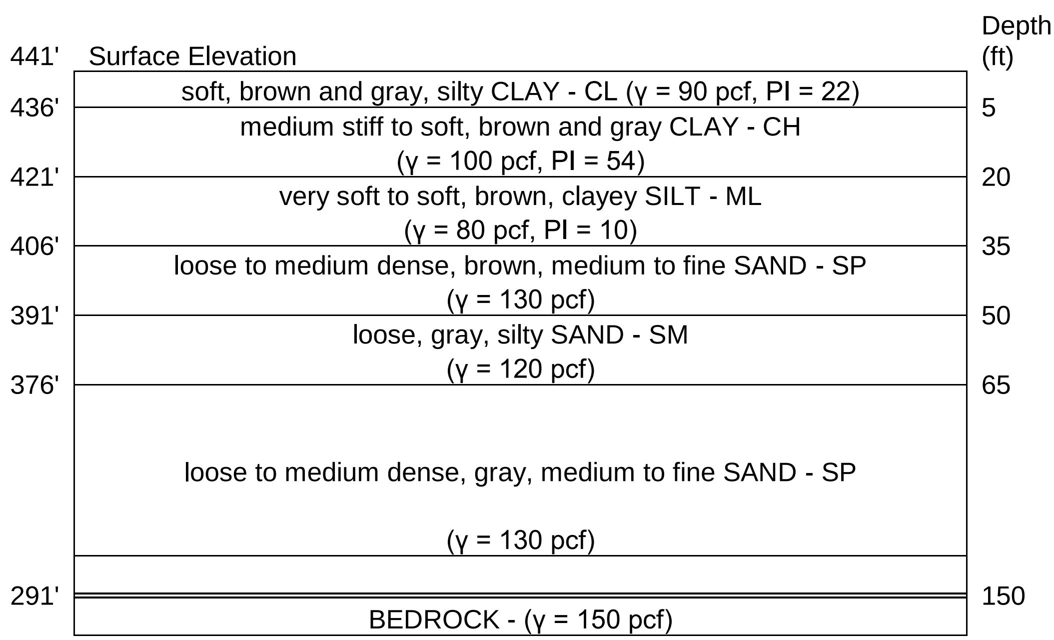
Several different earthquake scenarios were developed for the Midwest including those utilized for this study: a M7.7 earthquake originating from the NMSZ (at either the Northeast, Central, or Southwest fault lines), a M7.1 earthquake occurring in the center of the WVSZ, and a M6.0 earthquake occurring near downtown St. Louis well within the confines of the SCISZ. Generally accepted, these magnitudes are based upon current and historic seismicity, paleoliquefaction evidence, and general consensus among experts. Available for review in Appendix B, these scenario seismic hazard maps characterize the ground motion in terms of peak ground acceleration (PGA) and spectral accelerations (SA) at both 0.3 and at 1.0 second periods. (Bausch 2008)

The methodology used to develop these scenario hazard maps expanded on the previously established principles utilized for the national seismic hazard maps. Specifically, these maps were generated using the deterministic program hazDXv3.f. Provided by Art Frankel, this program was modified to apply the median site amplification to median ground motion attenuation relationships. While the scenario maps included the widely-accepted ground motion attenuation functions, they had to be considered at each grid point in order to include the effects of local subsurface conditions. The ground motions used were recorded on rock outcrops and included recordings from seven large magnitude earthquakes obtained through the PEER database and two synthetic time histories created by Atkinson and Beresnev (2002), as they are more representative of Midwest source characteristics, wave-propagation properties, and potential magnitudes than real records from elsewhere. Also, a distribution of amplification factors had to be developed, representing the range of possibilities at each grid point. A more in depth discussion on the formation of these and other seismic hazard maps can be reviewed in the USGS open file report 04-1294. (Cramer et al 2004)

Although these maps suggest relatively smooth contours, the earthquake hazard is calculated on finely-spaced grid to incorporate major geologic details. Instead, the scenario maps have undergone an extensive averaging and spatial variability analysis to balance the lines. (Cramer et al 2004)

To compare these hazard maps with local soil conditions, a SHAKE 2000 analysis was performed for St. Charles County. Positioned in the floodplain directly between the Mississippi and Missouri Rivers, the Smartt airport was chosen as the ideal location for a site-specific response analysis because of the relatively well-characterized subsurface conditions and available shear wave velocity profile.

The subsurface conditions were defined based on several borehole logs obtained from the geotechnical community. Figure 5.2 displays the soil profile input into the SHAKE 2000 program. Please note that this particular site is situated on top of approximately 150 feet of alluvium deposited from both rivers.



Note Figure is not drawn to scale

Figure 5.2. Subsurface Profile for the St. Charles Smartt Airport

The shear wave velocity profile was acquired through the USGS as part of a preliminary study to determine shallow p- and s-wave velocities and site resonances within the St. Louis metropolitan area. (Williams 2007) The profile below (Figure 5.3) corresponds relatively well with the anticipated subsurface conditions as indicated from the available borehole logs.

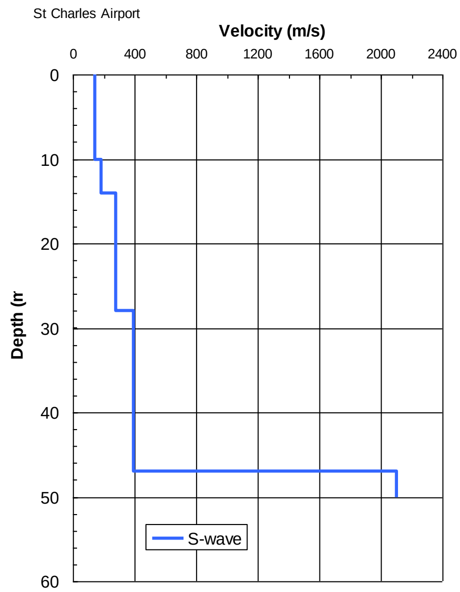


Figure 5.3. Shear Wave Velocity Profile for the St. Charles Smartt Airport
(Source: Williams 2007)

It is important to note that these scenario seismic hazard maps are not intended for use in site-specific analyses. (Cramer et al 2004) With that being said, the results of the SHAKE 2000 analysis differ slightly from the values used within the hazard map. Specifically, SHAKE 2000 returned a maximum peak ground acceleration of 0.11g for the Smartt Airport location as illustrated in Figure 5.4. Conversely, the NMSZ PGA Hazard Map (Figure 5.5) input into HAZUS-MH generalizes the entire St. Charles County area as having a maximum peak ground acceleration of 0.07g. While this difference may appear minor, its role in the overall outcome of these results is not insignificant. However, both SHAKE 2000 and HAZUS-MH results show amplification of the ground motion.

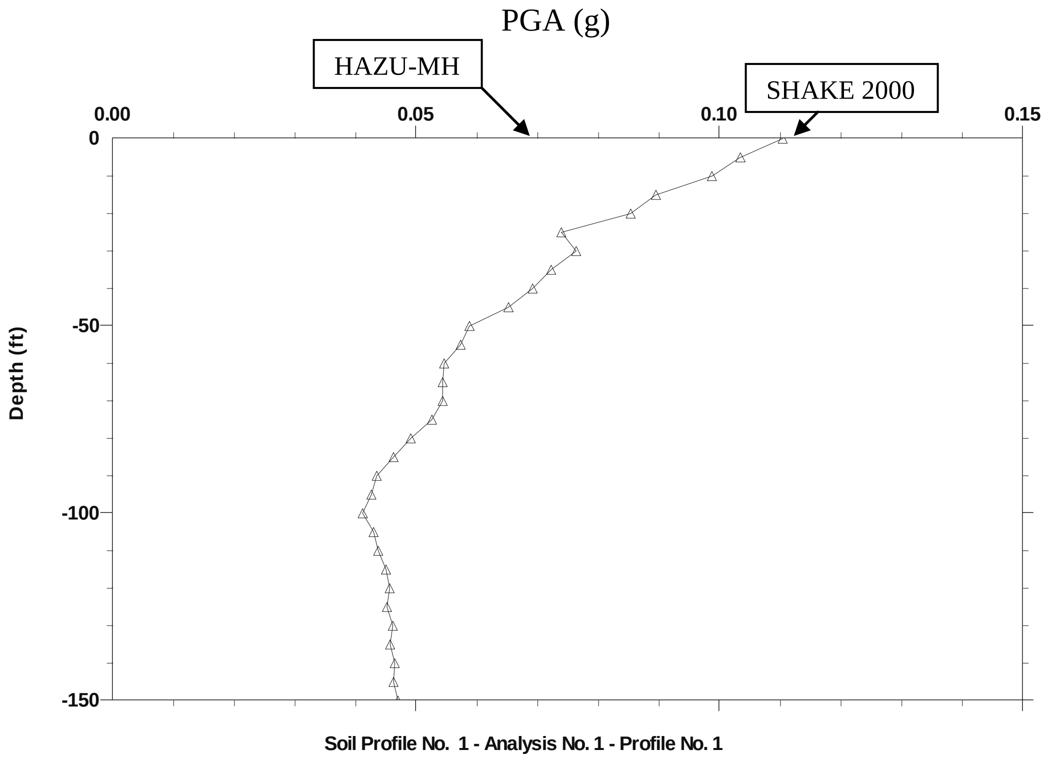


Figure 5.4. SHAKE 2000 PGA Output for St. Charles Smartt Airport

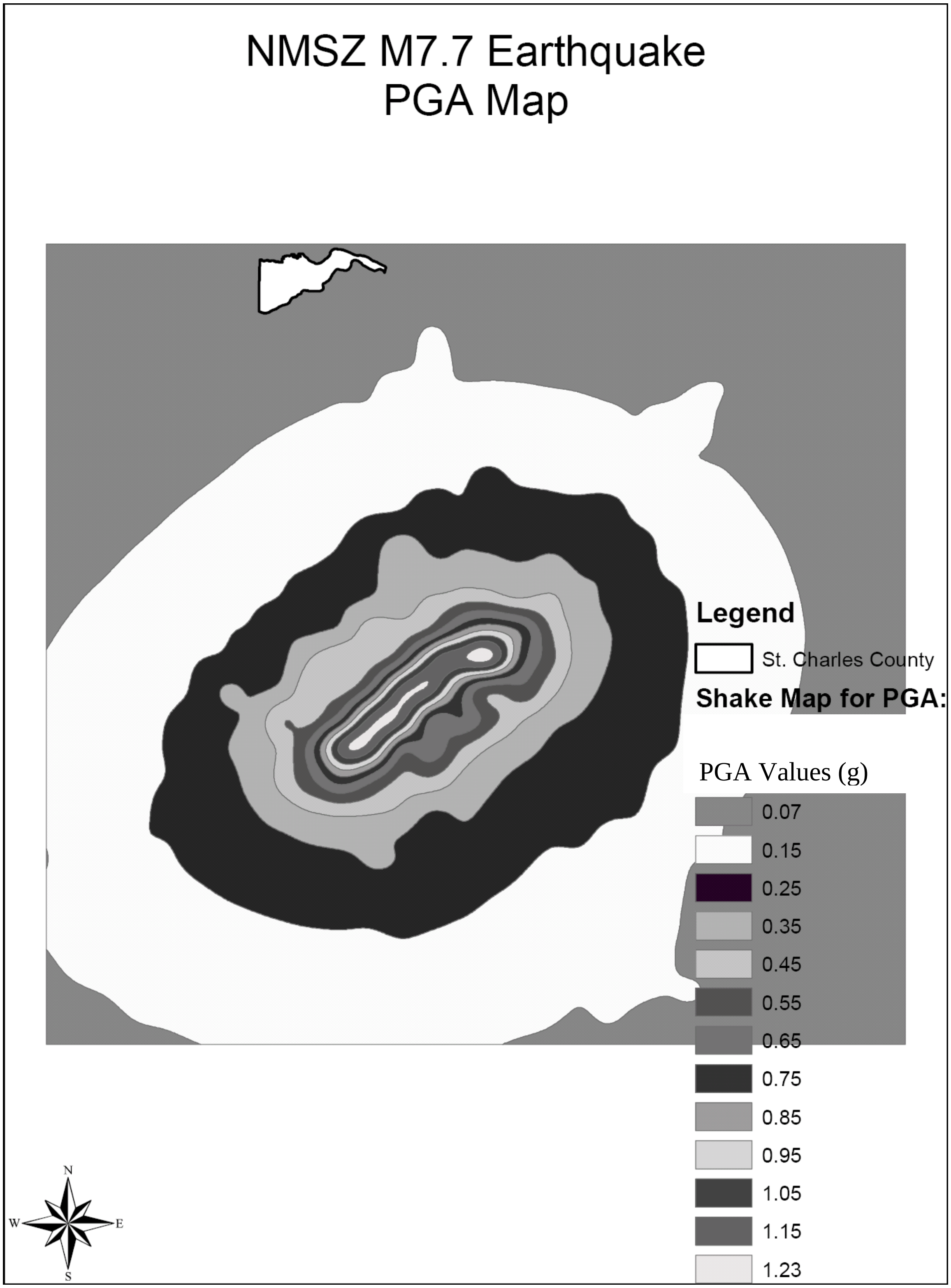


Figure 5.5. NMSZ PGA Hazard Map Utilized in HAZUS-MH

6. HAZARD LOSS ESTIMATION

6.1. GENERAL

As previously discussed, both HAZUS-MH and Arcview GIS are necessary for this analysis and therefore should be installed on the computer workspace. The HAZUS-MH software is not updated as frequently as Arcview GIS simply because the hazard software incorporates default census data. Thus, it is extremely important that the GIS version utilized be compatible with the most current HAZUS-MH software available.

The first step of any analysis is the creation of the study region, which can be as small as a single census block or as large as several states. According to the HAUS-MH methodology, this is the area to which the study region is restricted and nothing exists outside of this zone. Figure 6.1 shows the study region created for this study, consisting of only St. Charles County. During this process, the user must select the hazards for which this study region will be created. The hazard type(s) selected control the type and amount of data that will be aggregated as well as the analysis options available. While more than one hazard can be selected, only one hazard can be analyzed at a given time, not directly allowing for a combined analysis. (FEMA 2004)

Figure 6.1. St. Charles County HAZUS-MH Study Region

The HAZUS-MH software includes several data DVDs for the various U.S. localities that will be necessary to upload the default inventory for the study region previously created. The common components of this data include general building stock, occupancy categories, building types, and demographics. Other site-specific items available include essential facilities, high potential loss facilities, transportation systems, utility systems, hazardous material sites, and even user-defined facilities. Once a study region is open, these inventory categories can be mapped as an overlay.

This default data is all that is necessary to run a Level 1 analysis. (FEMA 2003c) However, this built in data is rather generalized and provides only approximate results ideal for an initial screening of the apparent risk a particular hazard poses to a particular study region. Therefore, the national databases may be modified with local data and hazard maps uploaded by the user to upgrade the analysis to a Level 2, allowing for a more accurate result. (FEMA 2003a) Data input to HAZUS-MH is supported by the Inventory Collection Tool (InCAST), a Building Inventory Tool (BIT), and Flood Information Tool (FIT). InCAST is a database that is designed to support the management of local building data necessary for advanced analyses. Similarly, BIT supports the importation of building data from large files (i.e. records from a tax assessor data file); and FIT allows users to transform flood data to the HAZUS-MH flood model's required format. (Luna et al 2008) For this research, the default data was assumed efficient, and therefore unaltered; however, additional hazard maps were deemed necessary for the earthquake analysis.

6.2. EARTHQUAKES

Running an earthquake analysis is a sequentially detailed procedure. The user must first define the earthquake scenario, which can be accomplished by several different means including deterministic, probabilistic, and user-defined approaches. All of these methods have a role in seismic hazard and risk analyses performed for decision-making purposes. While these methods often complement each other to provide additional insights to the seismic hazard, one method typically has priority over the others, depending on the quantitative nature of the decisions to be made, the seismic environment, and the scope of the project. (McGuire)

For the deterministic calculation of the scenario event, the user specifies only the location and magnitude of the earthquake. This technique provides three options for the selection of the appropriate location: (1) based on a database of seismic faults, (2) based on a database of historical earthquake epicenters, or (3) based on an arbitrary selection of epicenter. Specifically, HAZUS-MH includes a database of seismic fault segments. However, this fault map is only intended for the Western United States (WUS), and therefore, is not applicable to this investigation. Similarly, HAZUS-MH provides a database of historical earthquake events either synthetically created or recorded by three sources (Composite Earthquake Catalog 2002, Earthquake Data Base 2002, Earthquake Seismicity Catalog 1996) and contains over 8,000 records. This database has been sorted to remove any historical earthquakes with magnitudes less than 5.0. If utilized, the user accesses the database via HAZUS-MH and selects the appropriate historical earthquake epicenter which includes location, depth, and magnitude information. Under the arbitrary event option, the user specifies a scenario event magnitude and arbitrary epicenter. For the Central and Eastern United States (CEUS) regions, the user must also supply the depth of the hypocenter.

The Methodology also includes probabilistic seismic hazard contour maps developed for the USGS for the characterization of a probabilistic hazard. The USGS maps provide estimates of Peak Ground Acceleration (PGA) and spectral acceleration at periods of 0.3 and 1.0 second. Ground shaking estimates are available for eight hazard levels ranging from a 100 year and 2500 year return periods.

HAZUS-MH also provides a user-defined hazard option, which is the most complex means of defining an earthquake event. Specifically, the user provides peak ground shaking, liquefaction, landslide, and surface fault rupture maps for the study region and then defines the earthquake using the same parameters as before. This option permits the user to develop a scenario event that can not be adequately described by the previously discussed approaches. (FEMA 2003c)

This study utilized the user-defined ground motion methodologies to define several earthquake scenarios to be further discussed in the next chapter. Specifically, the USGS has recently developed several Central U.S. hazard maps for the NMSZ, WVSZ, and SCISZ, which allowed for the analysis of various earthquake events. Available for review in Appendix B, these hazard maps include Peak Ground Acceleration and Spectral Accelerations at both a relatively short period range (0.3 seconds), and a long period range (1.0 seconds). It is important to note that these hazard maps already include the effects of soil amplification. (Cramer 2008) Thus, only a liquefaction map (Figure 6.2) was necessary to further enhance the analysis, classifying it as an advanced Level 1 because the inventory data was not refined to better suit St. Charles County.

Figure 6.2. Liquefaction Potential Map

(Source: Hoffman 2008)

After the earthquake scenario has been defined, an appropriate attenuation function must be selected. These attenuation relationships define how ground motions decrease as a function of distance from the source. Seven different attenuation functions for the CEUS regions are included in the HAZUS-MH software. The majority of these functions are consistent with those used by the USGS in the 2002 update of the National Seismic Hazard Maps. Specifically, these attenuation functions include Atkinson and Boore (1995), Toro et al. (1997), Frankel et al. (1996), Campbell (2002), and Sommerville et al. (2002). The USGS has combined all of these five widely-accepted attenuation functions within a decision tree by assigning a specific weight or percentage based on its general approval, resulting in two additional models: the CEUS Event and the CEUS Characteristic Event. Table 6.1. shows the various combinations of the five CEUS attenuation functions for each arrangement.

Table 6.1. CEUS Combination Attenuation Functions

CEUS EVENT	
Atkinson and Boore (1997)	0.286
Toro, Abrahamson, and Schneider (1997)	0.286
Frankel, Mueller, Barnhard, Perkins et al. (1996)	0.286
Campbell (2002)	0.142

CEUS CHARACTERISTIC EVENT	
Atkinson and Boore (1997)	0.250
Toro, Abrahamson, and Schneider (1997)	0.250
Frankel, Mueller, Barnhard, Perkins et al. (1996)	0.250
Campbell (2002)	0.125
Sommerville, Collins, Abrahamson et al. (2002)	0.125

Data Source: Frankel et al 2002

Please note that the last two functions were assigned a lower weight because they are newer, and thus, have not been thoroughly assessed by the seismological community at the time these combination relationships were created. The CEUS Characteristic Event attenuation function is best suited to represent earthquakes in the NMSZ because it includes the Sommerville et al. (2002) relationship, which was primarily created for the characteristic earthquakes in the

New Madrid and Charleston areas. However, this function provides much lower ground motions when compared to the other functions for earthquakes with a magnitude between five and six. Also, the Sommerville et al. (2002) relationship is also based on a finite-fault model for smaller events outside of the NMSZ. For such cases, the CEUS Event attenuation function should be utilized, as it does not include the Sommerville relationship. (Frankel et al 2002)

It is important to note that the attenuation function is only one of several other factors that influence the decision tree used for calculating the overall hazard exposure. Other factors specifically related to this study include the previously mentioned fault system located in the NMSZ (Frankel et al 1996) and the magnitudes of the 1811-1812 earthquakes (Frankel et al 2002).

Only after all of this information has been assembled can the newly defined scenario be analyzed, requiring little computational processing. Specifically, HAZUS-MH evaluates the damage, functionality, and performance to infrastructural components such as the general building stock, essential facilities, transportation system, and utility system. Direct economic and social losses are estimated based on the damages to these components. Also, the methodology even quantifies the extent of induced physical damage resulting from fire or inundation. Figure 6.3 illustrates the interconnections between various models within the earthquake methodology as well as the individual outputs of each. These results can be viewed in tabular form or can be mapped on as an overlay on the study region, and will be discussed in detail in the following chapter. (FEMA 2003c)

A detailed step-by-step procedure including screen shots is available for review in Chapter 3 of the HAZUS-MH Earthquake User Manual. (FEMA 2003c)

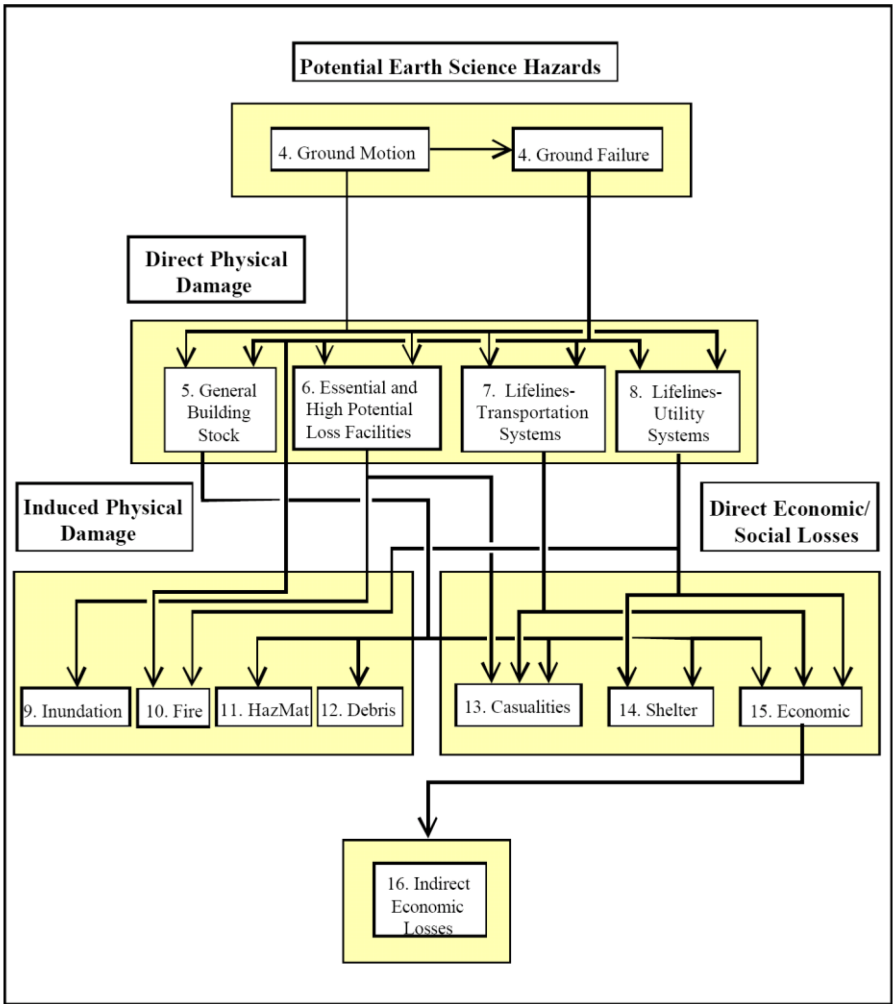


Figure 6.3. Earthquake Methodology Summary

(Source: FEMA 2003c)

6.3. FLOODS

As opposed to the earthquake procedure just described, a flood analysis requires a much more demanding process along with longer computational time. The user must first select the type of flood hazard to narrow the analysis, which in this case focuses only on riverine flooding. (FEMA 2003d)

Next, the user must import a high resolution (one foot preferred) Digital Elevation Model (DEM) readily available from the USGS website. Specifically, this data can be downloaded from the National Elevation Dataset (NED), a digital dataset with consistent datum, elevation unit, and projection. The USGS regression equations and gage records included within these models will be used to determine discharge frequency curves later in the analysis. It is essential that the DEM cover those watersheds that impact the region. To ensure this, the DEM should be slightly larger than the regions outermost boundaries, the coordinates of which can be determined by navigating through the Hazard menu. As Figure 6.4 illustrates, the DEM utilized in this analysis is significantly larger than St. Charles County in order to take into account both sides of the major rivers (Mississippi, Missouri, and even Illinois Rivers) that bound the region. The newly acquired data is incorporated into HAZUS-MH by specifying the DEM data paths. It is important to note that the Spatial Analyst extension must be active in ArcGIS in order for the DEM file to properly integrate into the study region. (FEMA 2003d)

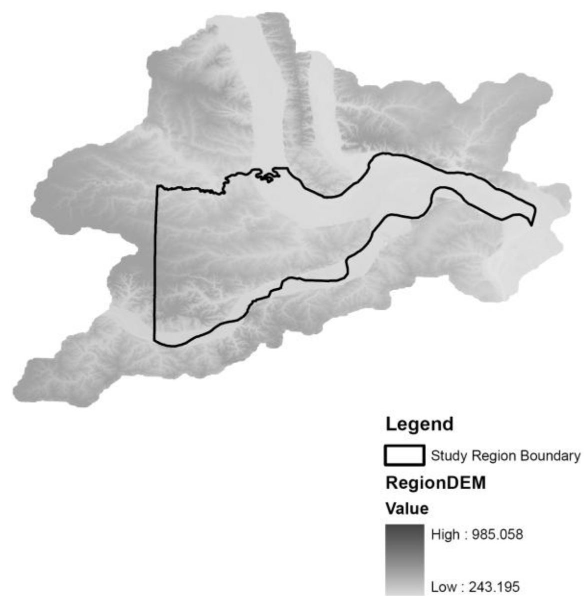


Figure 6.4. DEM for St. Charles County

The next step is to generate a stream network spanning all reaches of the region. This can take several hours depending on the size of the study region, the complexity of the DEM, along with the computer processing speed. (FEMA 2003d) While this is a time consuming process, it only needs to be performed once because all scenarios will be defined using this newly generated stream network. (FEMA 2004) The user must enter an appropriate stream drainage area, ranging anywhere from 0.25 to 400 square miles. This value represents the total land area that drains into any given reach. For this study, a relatively small drainage area of one square mile was selected, resulting in a highly defined stream network (Figure 6.4). The modeling process includes filling pits and accumulating flow for every cell within the DEM, ensuring reaches intersect the study region boundary, and even locating the low points where intermittent streams my form. (FEMA 2003b)

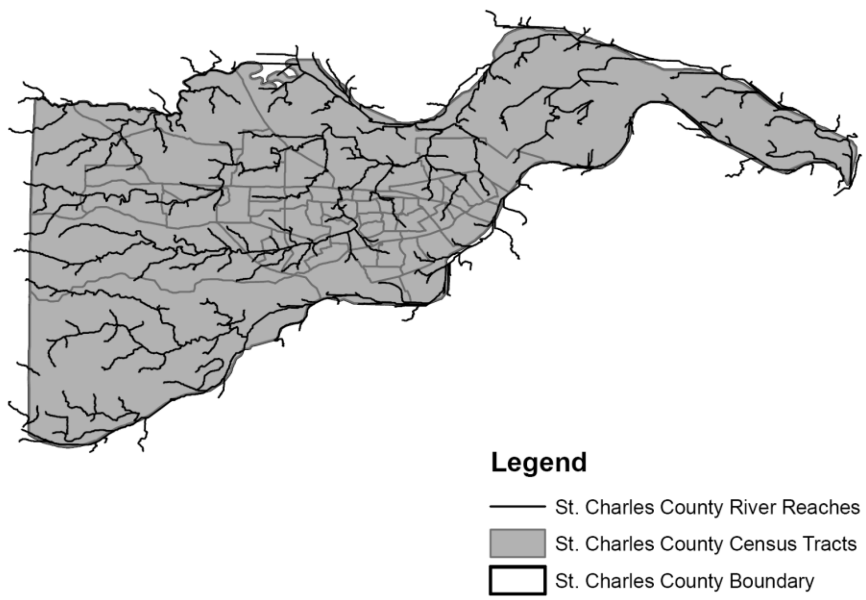


Figure 6.5. St. Charles County Stream Network

Once the stream network has been established, several study cases can be defined through the selection of specific stream reaches, to be further discussed in the following chapter. For each study case, a hydrologic analysis must be executed, which also requires significant processing time depending upon the number and characteristics of the stream reaches selected along with the computer speed. Due to a preset code concerning memory limit, there is a tendency for ArcMap and HAZUS-MH to experience memory lapses that could later lead to failure of the model to complete its analysis. In these instances, it is recommended that the user perform the hydrologic analysis for individual watershed regions. (FEMA 2003d)

After the hydrologic analysis is complete, the user must decide which flood hazard to analyze for the given scenario. There are several types of flood hazards including all return periods (10, 50, 100, 200, and 500), a single return period, single discharge level, or annualized loss. The amount of reaches chosen along with the available memory will most likely limit the analysis options. Also, this process requires significant computational time and other programs should not be running during the analysis. Once again, the current program coding often results in memory lapses that halt the processing status. However, the latest software patch available (HAZUS-MH MR3 Patch 2) allows the program to resume the analysis at the precise location where it last stalled due to memory limitations. Detailed within the flood user manual, there is a relatively simple procedure to remove the problematic river reaches from the analysis. (FEMA 2003d) For this study, all scenarios were evaluated for a 100 year flood event, the reason for which will be discussed in the following chapter.

Although not utilized for this study, it should be recognized that the software is equipped to handle several "what-if" scenarios. Specific to these analyses, the user can draw a proposed levee system to be included within the provided DEM. Also, the user can define the riverine flow velocity and flow regulation. Another important factor that can be considered is the flood warning, which specifies the amount of time residents are provided to make the appropriate accommodations. (FEMA 2003d)

Even still, there are a few input parameters that must be defined in order for the analysis to run. Specifically, the user must designate a date for the flood event in order for the agricultural losses to be accurately depicted. (FEMA 2003d) Replicating the same time frame as the Great Flood of 1993, August 1 was the date chosen for this study. Also, the evacuation buffer is added to the floodplain polygon and directly impacts the number of people affected by the flooding scenario. The user manual suggests a widely-accepted value of 500 feet be input for this option. (FEMA 2003d)

Only after all of this information has been assembled can the newly defined scenario be analyzed, requiring little computational processing time. Figure 6.6 summarizes the differences between the flood and earthquake methodologies. Specifically, the dimmed features are not evaluated within the flood module. Rather, Figure 6.7 illustrates the processes specific to the flood module. The flood loss estimation analysis evaluates damage to the general building stock, essential facilities, agriculture, vehicles, and select components of the lifeline systems. Also, the software estimates limited induced physical damage and social losses. From all of these results, the software is able to estimate both direct and indirect economic losses for the region.

A detailed step-by-step procedure including screen shots is available for review in Chapter 3 of the HAZUS-MH Flood User Manual. (FEMA 2003d)

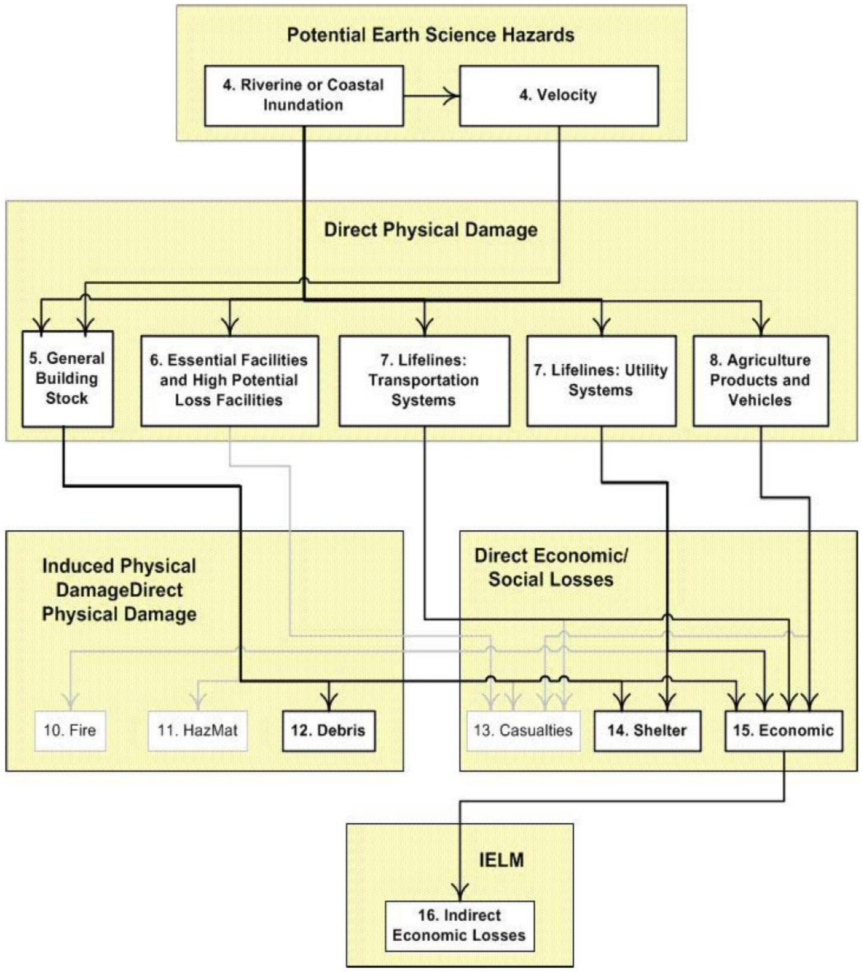


Figure 6.6. Differences Between Earthquake and Flood Methodologies

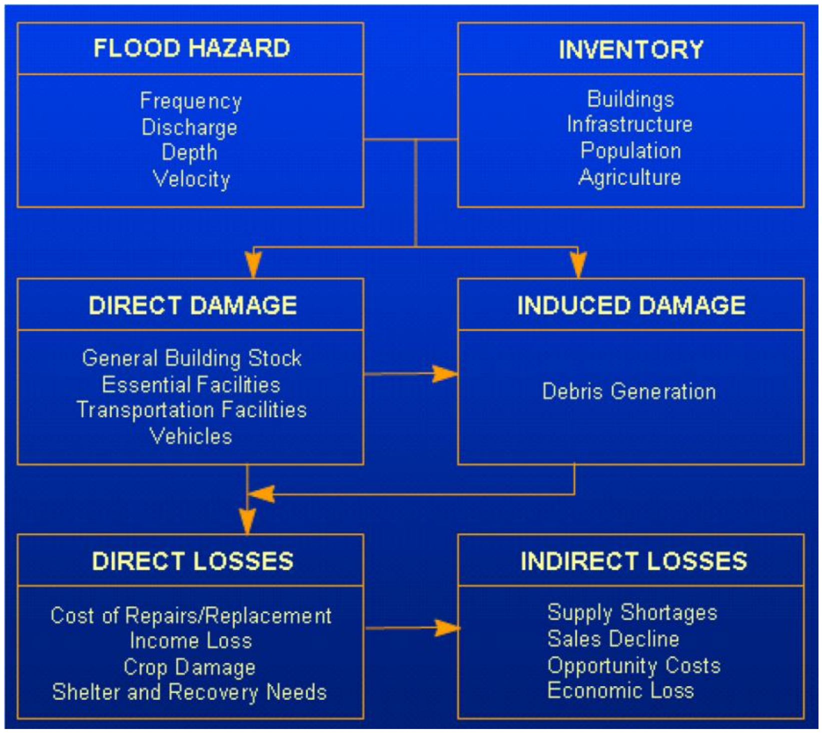


Figure 6.7. Flood Methodology Flow Chart

7. SCENARIOS

7.1. EARTHQUAKE

The selection of appropriate earthquake scenarios is crucial to conduct an adequate loss estimation study. Therefore, a review of deterministic and probabilistic earthquakes was performed to identify several scenarios reasonably plausible for the St. Charles County study region. Table 7.1 and the corresponding map (Figure 7.1) describe and illustrate the three active seismic zones considered for this study. Specifically, the New Madrid Seismic Zone (NMSZ), the Wabash Valley Seismic Zone (WVSZ), and the South Central Illinois Seismic Zone (SCISZ) each have substantial evidence in the form of prehistorical paleoliquefaction or historical or current seismicity, validating the possibility of future seismic activity. In fact, the table even provides the number of years since the last earthquake within each seismic zone greater in magnitude than 5.0 along with the recorded or approximated epicenter of the event. In addition to this historical seismicity, Table 7.1 includes the maximum magnitude earthquake conceivable for each seismic region as agreed upon by seismological experts. This magnitude sets the premise for each scenario analyzed and will be further discussed within this section. It is important to note that the distance from St. Charles County to the various seismic zones listed within the table is merely an approximation from the center of the seismic zone to the city of St. Charles, provided simply as a point of reference.

When developing the National Seismic Hazard Maps, the USGS consulted with the seismological, geological sciences, and engineering experts to decide what magnitude earthquake event should be considered, eventually reaching a consensus that a low probability, worst case scenario earthquake should be considered possible anywhere in the Midwest. While there is historic earthquake activity and paleoliquefaction evidence supporting seismicity, the exact location of the next possible event is still unknown at this point in time.

Table 7.1. Earthquake Scenarios Analyzed for St. Charles County

Source Zone	Evidence for Earthquake Source	Most Recent Earthquake (> M 5.0)	Approximate Epicenter of Most Recent Earthquake		Maximum Plausible Magnitude	Approximate Distance from St. Charles County
			Lat (N)	Long (W)		
NMSZ	historic earthquakes & paleoliquefaction evidence [1]	196 yrs b.p. [1]	36.2° [1]	89.8° [1]	7.7 [2]	160 miles
WVSZ	current seismicity & paleoliquefaction evidence [3]	<1 yr b.p. [4]	38.5° [4]	87.9° [4]	7.1 [5]	170 miles
SCISZ	current seismicity & paleoliquefaction evidence [6]	34 yrs b.p. [7]	38.6° [7]	90.1° [7]	6.0 [8]	15 miles

<u>References for Table 7.1:</u>

1. Hopper (1985)
2. Frankel et al. (2002)
3. Chen et al (2005)
4. USGS (2008)
5. Cramer et al. (2004)
6. Tuttle (1999)
7. NEIC (2007)
8. Cramer (2008)

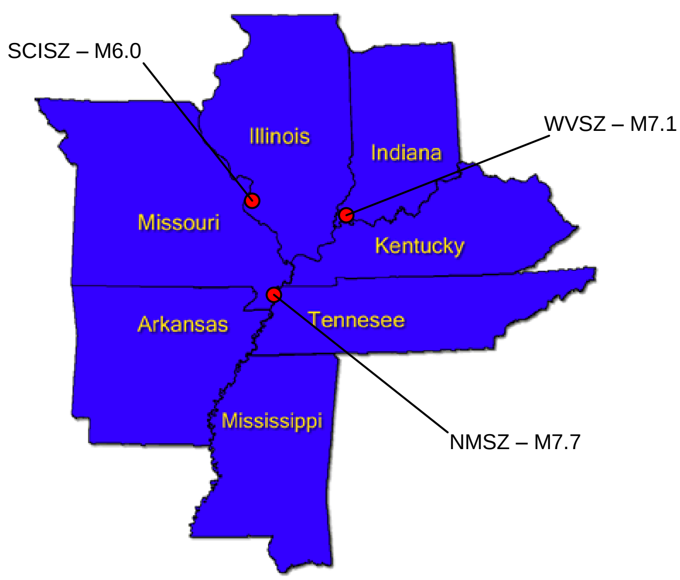


Figure 7.1. Location of Earthquake Scenarios

(Source: Adapted from CUSEC 2005)

7.1.1. Scenario 1: New Madrid Seismic Zone (M 7.7). A large magnitude earthquake with an epicenter location within the NMSZ is based on its well known historical seismicity and substantial paleoliquefaction evidence. The major faults responsible for generating earthquakes in this region are generally accepted from seismological data but are not discernible at the ground surface due to extensive, thick, alluvial sediments throughout the area. While the subsurface conditions do not allow for brittle failure, vast liquefaction fields provide surface evidence of repeated, large earthquake series. Both the magnitude and epicenters of the earthquakes have been approximated based on the age, width, distance, and distribution of the known liquefaction features. Based on cross-cutting stratigraphic relationships, radiocarbon dating, and archeological feature dating, at least three large earthquake series are documented: 196 years before present, approximately 550 years before present, and an estimated 1,100 years before present. (Chen et al. 2005) Also, experts believe that the NMSZ produced earthquakes larger than magnitude 7.5 once every 500 years on average. (Tuttle et al 2002)

Although debatable, the moment magnitudes of these earthquake series are estimated anywhere from 7.5 to even greater than 8. Following the Mchar logic tree method specified by the USGS, a moment magnitude of 7.7 was selected to characterize the largest earthquake events of the 1811-1812 sequence. According to this methodology, there are three faults that comprise the NMSZ: the Northeast, Central, and Southwest faults. (Frankel et al 2002) It is important to note that a separate analysis was performed for each of these faults and the resulting direct losses were compared, with no apparent differences.

The NMSZ scenario earthquake is approximately 160 miles from St. Charles County, and as such offers a far field condition of study. While the likelihood of such a large magnitude event occurring presently is relatively low, it nonetheless offers an extreme risk to the Midwest. Therefore, even the slight possibility of such an event is of major concern to community developers and planners.

7.1.2. Scenario 2: Wabash Valley Seismic Zone (M 7.1). A large magnitude earthquake scenario originating from the WVSZ is based on recently discovered paleoliquefaction features along the banks of the Wabash River and its tributaries. (Chen et al 2005) Also, several westward dipping thrust faults have been identified in this region through seismic reflection profiles. (McBride et al 2002) At least seven earthquake events are recognized in this zone based on radiocarbon dating, cross-cutting stratigraphic relationships, and archeological culture feature dating. The magnitudes of such events are estimated based on the age, width, distance, and distribution of known liquefaction features. The largest of which had an epicenter near Vincennes and is estimated to have occurred approximately 6,100 years before present. (Chen et al. 2005) Current research is still uncovering new evidence of additional historical earthquakes within this seismic zone. Most recently (April 18, 2008), a 5.2 magnitude earthquake arose near Bellmont, Illinois, well within the WVSZ. This earthquake resulted in only minor damage but has served as a warning and reminder of the potential risk of the area. (USGS 2008)

The current seismicity coupled with the newly discovered paleoliquefaction features suggest that this seismic zone is capable of producing large magnitude earthquakes ranging anywhere from M 7.0 to M 7.8. Thus, a 7.1 magnitude event was chosen for this study based on the USGS hazard maps recently developed. (Cramer 2008)

While the WVSZ is approximately 175 miles east of St. Charles County, the occurrence of a large magnitude earthquake there could undoubtedly affect the study region, and therefore, must be analyzed.

7.1.3. Scenario 3: South Central Illinois Seismic Zone (M 6.0). A moderate sized earthquake scenario originating from the SCISZ is based on recent seismicity. Specifically, the USGS National Earthquake Information Center (NEIC) recorded a 5.6 magnitude earthquake occurring just southeast of St. Louis (38.55, -90.13) in 1974. (NEIC 2007) While this particular event is only approximately 30 miles southeast of the closest portion of St. Charles County, the seismic zone extends further into south central Illinois.

Evidence of the seismic zone limits lies within the newly discovered paleoliquefaction features along the banks of the Kaskaskia River and its subsequent tributaries: Shoal Creek, Mud Creek, and Silver Creek. The seismicity in this region is believed to emanate from a network of interconnected basement faults but could also be associated with any number of the significant geologic structures in the area: the Centralia, St. Louis, and New Madrid faults; Valmeyer and Waterloo-Dupo anticlines; Du Quoin monocline; and an unidentified source near Shoal Creek. These features are not currently known to be active, but have not been thoroughly investigated yet. (Tuttle 1999) Similar to the other seismic zones, cross-cutting stratigraphic relationships along with radiocarbon dating has identified at least two episodes of liquefaction, the older more extensive of which occurring approximately 6,825 years before present time and the other occurring less than 3,990 years ago. After analyzing the known liquefaction features, seismological experts believe that this seismic zone is capable of producing a 7.5 magnitude earthquake. (Chen et al. 2005)

Given the close proximity of the SCISZ to St. Charles County, the current recorded seismicity, along with the newly discovered paleoliquefaction evidence, the impacts of such a scenario had to be analyzed, offering a close proximity, high probability event.

7.2. FLOOD

Bounded by the Missouri River on the south and the Mississippi River on the north and east, St. Charles County is a roughly triangular area dissected by numerous inland streams and tributaries. As previously described, the HAZUS-MH flood analysis includes first developing a stream network spanning all reaches of the study region. This process not only delineates known tributaries but also analyzes the low areas where intermittent streams may form. As Figure 7.2 illustrates, the tributaries and streams within St. Charles County can easily be associated with the parent river. Thus, the decision was made to evaluate each major river and subsequent tributaries separately.

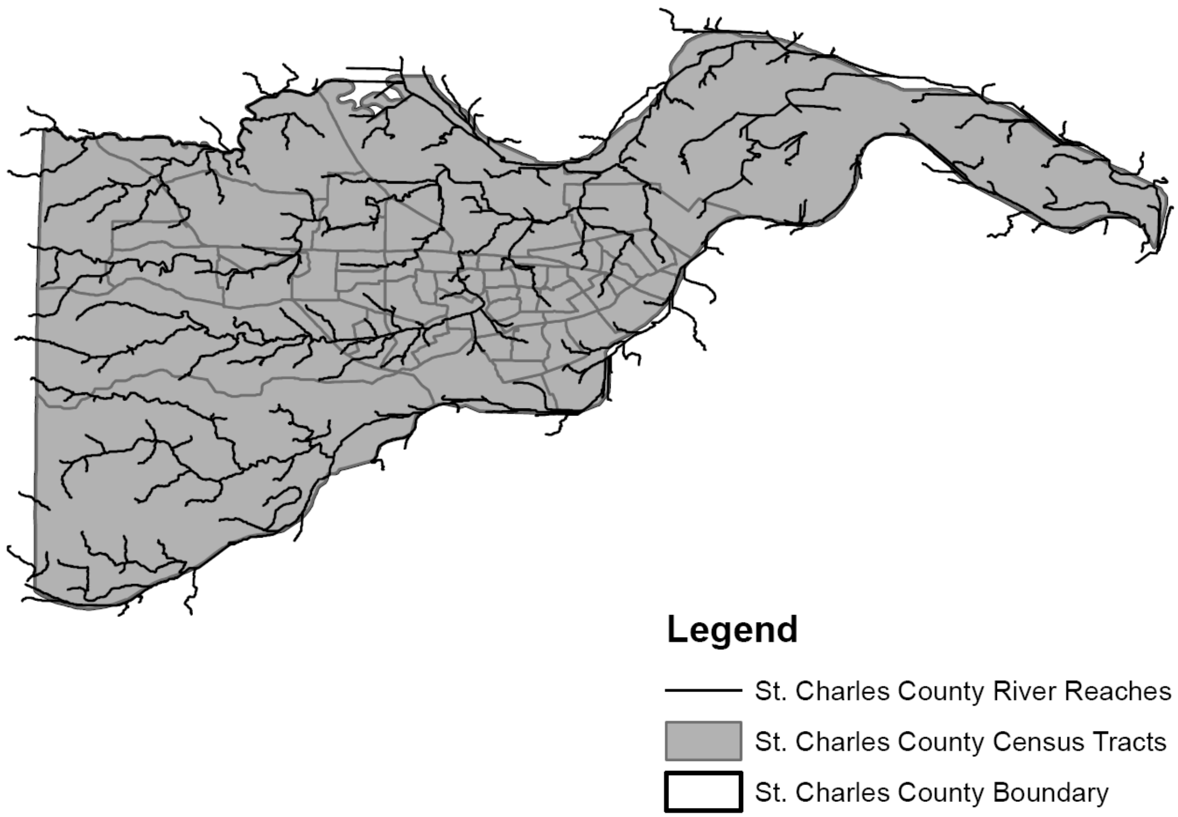


Figure 7.2. River Reaches For St. Charles County Determined Using HAZUS-MH

According to Figure 7.3, the 500-year floodplain with St. Charles County extends only slightly beyond the 100-year floodplain, especially along the smaller, intermittent streams. These slight differences can most likely be attributed to a lack of sufficient data to more accurately delineate these boundaries. (East-West Gateway 2004) Specifically, over 5,000 years of statistics are necessary to adequately define a 500 year flood, which is obviously not yet available. (Hoffman 2008) Nonetheless, a return period of 100 years was also chosen to represent the most likely flood event to affect St. Charles County. Also, the U.S. Army Corps of Engineers determined that the recurrence interval for the Great Flood of 1993 was 175 years near the St. Louis metropolitan area, justifying the recurrence interval selection. (Lovelace and Strauser 1995)

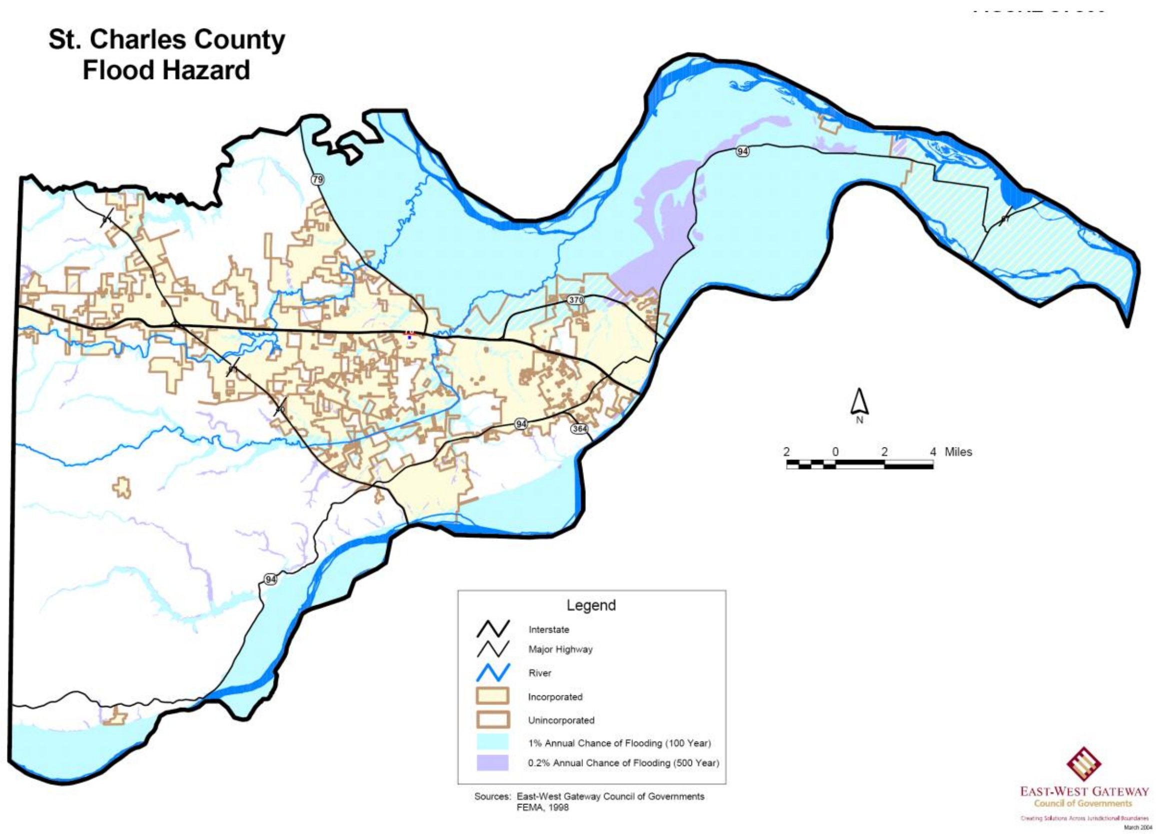


Figure 7.3. St. Charles County Flood Hazard
(Source: East-West Gateway 2004)

7.2.1. Scenario 1: Missouri River Reaches (100-Year). Like most waterways, the Missouri River has a long-running history of flooding. Specifically, flood frequency averages once every other year, with a major flood episode occurring once every six years on average. (Fulcher et al 1995)

St. Charles County has experienced extensive growth, resulting in a dramatic increase in developments throughout the region. In fact, most of the County’s upland area has already been urbanized or has been acquired for the purpose of future development, leaving behind little room for further expansion. Currently, commercial and industrial developments are pouring into floodplain regions, placing them at risk to potential flood damage.

Given this urban expansion within the floodplains of the Missouri River reaches (Figure 7.4) and the history of flooding, the impacts of such a scenario had to be analyzed, as a high probability event.

It is important to note that the flood boundaries calculated within HAZUS-MH are different than those generally accepted, as depicted in the previous figure (Figure 7.3). These discrepancies can most likely be attributed to the fact that the software analyzes the DEM to locate levees, either natural or man-made, and then adjusts the floodplain boundaries accordingly. Thus, these delineated floodplains are most likely underestimated.

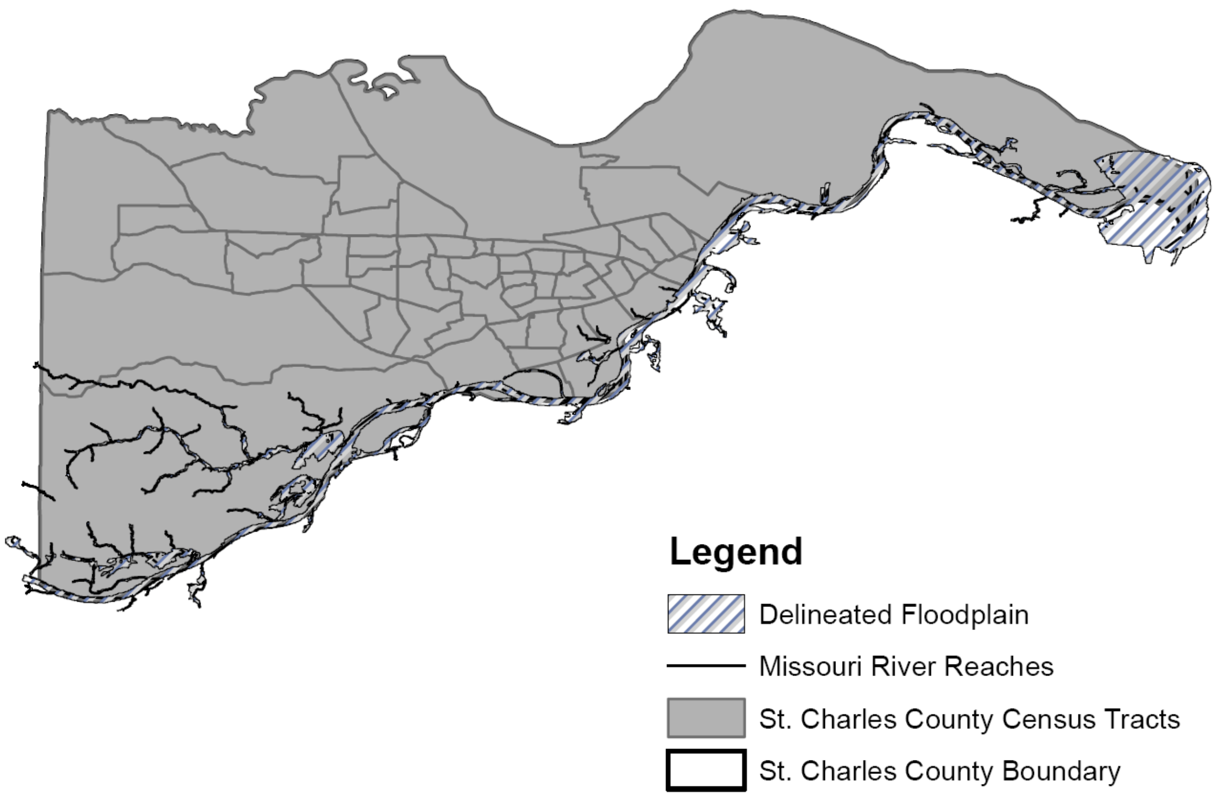


Figure 7.4. Delineated Floodplain for 100-Year Flood Along the Missouri River Reaches

7.2.2. Scenario 2: Mississippi River Reaches (100-Year). The Mississippi River is subject to the same flood frequency as the Missouri River. However, while St. Charles County experiences flooding events of varying magnitude almost annually, there have only been 15 major flood events since 1884; the most severe of which was the Great Flood of 1993, occurring along the Mississippi River.

Once again, the substantial development across the region has resulted in the urban expansion of the floodplains. Several commercial and industrial developments, such as Lakeside 370, are currently under construction in regions that were inundated during the Great Flood of 1993. Delineated by HAZUS-MH, Figure 7.3 illustrates the 100-year floodplain for the Mississippi and Missouri River Reaches.

Given this floodplain development and the substantial history of flooding, the impacts of such a scenario had to be analyzed, as a high probability event.

Once again, the flood boundaries calculated within HAZUS-MH are different than those depicted in Figure 7.3. Specifically, the delineated floodplain boundaries do not extend nearly as far into the County region as expected. These discrepancies can most likely be attributed to the fact that the software analyzes the DEM to locate levees, either natural or man-made, and then adjusts the floodplain boundaries accordingly.

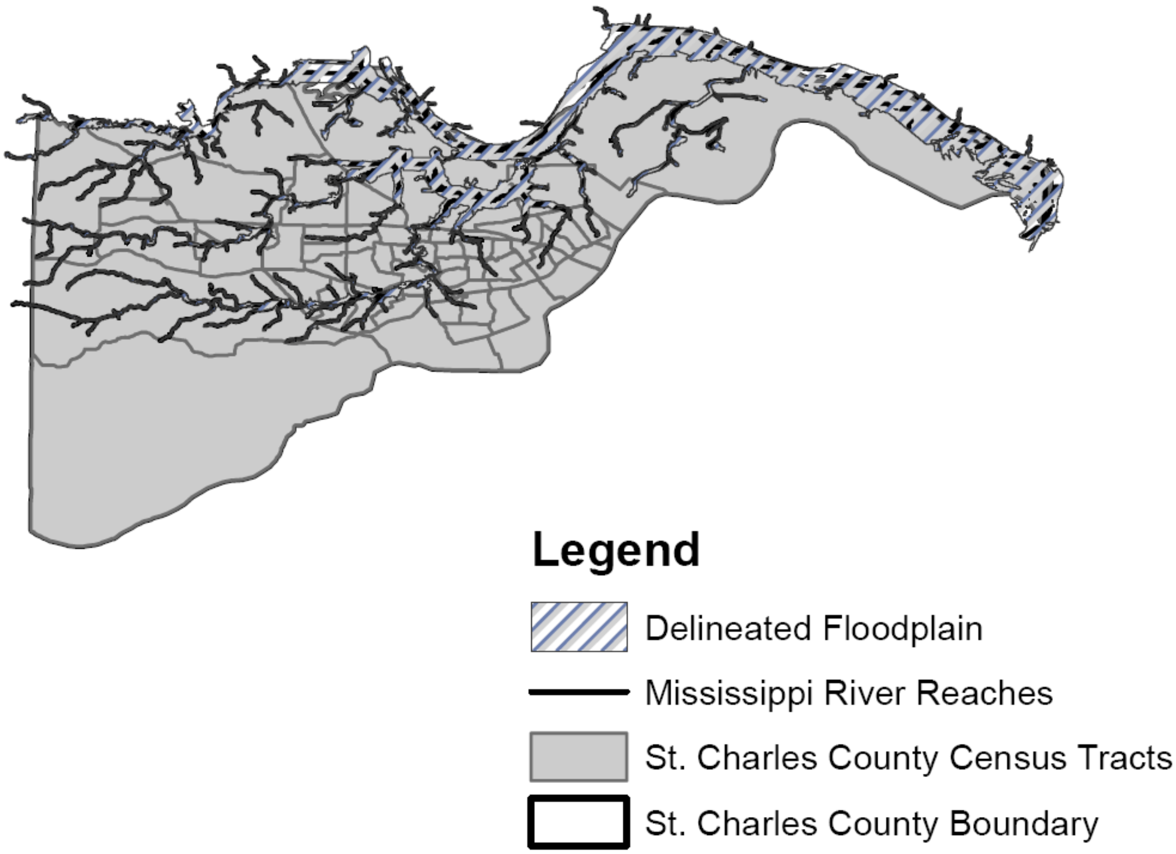


Figure 7.5. Delineated Floodplain for 100-Year Flood Along the Mississippi River Reaches

8. RESULTS AND ANALYSIS

8.1. GENERAL

To compare the effects of these natural disasters, the various scenarios must first be compared within the hazard and then the damages can be compared between hazards, determining which one poses the largest risk for St. Charles County.

Included within HAZUS-MH, the inventory contains information particular to the general building stock, essential facilities, transportation system, utility system, and other demographics for the study region created. Summarized within this section, this inventory is based upon the results of the 2000 census and several subcontracted research efforts. All of the analyses utilized only this default data included within the CD-ROM inventory. (FEMA 2003a)

All of the scenarios use key common data to ensure that there are no inventory discrepancies when switching between hazards. However, the earthquake model displays data at the census tract level while the flood model presents data at the census block level, allowing for slight differences in the presentation of results. (FEMA 2003a)

Modeled in HAZUS-MH, the St. Charles County region spans approximately 592 square miles and includes 57 census tracts and 5,655 census blocks. With a population of 283,883, there are over 94,000 buildings within the region which have an aggregate replacement value of 21.25 billion dollars, excluding their contents. It is important to note that the building replacement cost models within the software are based on industry-standard cost-estimation models and algorithms. (FEMA 2003a) The general building stock includes residential, commercial, industrial, agricultural, religious, government, and educational buildings; and, the building stock exposure can be described by either building type (Table 8.1) or general occupancy (Table 8.2). Since St. Charles is one of the fastest growing counties in Missouri, approximately 93 percent of the structures are residential housing with substantial commercial development. In terms of building construction types within the region, wood frame construction constitutes 70 percent of the building inventory.

Table 8.1. St. Charles County Building Stock Exposure by General Occupancy

Building Stock Exposure	
General Occupancy	**Replacement Value (millions of dollars)**
Residential	16,610.90
Commercial	3,052.04
Industrial	808.97
Agriculture	62.57
Religion	324.99
Government	100.39
Education	303.70
Total	**21,263.61**

Table 8.2. St. Charles County Building Stock Exposure by Building Type

Building Stock Exposure	
Building Type	**Replacement Value (millions of dollars)**
Wood	13,312.20
Steel	916.76
Concrete	1,385.54
Masonry	5,442.22
Manufactured Housing	206.89
Total	**21,263.61**

The software separates critical facilities as either essential facilities or high potential loss facilities. As shown in Figure 8.1, essential facilities include hospitals, medical clinics, emergency operation facilities, fire stations, police stations, and schools. High potential loss facilities include dams, levees, military installations, nuclear power plants, and hazardous material sites. (FEMA 2003a) Table 8.3 summarizes these critical facilities within St. Charles County. There are also several hazardous material facilities within the region that pose significant risk due to their toxicity, flammability, reactivity, or radioactivity Significant casualties or property damage could result from any release induced by either an earthquake or flood. Due to the large number of variables that must be considered, HAZUS-MH does not attempt to estimate losses for such accidents or other various cascading effects. Thus, it is the responsibility of local planners to identify the hazardous material facilities that are most likely to have a release as a direct result of a natural disaster.

Table 8.3. St. Charles County Critical Facilities

Critical Facilities	
Facilities	**Total**
Essential Facilities	
Hospitals	4 (with 546 beds)
Emergency Operation Centers	0
Fire Stations	14
Police Stations	15
Schools	92
High Potential Loss Facilities	
Dams	97 (18 high hazard)
Levees	Determined by DEM
Hazardous Material Sites	83
Military Installations	0
Nuclear Power Plants	0

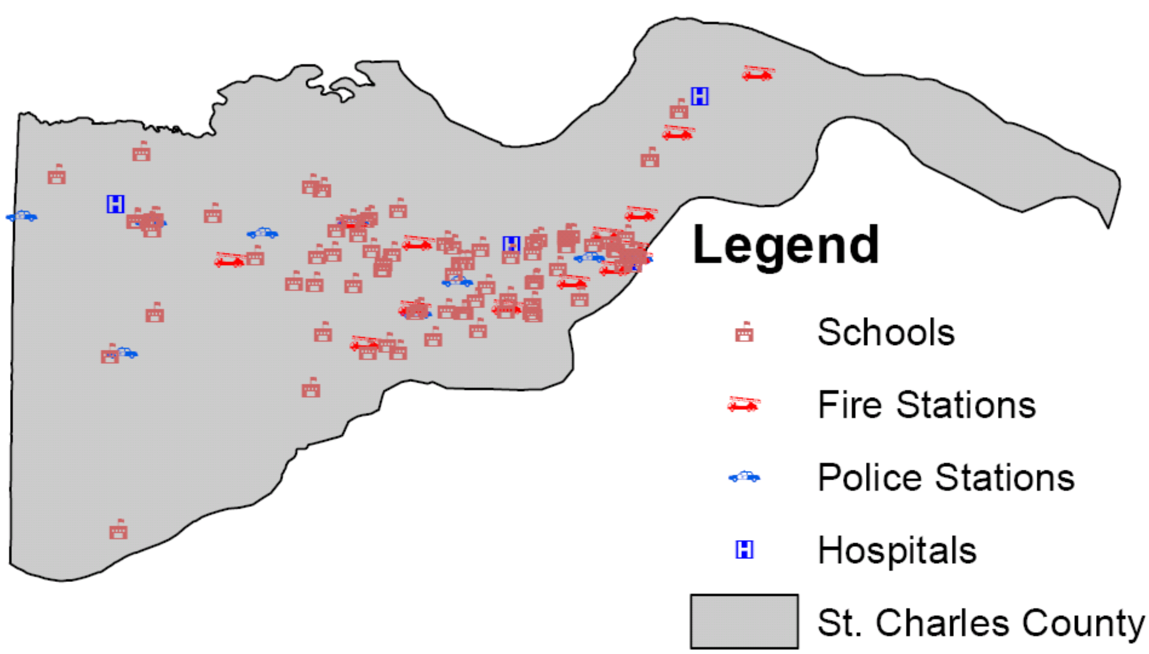


Figure 8.1. St. Charles County Essential Facilities

Within HAZUS-MH, the lifeline inventory is divided between transportation and utility systems, which are further classified into pre-defined component categories. There are seven transportation system components including highways, railways, light rail, bus, ports, ferry, and airports. There are six utility system components such as potable water, waste water, natural gas, crude and refined oil, electric power, and communications. (FEMA 2003a) The lifeline inventory data is detailed in Tables 8.4 and 8.5 and illustrated in Figures 8.2 and 8.3, respectively. The St. Charles County transportation system inventory replacement value totals approximately 1.67 billion dollars, the vast majority of which represented by highway segments and bridges. Similarly, the County's utility system dollar exposure, which is greater than 1.5 billion dollars, is dominated by the waste water system.

Table 8.4. St. Charles County Transportation System Inventory

Transportation System Lifeline Inventory			
System	**Component**	**Number**	**Replacement Value (millions of dollars)**
Highway	Segments	68	855.00
	Bridges	216	331.40
	Facilities	0	0.00
		Subtotal=	**1186.40**
Railway	Segments	32	79.60
	Bridges	4	0.40
	Facilities	2	4.50
		Subtotal=	**84.50**
Light Rail	Segments	0	0.00
	Bridges	0	0.00
	Facilities	0	0.00
		Subtotal=	**0.00**
Bus	Facilities	2	2.20
		Subtotal=	**2.20**
Port	Facilities	4	8.60
		Subtotal=	**8.60**
Ferry	Facilities	0	0.00
		Subtotal=	**0.00**
Airport	Runways	11	352.10
	Facilities	8	44.90
		Subtotal=	**397.00**
		TOTAL=	**1678.70**

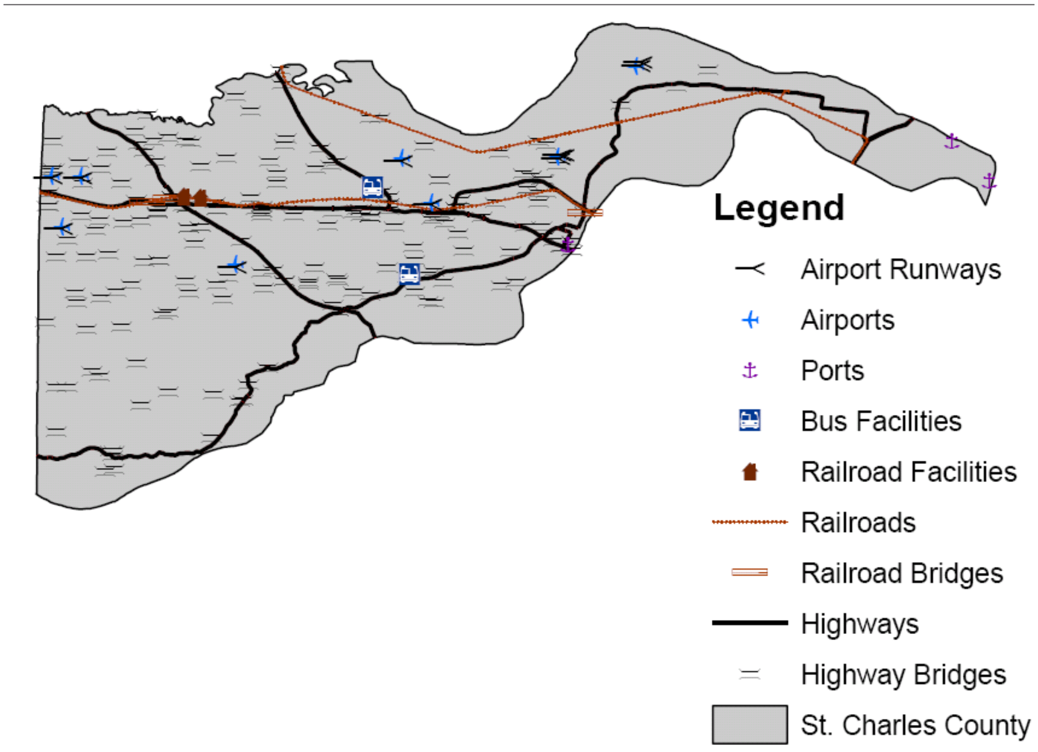


Figure 8.2. St. Charles County Transportation System

8.5. St. Charles County Utility System Inventory

Utility System Lifeline Inventory			
System	**Component**	**Length / Number**	**Replacement Value (millions of dollars)**
Potable Water	Distribution Lines	3,820 km	76.40
	Facilities	3	102.90
		Subtotal=	**179.30**
Waste Water	Distribution Lines	2,292 km	45.80
	Facilities	19	1303.40
		Subtotal=	**1349.20**
Natural Gas	Distribution Lines	1528 km	30.60
	Facilities	0	0.00
		Subtotal=	**30.60**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal=	**0.00**
Electrical Power	Facilities	1	113.30
		Subtotal=	**113.30**
Communication	Facilities	4	0.40
		Subtotal=	**0.40**
		TOTAL=	**1672.80**

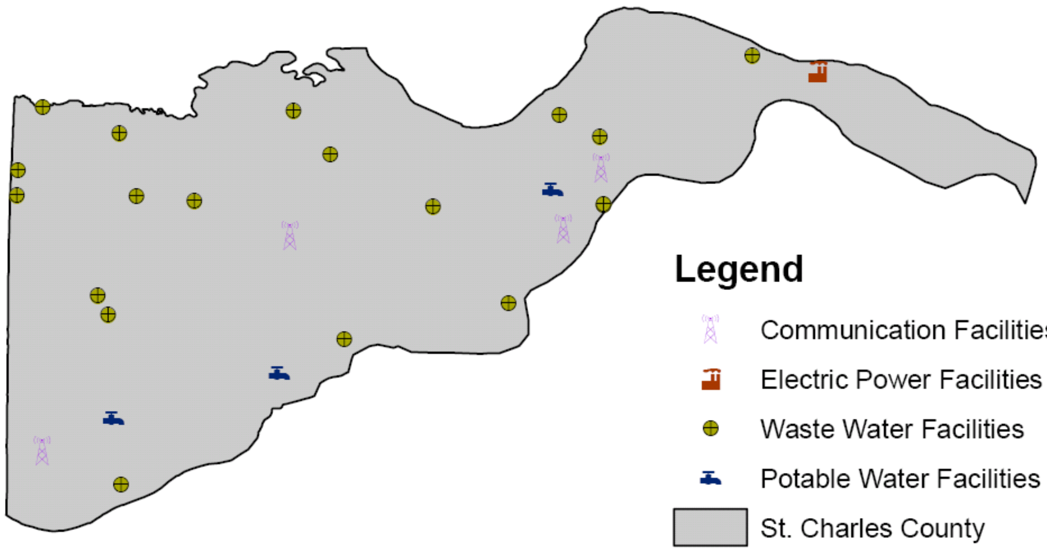


Figure 8.3. St. Charles County Utility System

Unique to the flood module, HAZUS-MH also includes vehicle inventory to account for the anticipated damages to all means of transportation due to various flooding events. These risks extend to all types of vehicles including cars, light trucks, and heavy trucks and are considered at both the day and evening times. Unlike most other assets, vehicles can be moved out of harms way provided sufficient warning. (FEMA 2003b) However, there are many different circumstances that still undoubtedly lead to vehicle damage no matter how much warning time. For this analysis, the worst case scenario was considered, allowing no warning time to residents. Utilizing this philosophy, approximately 535.9 million dollars are exposed during the day and 934.6 million dollars during the evening, which makes logical sense. While cars constitute nearly half of the dollar exposure, there is still a significant risk posed to light and heavy trucks.

Similarly, HAZUS-MH provides default agricultural inventory for St. Charles County to use in flood module damage estimates. The quantity of crops considered is limited by the available damage functions. Thus, the agricultural inventory, available within Appendix C, represents only the top 20 products within Missouri. (FEMA 2003b) As expected, the primary crops are soy bean, corn, and wheat.

A more specific description of this default inventory database as well as the census data necessary to provide damage and loss estimates is available in Chapter 3 of the HAZUS-MH Technical Manual. (FEMA 2003a)

8.2. EARTHQUAKE ANALYSIS

8.2.1. Direct Earthquake Damage.

8.2.1.1 General Building Stock Damage. The methodology uses fragility and capacity curves to describe the probability of reaching or exceeding different damage states. Specifically, the extent of damage to both structural and nonstructural components of a building are defined by one of five damage states: none, slight, moderate, extensive, and complete. There is not one distinct set of definitions for these damage states. Rather, HAZUS-MH defines these damage states for all model building types, 16 in total, with references to observable damage incurred by structural and nonstructural components. (FEMA 2003a) The simplest way to display these damage results are according to general occupancy classes. Thus, Table 8.6 summarizes the number of buildings damaged within these pre-defined occupancy classes for each earthquake scenario analyzed. A total of 94,771 buildings were evaluated within St. Charles County, most of which are a residential type. As expected, the vast majority of these buildings remained unharmed after each of these earthquakes. Nonetheless, the NMSZ magnitude 7.7 earthquake resulted in more total structures damaged. Specifically, 1,651 buildings experienced some form of damage, with the majority being only slightly affected. While the WVSZ scenario resulted in less than half as many total buildings damaged, the general trend remained the same with most incurring only slight damages. By comparison, the SCISZ earthquake resulted in more extensive damage to the general building stock. Given the close proximity of this scenario, 552 of the 1,260 buildings were damaged beyond repair. However, it is important to note that very few structures were extensively damaged. It is rather suspicious that no structures were extensively damaged while nearly half of the affected structures were completely destroyed.

Table 8.6. Building Damage Count by General Occupancy for Each Earthquake Scenario

General Occupancy Classes	Number of Buildings					
	None	**Slight**	**Moderate**	**Extensive**	**Complete**	**Total**
NMSZ - M7.7						
Single Family Res.	83,771	916	74	1	0	84,762
Other Residential	7,149	531	65	0	0	7,745
Commercial	1,486	38	5	0	0	1,529
Industrial	360	10	1	0	0	371
Government	89	3	0	0	0	92
Education	64	2	0	0	0	66
Religion	144	3	0	0	0	147
Agriculture	57	2	0	0	0	59
TOTAL	**93,120**	**1,505**	**145**	**1**	**0**	**94,771**
Total Damaged Structures = 1,651						
WVSZ - M7.1						
Single Family Res.	84,240	489	33	0	0	84,762
Other Residential	7,578	158	9	0	0	7,745
Commercial	1,513	14	1	0	0	1,528
Industrial	368	3	0	0	0	371
Government	91	1	0	0	0	92
Education	65	1	0	0	0	66
Religion	146	2	0	0	0	148
Agriculture	58	1	0	0	0	59
TOTAL	**94,059**	**669**	**43**	**0**	**0**	**94,771**
Total Damaged Structures = 712						
SCISZ - M6.0						
Single Family Res.	83,779	487	33	0	464	84,763
Other Residential	7,507	156	9	0	73	7,745
Commercial	1,504	14	1	0	9	1,528
Industrial	363	3	0	0	5	371
Government	90	1	0	0	0	91
Education	65	1	0	0	0	66
Religion	145	2	0	0	1	148
Agriculture	58	1	0	0	0	59
TOTAL	**93,511**	**665**	**43**	**0**	**552**	**94,771**
Total Damaged Structures = 1,260						

The general building stock represents typical buildings of a given type designed to a specific code of seismic standards (high-, moderate-, or low-code). (FEMA 2003a) Given that

St. Charles County only just recently adopted the 2003 IBC building code with seismic design provisions, the structures within the region are either designed to a low-code or are designated pre-code. Structures designated pre-code are not considered in the analysis, thus explaining the discrepancies in total number of buildings evaluated. As Table 8.7 illustrates, approximately 76,800 buildings within St. Charles County were constructed using a low seismic design standard, suggesting that the remainder are pre-code structures. Because these low-code structures incorporate some seismic provisions, they are far less susceptible to earthquake damage when compared to pre-code structures where such provisions are neither required nor enforced. Of these low-code buildings, the vast majority are wood structures, as they represent the extensive network of residential housing within St. Charles County. Also, there are a substantial number of unreinforced masonry structures and manufactured homes, which are at great risk to earthquake damage. However, steel, concrete, precast, and reinforced masonry are much less vulnerable.

Although each building type has a distinct set of damage definitions, wood, unreinforced masonry, and manufactured homes are the primary structural forms affected throughout the region for each earthquake scenario analyzed. As defined by FEMA (2003a), the damage states associated with each of these particular building types are available below. Throughout these definitions, cracks are assumed to be visible cracks with a maximum width of less than 1/8 inch, anything wider is referred to as large. These damage states include references to observable damage incurred by both structural and nonstructural components. Non-structural components are the architectural elements within buildings including partition walls, ceilings, electrical systems, etc. Non-structural damage is considered independently from the model building type. That is, these architectural components are assumed to incur the same damage whether in a light wood building or a steel frame structure.

Wood (light frame):

- **Slight Structural Damage:** Small cracks at corners of doors, window openings, and wall-ceiling intersections; small cracks within stucco, plaster walls, and masonry chimneys.
- **Moderate Structural Damage:** Large cracks at corners of doors and window openings; small diagonal cracks across wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
- **Extensive Structural Damage:** Large diagonal cracks across wall panels or plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; small cracks in foundations and slippage of structure over foundation; partial collapse of soft story configurations.
- **Complete Structural Damage:** Structure may have large permanent lateral displacement or may be in imminent danger of collapse due to wall failure; some structures may slip and fall off the foundation; large foundation cracks.

Structures with Unreinforced Masonry Bearing Walls:

- **Slight Structural Damage:** Diagonal, stair-step hairline cracks on masonry wall surfaces; larger cracks around door and window openings; movements of lintels; cracks at the base of parapets.
- **Moderate Structural Damage:** Most wall surfaces exhibit diagonal cracks with some being large; masonry walls may have visible separation from diaphragms; some masonry may fall from walls; significant cracking of parapets.
- **Extensive Structural Damage:** Most walls have suffered extensive cracking; some parapets and end walls have fallen; beams or trusses may have shifted relative to their supports.
- **Complete Structural Damage:** Structure has collapsed or is in imminent danger of collapse due to wall failure.

Manufactured Homes:

- **Slight Structural Damage:** Damage to some porches, stairs, or other attached components.
- **Moderate Structural Damage:** Major movement of the home over its supports resulting in some damage to siding and stairs and requiring resetting.
- **Extensive Structural Damage:** Home has fallen partially off of its supports, often severing utility lines.
- **Complete Structural Damage:** Mobile home has totally fallen off its supports, usually severing utility lines.

The SCISZ earthquake affected far more of these low-code structures due to the close proximity of the ground shaking. The results of each earthquake scenario follow the same trend as previously described. That is, the far-field earthquakes only resulted in slight to moderate damage to structures, whereas over 75 percent of the damaged buildings associated with the St. Louis scenario are classified as complete.

Table 8.7. Building Damage Count for Low Seismic Design Level by Building Type for Each Earthquake Scenario

Building Type	Number of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
NMSZ - M7.7						
Wood	66,232	126	0	0	0	66,358
Steel	184	2	0	0	0	186
Concrete	58	0	0	0	0	58
Precast	59	0	0	0	0	59
Reinforced Masonry	2	0	0	0	0	2
Unreinforced Masonry	7,979	126	7	0	0	8,112
Manufactured Home	1,988	34	2	0	0	2,024
TOTAL	**76,502**	**288**	**9**	**0**	**0**	**76,799**
	Total Damaged Structures = 297					
WVSZ - M7.1						
Wood	66,312	46	0	0	0	66,358
Steel	186	0	0	0	0	186
Concrete	58	0	0	0	0	58
Precast	59	0	0	0	0	59
Reinforced Masonry	2	0	0	0	0	2
Unreinforced Masonry	8,052	58	2	0	0	8,112
Manufactured Home	2,008	15	1	0	0	2,024
TOTAL	**76,677**	**119**	**3**	**0**	**0**	**76,799**
	Total Damaged Structures = 122					
SCISZ - M6.0						
Wood	65,953	46	0	0	359	66,358
Steel	184	0	0	0	2	186
Concrete	58	0	0	0	0	58
Precast	59	0	0	0	0	59
Reinforced Masonry	2	0	0	0	0	2
Unreinforced Masonry	8,008	58	2	0	44	8,112
Manufactured Home	1,983	15	1	0	25	2,024
TOTAL	**76,247**	**119**	**3**	**0**	**430**	**76,799**
	Total Damaged Structures = 552					

8.2.1.2 Critical Facilities Damage. The damage state probabilities for essential facilities are determined on an individual basis, meaning that the ground motion parameters are computed at the location of each facility. All other economic losses associated with these facilities are computed as part of the general building stock methodology. (FEMA 2003a) The primary concern is how well these essential facilities are able to respond to any subsequent emergencies that may follow an earthquake event such as rescue, medical, fire, crime, etc. Table 8.8 shows the functionality of the essential facilities within St. Charles County immediately following the various earthquake scenarios analyzed. In the event of any of these earthquakes, the essential facilities servicing the region should still operate as usual while experiencing only slight inconveniences. The functionality of these essential facilities is expected to increase with time. For instance, the hospitals are expected to be near full operation 90 days after each event.

Table 8.8. Essential Facilities Functionality Immediately Following Earthquakes

Earthquake Scenarios	Essential Facilities Functionality (%)			
	Fire Stations	Hospitals	Police Stations	Schools
NMSZ - M7.7	94.1	96.4	94.1	94.1
WVSZ - M7.1	96.6	98.1	96.6	96.6
SCISZ - M6.0	95.2	96.5	96.6	96.0

Although high potential loss facilities can result in extensive losses if damaged, HAZUS-MH does not currently perform damage and loss estimates for these facilities as part of the analysis. The results of these damage estimates are utilized in other modules of the software to predict casualties due to structural damage, economic losses due to building damage, indirect economic losses resulting from building damage and closure, and other economic and social impacts, all to be further discussed within this chapter. (FEMA 2003a)

8.2.1.3 Lifeline Damage. The methodology estimates damage to the lifeline inventory previously discussed. Damage states are classified as either none, slight, moderate, extensive, or complete. Detailed in Chapter 7 and 8 of the earthquake technical manual, these damage states are uniquely defined for each lifeline system component for those associated with both the transportation and utility systems. However, all damage states are quantified by a damage ratio of repair to replacement costs for evaluation of direct economic loss. (FEMA 2003a)

Fragility curves are included for each highway system component to describe the probability of exceedance for each damage state due to the input ground motion. However, several transportation system components such as roadway segments, railroad tracks, and airport runways, are assumed to be damaged by ground failure only. If ground failure maps are not provided as is the case with this study, damage estimates to these components will not be computed. Therefore, no damages were returned for any of these transportation system components from any of the earthquake scenarios evaluated. However, bridges (highway and railroad) and transportation facilities are vulnerable to both ground shaking and ground failure. (FEMA 2003a) Even still, the earthquake scenarios studied resulted in minimal damages to these components. Specifically, all events resulted in only minor damage to approximately one percent of the total number of bridges (216) within St. Charles County. For bridges, minor damage is defined by minor cracking and spalling of the abutments, shear keys, hinges, and decks. (FEMA 2003a) Also, none of the earthquakes caused any damage to the transportation facilities, specifically those associated with railway, bus, port, and airport systems.

The software also provides component restoration curves for each damage state to evaluate the loss of function. These curves describe the percentage of the system component is expected to be operational as a function of time following the earthquake event. (FEMA 2003a) All of the earthquake scenarios reported 100 percent functionality for roads, railroads, and airport runways due to the lack of damage results. Because the earthquake events resulted in very minor bridge damage, all returned approximately 99.5 percent functionality, which steadily increased with time.

It is important to note that the interdependence of the individual components on the overall transportation system functionality is not currently addressed by this methodology.

The methodology used to determine the utility system damage/performance is the same as that described for the transportation system. However, all utility system components are susceptible to damage due to ground shaking, which could ultimately result in disruption to the entire network. Specifically, Table 8.9 summarizes the damage, as a percentage, incurred by the potable water and waste water facilities. These damage states refer to the performance, or rather malfunction, of the various systems components such as wells, storage tanks, pumping plants, and treatment plants. (FEMA 2003a) Once again, there are three potable water facilities and 19 waste water facilities scattered throughout St. Charles County. These facilities would only be slightly to moderately damaged no matter what earthquake event. Even still, the SCISZ earthquake would result in the most damage.

Table 8.9. Utility System Facilities Damage for Each Earthquake Scenario

Utility System Facilities	Damage State (%)				
	None	Slight	Moderate	Extensive	Complete
NMSZ - M7.7					
Potable Water Facilities	90	9	1	0	0
Waste Water Facilities	90	9	1	0	0
WVSZ - M7.1					
Potable Water Facilities	97	3	0	0	0
Waste Water Facilities	97	3	0	0	0
SCISZ – M6.0					
Potable Water Facilities	81	15	4	0	0
Waste Water Facilities	82	14	4	0	0

Utility pipeline damage is not described in the form of a pre-defined damage state. Rather, pipelines are defined by the number of repairs necessary per kilometer length of pipe. As Table 8.10 illustrates, all of the earthquake scenarios produced similar results with respect to the number of leaks throughout the various utility system pipelines. However, the SCISZ produced approximately ten times as many breaks as the other scenarios.

Table 8.10. Utility System Pipeline Damage for Each Earthquake Scenario

Earthquake Scenarios	Utility System Pipelines		
	Total Length (km)	Number of Leaks	Number of Breaks
NMSZ - M7.7			
Potable Water	3,820	13	3
Waste Water	2,292	10	3
Natural Gas	1,528	11	3
WVSZ - M7.1			
Potable Water	3,820	9	2
Waste Water	2,292	7	2
Natural Gas	1,528	7	2
SCISZ – M6.0			
Potable Water	3,820	17	34
Waste Water	2,292	13	27
Natural Gas	1,528	14	29

For electric power and potable water systems, HAZUS-MH also performs a simplified system performance analysis to determine the number of households without service. (FEMA 2003a) No households are expected to be without water or electricity no matter which earthquake scenario occurs.

8.2.2. Induced Earthquake Damage.

8.2.2.1 Debris Generation. HAZUS-MH estimates the amount of debris generated by a specific earthquake event. The model breaks the debris into two general categories: brick/wood and reinforced concrete/steel. This distinction is made due to the different equipment required to handle the materials. Specifically, the reinforced concrete/steel typically falls in large pieces that must be broken into smaller pieces before being hauled away. All other debris is smaller and more easily moved with equipment. (FEMA 2003a) Table 8.11 summarizes the amount of debris generated for each earthquake scenario analyzed within this study. The SCISZ scenario resulted in much more rubble than the other events. It is important to note that these debris estimates only include those generated from building damage, not bridges or other lifelines. Thus, these results are proportional to the amount of building damage incurred after each scenario. (FEMA 2003a)

Table 8.11. Debris Generated by the Various Earthquake Scenarios

Earthquake Scenarios	Debris Generated (tons)		
	Brick / Wood	Concrete / Steel	TOTAL
NMSZ - M7.7	5,000	1,000	**6,000**
WVSZ - M7.1	3,000	0	**3,000**
SCISZ – M6.0	30,000	36,000	**66,000**

8.2.2.2 Fires Following Earthquake. Fires that ignite following an earthquake can often cause extensive damage not normally considered during damage estimates. However, HAZUS-MH utilizes a simplified Monte Carlo simulation model to estimate the number of ignitions, the extent of damage in terms of burnt area, the number of people displaced from their residences, and the value of property damaged by the fire. (FEMA 2003a) Table 8.12 summarizes the impacts of fires following each of the earthquake scenarios. The SCISZ M6.0 earthquake yielded the most fires and subsequent damage. However, very little of the St. Charles County region was exposed to these fires. In fact, the largest area burned is 0.05 square miles, less than 0.01 percent of the total county area. Even though very little area is exposed, several people would be displaced and a large amount of property would be damaged as a result of these fires.

Table 8.12. Summary of Fires Following Each of the Earthquake Scenarios

Earthquake Scenarios	Number of Ignitions	Burnt Area (mi^2)	Population Displaced	Value of Damaged Property ($)
NMSZ - M7.7	2	0.02	60	4.36
WVSZ - M7.1	1	0.01	22	1.80
SCISZ - M6.0	4	0.05	174	13.49

There are several factors that affect the severity of the fires following an earthquake. To better forecast fires following an earthquake, extensive input with respect to the level of readiness of local fire departments and the types and availability or functionality of water systems must be supplied. (FEMA 2003a)

8.2.3. Social Impact.

8.2.3.1 Shelter Requirements. HAZUS-MH estimates the number of households that are expected to be displaced from their homes due to loss of habitability (damage, water, power, etc.) and the number of displaced people that will require temporary accommodations in public shelters. The software analyzes the demographics associated with the displaced households to quantify how many will actually seek shelter. For instance, many people that require temporary shelter are often low income or elderly. (FEMA 2003a) For the three scenarios evaluated, only the SCISZ event caused enough damage to displace households, 589 in total. However, only 123 people out of a total population of 283,883 will seek short term shelter.

8.2.3.2 Casualties. The software also estimates the number of people that will be injured or killed by the earthquake at various times during the day. Specifically, the casualty estimates are provided for three times of day: 2:00 a.m., 2:00 p.m., and 5:00 p.m. These times most accurately represent the periods of time that different sectors of the community are at their peak occupancy loads. The early morning estimate characterizes the increased residential occupancy load, the afternoon estimate considers that the educational, commercial, and industrial sector loads are maximized, and the evening estimate represents peak commuting time. (FEMA 2003a)

The casualties are divided among four severity levels, the extent of which are described as follows:

- Severity Level 1: Victim’s injuries require medical attention but hospitalization is not necessary.
- Severity Level 2: Victim’s injuries require hospitalization but are not considered life-threatening.
- Severity Level 3: Victim’s injuries require hospitalization and can become life-threatening if not promptly treated.
- Severity Level 4: Victim’s are killed.

The module is based on the assumption that there is a strong correlation between building damage, both structural and nonstructural, and the number and severity of casualties. (FEMA 2003a)

Table 8.13 provides a summary of the casualties estimated for each of the earthquake scenarios at different times of day. Consistent with the previous results, the WVSZ and the NMSZ earthquakes resulted in only a few slight injuries in which hospitalization is not even required. However, the lower magnitude, close-proximity, SCISZ event resulted in several injuries, including seven deaths. The extensive number of casualties for this scenario directly correlates with the large amount of completely damaged structures. In fact, the methodology estimates the fraction of the total floor area of each building type that is likely to collapse and possibly injure others. (FEMA 2003a) While these injuries fluctuate depending upon the time of day the earthquake occurs, the estimated deaths remain the same, possibly representing a cautious estimate provided within the software. As expected, more injuries resulted if the earthquake were to occur early in the morning because people will have little to no time to react to the situation. Also, these injuries were incurred in various locations depending upon the time of day the earthquake took place. During the early morning most injuries were sustained within residential housing. However, in the early afternoon, the majority of injuries were incurred in commercial, educational, and industrial facilities. At rush hour, injuries occur in nearly all facilities but primarily residential and commercial buildings.

Table 8.13. Casualties Summary for Each of the Earthquake Scenarios

Time of Day	Injury Severity Level				
	Level 1	Level 2	Level 3	Level 4	Total
NMSZ - M7.7					
2 a.m.	3	0	0	0	**3**
2 p.m.	2	0	0	0	**2**
5 p.m.	2	0	0	0	**2**
WVSZ - M7.1					
2 a.m.	1	0	0	0	**1**
2 p.m.	1	0	0	0	**1**
5 p.m.	1	0	0	0	**1**
SCISZ - M6.0					
2 a.m.	117	33	4	7	**161**
2 p.m.	83	26	4	7	**121**
5 p.m.	88	27	5	7	**127**

8.2.4. Economic Loss.

8.2.4.1 General Building Stock Losses. Based on previous damage state results, the total economic loss is estimated for each earthquake including building and lifeline related losses. The building related losses are broken into two general categories: direct and indirect building losses. The direct building losses include the estimated costs of repair or replacement of damage caused to the building and its contents. Conversely, the business interruption losses are those associated with limited or closed operation due to the damage sustained during the earthquake. Also, business interruption losses include the temporary living expenses for those people displaced from their homes. (FEMA 2003a)

Table 8.14 below provides a summary of the losses associated with the incurred building damage. The SCISZ scenario resulted in 196.98 million dollars in losses, more than five times as much as the NMSZ and WVSZ events combined. Nonetheless, the NMSZ resulted in 24.85 million dollars in losses which is still quite a substantial amount of money. The WVSZ only caused 9.04 million dollars in both direct and indirect building-related losses. The vast majority of losses for each scenario can be traced to capital stock losses, particularly both structural and non-structural damage as well as replacement of contents. On average, less than 10 percent of the estimated losses were related to business interruption throughout the region. Given the predominance of residential housing, the largest loss was sustained by the single family units, comprising on average 60 percent of the total loss.

Table 8.14. Building-Related Losses for St. Charles County for Each Earthquake Scenario

Earthquake Scenarios	Indirect Losses (millions of $)				Direct Losses (millions of $)				TOTAL (millions)
	Wage	Capital-Related	Rental	Relocation	Structural	Non-Structural	Content	Inventory	
NMSZ - M7.7									
Single Family	0.00	0.00	0.10	0.01	1.09	6.12	3.60	0.00	10.92
Other Res.	0.01	0.00	0.08	0.00	0.26	1.59	0.57	0.00	2.51
Commercial	0.40	0.35	0.33	0.01	0.50	3.26	2.41	0.07	7.33
Industrial	0.02	0.02	0.02	0.00	0.13	1.24	0.86	0.18	2.47
Others	0.06	0.01	0.01	0.00	0.12	0.78	0.63	0.01	1.62
TOTAL	0.49	0.38	0.54	0.02	2.10	12.99	8.07	0.26	**24.85**
WVSZ - M7.1									
Single Family	0.00	0.00	0.05	0.00	0.54	2.40	1.32	0.00	4.31
Other Res.	0.00	0.00	0.04	0.00	0.09	0.59	0.21	0.00	0.93
Commercial	0.10	0.09	0.10	0.00	0.16	1.10	0.83	0.02	2.40
Industrial	0.00	0.00	0.00	0.01	0.03	0.40	0.28	0.06	0.78
Others	0.03	0.01	0.00	0.00	0.05	0.28	0.24	0.00	0.61
TOTAL	0.13	0.10	0.19	0.01	0.87	4.77	2.88	0.08	**9.04**
SCISZ - M6.0									
Single Family	0.00	0.00	2.45	0.28	18.15	65.72	19.68	0.00	106.28
Other Res.	0.03	0.01	0.99	0.03	2.01	13.03	3.58	0.00	19.68
Commercial	2.60	2.54	1.43	0.07	4.29	18.50	10.21	0.34	39.98
Industrial	0.38	0.22	0.10	0.01	2.03	11.94	7.57	1.90	24.15
Others	0.24	0.04	0.06	0.02	0.81	3.41	2.26	0.05	6.89
TOTAL	3.25	2.81	5.03	0.41	27.29	112.60	43.30	2.29	**196.98**

8.2.4.2 Lifeline Losses. For both transportation and utility lifeline systems, HAZUS-MH computes the direct repair cost for each component. As previously discussed, several transportation system components such as roadway segments, railroad tracks, and airport runways, are assumed to be damaged by ground failure only. If ground failure maps are not provided as is the case with this study, damage estimates to these components will not be computed. Therefore, no damages, and subsequently direct economic losses, were returned for any of these transportation system components across any of the earthquake scenarios evaluated. It is reasonable to assume that these estimates would be larger if all components were considered.

By far, the SCISZ earthquake event resulted in the largest economic losses associated with the region's transportation system, totaling 8.9 million dollars (Table 8.15). Both the NMSZ and the WVSZ events produced similar losses with approximately 2.04 and 1.06 million dollars respectively. Over half of the estimated losses are linked with the airports within the region, with the remainder due to the various transportation facilities.

The same methodology was employed to estimate the direct economic losses for the utility system within St. Charles County (Table 8.15). Specifically, these results estimate the cost of either repairing or replacing system components. Yet again, the SCISZ magnitude 6.0 earthquake event produced the largest amount of losses, totaling over 26 million dollars. The NMSZ magnitude 7.7 earthquake resulted in approximately 16.5 million dollars, which is still a substantial amount of capital. And, the WVSZ magnitude 7.1 event only resulted in nearly 2.9 million dollars in necessary repairs/replacements. For each scenario, the vast majority of losses are attributed to damages to the 19 waste water facilities within the region.

Table 8.15. Direct Economic Loss for the St. Charles County Utility System Due to Earthquake

System	Component	Number / Length	Economic Loss (millions of dollars)		
			NMSZ - M7.7	WVSZ - M7.1	SCISZ - M6.0
Potable Water	Facilities	3	0.61	0.19	1.6
	Distribution Lines	3,820 km	0.06	0.04	0.36
Waste Water	Facilities	19	7.75	2.38	19.32
	Distribution Lines	2,292 km	0.05	0.03	0.29
Natural Gas	Facilities	0	0	0	0
	Distribution Lines	1528 km	0.05	0.03	0.31
Electric Power	Facilities	1	0.67	0.21	4.89
Communication	Facilities	4	0	0	0.01
		TOTAL=	**9.19**	**2.88**	**26.78**

Currently, losses for business interruption due to lifeline outages can not be accurately calculated and are therefore not considered within these results. (FEMA 2003a)

8.2.4.3 Long-Term Indirect Economic Losses. Earthquakes often produce economic losses in sectors not sustaining direct damage. Thus, HAZUS-MH considers the long-term economic impacts of the region for 15 years after the earthquake event. Specifically, the model quantifies this information in terms of post-earthquake effects on the demand and supply of products, employment, income and tax revenues. This indirect economic impact is estimated both with and without additional outside aid, such as funding and/or services from FEMA or other non-profit, relief organizations. (FEMA 2003a)

Detailed in Appendix C, the long-term indirect economic impact each scenario brought upon St. Charles County varies drastically. While the SCISZ magnitude 6.0 earthquake had a remarkable effect on the region, the NMSZ and the SCISZ events had little to no long-term impact. None of the earthquake scenarios analyzed had any effect, positive or negative, on the region's employment. The employment impact does not differ whether or not outside aid is available. However, the income impact on the region varies depending on the availability of additional funding as recovery and rebuilding efforts progress. For example, only one million dollars in resulted initially following the SCISZ magnitude 6.0 earthquake, which progressively increased to a consistent seven million dollars each year if support was offered. Yet, an influx of three million dollars initially resulted increasing to 13 million in the following years if funding was not available, because the burden lies completely on the County and its residents. This income is evenly distributed across several industries such as construction, manufacturing, transportation, trade, finance, government, and other services. Regardless of funding, the NMSZ scenario did not even return a full million dollar increase in income throughout the entire 15 year time frame following the earthquake. Similarly, the WVSZ only impacted the income of the region if outside funding is no longer available.

Often, natural disasters tend to stimulate employment and revitalize the affected region. According to these results, none of the earthquake scenarios resulted in any long-term income or employment losses for St. Charles County.

8.2.5. Summary. According to these results, the magnitude 6.0 earthquake within the SCISZ would have the greatest impact on St. Charles County. Specifically, this scenario surpassed the others in direct and induced damages, social impact, and direct and indirect economic losses.

While the NMSZ magnitude 7.7 earthquake damaged a greater number of buildings, the majority of the structures were only slightly affected. However, the SCISZ earthquake resulted in far more extensive damage to the same general building stock. In fact, nearly half of the impacted structures were damaged beyond repair, typically indicating danger of collapse. Again, all of the structures within St. Charles County are either designed to a low seismic code or are designated pre-code due to the recent adoption of a building code with seismic provisions. These pre-code structures are not considered separately in the analysis. However, the SCISZ event damaged more low-code structures than the other two scenarios. Also, each earthquake scenario produced similar results pertaining to the performance of critical facilities. That is, the critical facilities were only slightly impacted and should be able to operate with only minor inconveniences immediately following the earthquake, with functionality steadily increasing with time.

Due to the fact that ground failure maps were not provided within these analyses, no damages were computed for any surficial transportation lifeline systems such as railways, roadways, and airport runways. However, the bridge network is also vulnerable to ground shaking which caused only minor damage to approximately one percent of all bridges within St. Charles County as a direct result of the earthquake scenarios. Even still, the utility system within the region experienced significant performance failures to both the facilities (including various system components such as wells, storage tanks, pumping plants, and treatment plants) and pipelines. While each earthquake scenario analyzed returned significant damages to the region's utility system, the SCISZ earthquake had the most detrimental impact by far. Specifically, the potable water and waste water facilities were moderately damaged and the constituent pipelines suffered several leaks and over twice as many breaks.

Induced damages include the amount of debris and number of fires generated as a direct result of an earthquake. The NMSZ event produced only 6,000 tons of debris and the WVSZ event produced half of that. By comparison, the SCISZ scenario produced a total of 66,000 tons of debris, a direct correlation to the large number of completely damaged structures. The number of ignitions immediately following an earthquake is minimal no matter which scenario is considered. Even still, the SCISZ earthquake event induced the most fires and subsequently the largest area burned, population displaced, and property damaged.

The social impact on St. Charles County was extensive only when considering the magnitude 6.0 SCISZ earthquake. For the three scenarios evaluated, only the SCISZ event caused enough damage to displace households, 589 in total. However, only 123 people out of a total population of 283,883 will seek short term shelter. This estimate is a function of the region's demographic data. Also, the higher-magnitude, far-field NMSZ and WVSZ scenarios resulted in only a few slight injuries in which hospitalization is not even required. By comparison, the lower-magnitude, close-proximity SCISZ event resulted in several injuries, including seven deaths. For this scenario, the number of people affected varies from 121 to 161 depending on the time of day that the earthquake occurs, with more injuries resulting early in the morning due to limited reaction time.

The economic losses, both direct and indirect, resulting from the SCISZ scenario greatly exceeds those associated with the NMSZ and the WVSZ. Specifically, the NMSZ resulted in a total of 36.08 million dollars in losses and the WVSZ only 12.98 million dollars. However, the SCISZ scenario produced 232.55 million dollars in total losses, nearly five times greater than the damages of the other scenarios combined. These totals are comprised of building-related losses, transportation system losses, and utility system losses, as previously discussed within this section. Figure 8.4 shows the contribution of each of these components for the SCISZ scenario. As indicated within the figure, the majority of the losses are attributed to building damage. Also, only the SCISZ earthquake scenario resulted in any significant long-term economic impact throughout St. Charles County.

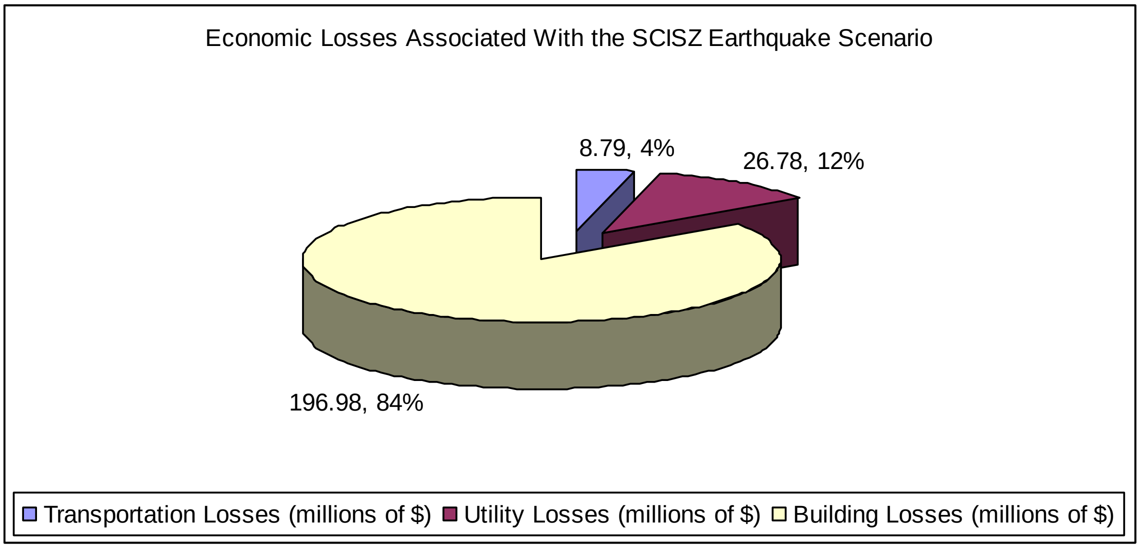


Figure 8.4. Economic Losses Associated With the SCISZ Earthquake Scenario

8.3. FLOOD ANALYSIS

8.3.1. Direct Flood Damage.

8.3.1.1 General Building Stock Damage. For the analysis of the general building stock the methodology assumes that the building inventory is evenly distributed throughout the census block. For any given census block, each occupancy class is assigned an appropriate damage function and computed water depths are used to determine the percent of damage. This percent is then multiplied by the replacement value for the occupancy class to produce a total economic loss, to be discussed in detail later. Thus, the general damage states, as defined by FEMA (2003b), are derived from the percent damage as follows:

- 1% - 10%: Damage is considered slight
- 11% - 50%: Damage is considered moderate
- 51% - 100%: Damage is considered substantial

As Table 8.16 illustrates, a total of 2,129 buildings are at risk to a 100-year flood event occurring along the Mississippi River reaches. However, over half of these buildings experienced no damage due to impending flood waters. Even still, HAZUS-MH estimates that 935 buildings will be at least moderately damaged, 253 of which are considered a total loss. While these affected structures only represent approximately eight percent of the total number of buildings within St. Charles County, it is still a testament to the wide range of influence the Mississippi River has on the region. Dissimilarly, only 52 buildings lie within the floodplain for the Missouri River 100-year flood scenario, 23 of which were at least moderately damaged and 5 damaged beyond repair.

Table 8.16. Building Damage by General Occupancy for Both Flood Scenarios

General Occupancy	Building Count by Range of Damage (%)							
	None	**1-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51-100**	**Total**
Mississippi River - 100 year								
Agriculture	0	0	0	0	0	0	0	0
Commercial	0	0	4	0	0	0	0	4
Education	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0
Residential	1,197	0	44	113	260	261	253	2,128
TOTAL	**1,197**	**0**	**48**	**113**	**260**	**261**	**253**	**2,132**
	Total Damaged Structures = 935							
Missouri River - 100 year								
Agriculture	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0
Residential	29	0	0	2	8	8	5	52
TOTAL	**29**	**0**	**0**	**2**	**8**	**8**	**5**	**52**
	Total Damaged Structures = 23							

The flood methodology also summarizes the previously discussed building damage according to building type (Table 8.17). The vast majority of affected structures are primarily wood, which are prone to long-term flood damage. Also, substantial manufactured housing and masonry structures are also affected. For the most part, steel and concrete structures are less vulnerable to water damage.

Table 8.17. Building Damage by Building Type for Both Flood Scenarios

Building Type	Building Count by Range of Damage (%)							
	None	**1-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51-100**	**Total**
Mississippi River - 100 year								
Concrete	0	0	0	0	0	0	0	0
Manufactured	211	0	0	0	0	2	76	289
Masonry	205	0	6	17	42	47	27	344
Steel	0	0	1	0	0	0	0	1
Wood	781	0	41	96	218	212	150	1,498
TOTAL	**1,197**	**0**	**48**	**113**	**260**	**261**	**253**	**2,132**
Total Damaged Structures = 935								
Missouri River - 100 year								
Concrete	0	0	0	0	0	0	0	0
Manufactured	0	0	0	0	0	0	0	0
Masonry	4	0	0	0	0	1	0	5
Steel	0	0	0	0	0	0	0	0
Wood	25	0	0	2	8	7	5	47
TOTAL	**29**	**0**	**0**	**2**	**8**	**8**	**5**	**52**
Total Damaged Structures = 23								

While it is unlikely that a building will suffer structural failure due to inundation, the structural finishes and contents may be severely damaged due to flood waters. (FEMA 2003b)

8.3.1.2 Critical Facilities Damage. The performance of essential facilities is determined on a site-specific basis. That is, the essential facility is considered a point site based on the provided latitude and longitude coordinates. Then, the depth of flooding can be resolved from the grid cell in which the facility lies, resulting in an estimate of functionality. However, damage to the actual building and its contents are approximated in the same manner as the previously discussed general building stock. (FEMA 2003b)

After analyzing the 100-year flood hazard for St. Charles County region, very few essential facilities reside within any flood boundaries. Specifically, only two of the 92 schools are potentially at risk to damage from such a flooding event occurring along the Mississippi River. The anticipated damage associated with the buildings is approximately 64,790 dollars and those associated with their contents is 384,120 dollars. Even still, these two schools are expected to be functional with a restoration time of approximately 480 days.

Similar to the earthquake methodology, damage associated with high potential loss facilities (i.e. dams, levees, hazardous waste sites, military installations, nuclear power plants, etc.) are not currently performed as part of the flood methodology. (FEMA 2003b)

8.3.1.3 Lifeline Damage. The flood model has developed damage and loss functions for the lifeline infrastructure that are most susceptible to the impact of flooding. Specifically, the selection of these components are based on their vulnerability to several different flooding hazards including inundation (a function of water elevation), scour (a function of both floodwater velocity and duration), and hydraulic loading (a function of water elevation and velocity). Most of the previously defined lifeline components are vulnerable to inundation. Bridges, foundations, and buried pipelines are especially susceptible to scour. And, bridge decks are vulnerable to hydraulic loading of flood debris. The extent and severity of damage to these few selected components are estimated directly from the depth of flooding and the appropriate damage curve. (FEMA 2003b)

When assessing the performance of the transportation system, the HAZUS-MH flood module only estimates damage to the region's bridge network. All other transportation components will be addressed in future versions of the software. (FEMA 2003b)

However, none of the 216 bridges throughout St. Charles County experienced substantial damage from either of the flood scenarios considered. This coincides with the expectation of little to no damage for bridges due to inundation, as most bridges are typically designed for 500-year floods. In fact, the software assumes a one percent probability of failure for floods with a return period of 100 years, as is the case with both scenarios. It is reasonable to assume that these damage estimates would be much more realistic if all transportation system components were considered.

When considering the impact of flooding on the St. Charles County utility system, HAZUS-MH estimates damage, losses, and functionality for all components of the potable water and waste water utility systems. (FEMA 2003b) There were no damages associated with the potable water system throughout St. Charles County for either scenario. However, the Mississippi River flood analysis affected some of the waste water facilities. Out of 19 total waste water facilities, five were damaged and two were classified as non-functional while waters remained at flood stage. The average damage throughout these facilities was 16.4 percent with a total loss of approximately 56.4 million dollars. The software only estimates losses, not damages, associated with the natural gas system; which both flood scenarios reported no such losses. Also, the flood model provides a limited analysis on selected electric power system components especially vulnerable to damage when inundated including generating plants and substations. (FEMA 2003b) Neither flood scenario resulted in any damages to these electric system components. The flood methodology has also deferred estimating damage and subsequent losses associated with the communication system to later versions of the software. (FEMA 2003b)

8.3.2. Induced Flood Damage.

8.3.2.1 Debris Generation. The flood module focuses only on building-related debris, excluding natural, flood-induced debris such as vegetation, mud, or sediment. When estimating the amount of debris that will be generated by the flood, the model considers the debris as three separate categories: finishes (dry wall, insulation, etc.), structural (wood, brick, etc.), and foundations (concrete slab, concrete block, rebar, etc.). Again, these distinctions are made due to the different types of equipment necessary to remove the debris. However, the flood analyses consider interior building materials that are often ruined by rising water levels, whereas the earthquake analyses only include construction materials. (FEMA 2003b)

Table 8.18 summarizes the debris generated by each flood scenario analyzed. The Mississippi River flood event produced much more debris than the Missouri River scenario. Building finishes comprise nearly half of all of the estimated debris. However, it is important to recognize that these debris estimates do not include those associated with building contents or lifelines. (FEMA 2003b)

Table 8.18. Debris Generated by Each Flood Scenario

Flood Scenarios	Debris Generated (tons)			
	Finishes	Structures	Foundations	TOTAL
Mississippi River - 100 year	14,068	8,502	7,085	29,655
Missouri River - 100 year	781	326	255	1,362

8.3.3. Social Impact.

8.3.3.1 Shelter Requirements. HAZUS-MH estimates the number of people displaced from their homes as well as the number of displaced people that will require temporary accommodations in public shelters. However, modifications have been made to the earthquake algorithm to reflect the obvious differences in sheltering needs between earthquakes and floods. That is, flood sheltering needs are based on the displaced population as opposed to the damage state of the structure. The model must also take into account not only those residences inundated by floodwaters but also those without entry to the property due to inaccessible roadways. When estimating the number of people requiring short term shelter, the program also accounts for various factors such as income, age, etc. (FEMA 2003b)

The Missouri River 100-year flood scenario displaced a total of 429 people with 118 seeking short term shelter. Due to the vast extent of the stream network, the Mississippi River 100-year flood scenario displaced over 8,000 residents, 5,700 of which would require temporary shelter.

8.3.3.2 Casualties. Currently, HAZUS-MH does not estimate casualties due to flooding. Data on flood-related injuries is not readily available and is often limited to fatalities. The developers are continuing to work on the creation of an appropriate casualty model in hopes of implementation within later releases. (FEMA 2003b)

8.3.4. Economic Losses.

8.3.4.1 General Building Stock Losses. The direct economic losses associated with the general building stock are estimated by multiplying the percent damage from the previous section by the replacement value for a particular general occupancy class. These losses are presented as one aggregate building loss, as opposed to separating structural and non-structural components. (FEMA 2003b)

The methodology calculates capital stock losses to account for building repair costs and associated loss of building contents and business inventory. The contents replacement value is estimated as a percentage of the structure's overall replacement value. Income losses are also projected and include losses due to relocation, business interruption, and rental income losses. These income losses are time-dependent, and therefore, require an approximation of down time. (FEMA 2003b)

Table 8.19 summarizes the direct economic losses associated with the general building stock for each flood scenario evaluated. Because the Mississippi flood resulted in much more damage than the same event along the Missouri River, it is expected that the Mississippi River analysis would return larger loss predictions. Specifically, the Mississippi River scenario resulted in over 267.5 million dollars in losses while the Missouri River only resulted in 18.1 million. For both scenarios, the vast majority of losses are due to building and content damage.

8.19. Direct Economic Losses for General Building Stock Due to Each Flood Scenario

Flood Scenarios	Indirect Losses (millions of dollars)				Capital Stock Losses (millions of dollars)			TOTAL
	Wage	Capital-Related	Rental	Relocation	Building Damage	Content Damage	Inventory Loss	
Mississippi	1.12	0.38	0.09	0.33	130.54	131.45	3.76	**267.67**
Missouri	0.09	0.02	0.00	0.01	7.96	9.66	0.44	**18.18**

The HAZUS-MH flood module also estimates the losses associated with the depreciation of damaged properties. Only capital stock losses, particularly buildings and contents, depreciate in value due to flood damage (Table 8.20). These depreciated direct economic losses associated with the general building stock are based on industry-standard depreciation methods. (FEMA 2003b)

Table 8.20. Depreciated Direct Economic Losses for General Building Stock Due to Flooding

Flood Scenarios	Capital Stock Losses (millions of dollars)		TOTAL
	Building Damage	Content Damage	
Mississippi	91.95	90.72	**182.68**
Missouri	5.53	6.34	**11.87**

8.3.4.2 Lifeline Losses. As previously discussed, the current version of HAZUS-MH has very limited approach to analyzing the impact of flooding on a study region’s lifeline system. Specifically, only highway bridges are assessed and all other transportation components will be addressed in future versions of the software. Even still, none of the 216 bridges throughout St. Charles County experienced substantial damage from either of the flood scenarios considered. Thus, neither scenario reported any direct losses associated with the transportation system.

Similarly, only a few components of the utility system were analyzed within this flood module. Particularly, the program estimates the losses associated with the potable water and waste water systems. Since there were no reported damages with the potable water system for either scenario, there were no subsequent direct economic losses. However, the Mississippi River flood analysis resulted in moderate damage to several of the waste water facilities resulting in a total loss of approximately 56.4 million dollars.

Most likely these estimates inaccurately quantify the amount of damage associated with this lifeline system. It is reasonable to assume that these loss estimates would be more realistic if all components of the infrastructure are evaluated.

8.3.4.3 Agricultural Losses. The damage functions for crops depend on when the flood occurs along with the duration of flooding. Losses are estimated based on the area of inundation versus total crop land while taking into account output, investment, and income. The model does not develop a specific duration factor; rather, it makes several loss estimates for a range of durations. (FEMA 2003b) Specifically, the loss estimations are made for flood events lasting 3, 7, or 14 days, as illustrated in Table 8.21. Given the season that these flooding events were analyzed (August 1), the primary crops that were damaged were corn, soybeans, and wheat. The Mississippi River 100 year flood event resulted in over twice as many crop losses as the same scenario for the Missouri River.

Table 8.21. Crop Losses Associated with Each Flooding Scenario

Crops	Crop Losses (millions of dollars)				
	Day 0	Day 3	Day 7	Day 14	Total
Mississippi River - 100 year					
Corn	0.00	5.14	6.85	6.85	18.85
Soybeans	0.00	4.99	6.65	6.65	18.29
Wheat	0.00	0.63	0.84	0.84	2.30
TOTAL	**0.00**	**10.76**	**14.34**	**14.34**	**39.44**
Missouri River - 100 year					
Corn	0.00	1.98	2.64	2.64	7.26
Soybeans	0.00	1.90	2.53	2.53	6.96
Wheat	0.00	1.00	1.34	1.34	3.68
TOTAL	**0.00**	**4.88**	**6.51**	**6.51**	**17.90**

Care should be exercised when utilizing this model because the agriculture industry is in a constant state of change as farmers try to anticipate the market needs of the region. Also, the value of agriculture products varies widely across the nation due to unpredictable factors such as weather, insects, and market trends. (FEMA 2003b)

8.3.4.4 Vehicle Losses. To estimate flood damage to motor vehicles, the software calculates vehicle inventory within the study region, allocates vehicles by time of day at various parking locations, estimates the value of these vehicles, and applies a percent loss damage function corresponding to a particular flood depth. The vehicle damage functions consider the step-wise nature of induced damage to motor vehicles. That is, depths less than two feet cause little to no damage, whereas anything higher often results in a total loss. While still a work in progress, this loss estimation is highly complex and represents damages not normally considered. (FEMA 2003b)

It is well known that damages to motor vehicles can be quite substantial, especially for flooding events yielding little or no warning as is the case with both of these scenarios. As previously mentioned, the software provides loss estimates for vehicles at both day and night (Table 8.22). As expected, the losses associated with night time vehicular inventory are much more than those during the day. Also, the Mississippi River scenario resulted in far more economic losses within this category than the Missouri River scenario, primarily due to damage of privately owned cars.

Table 8.22. Direct Economic Losses for Vehicles Due to the Flooding Scenarios

Time of Day	Losses for Vehicles (millions of dollars)			
	Cars	Light Trucks	Heavy Trucks	Total
Mississippi River - 100 year				
Day	5.34	1.73	1.31	8.38
Night	8.49	2.70	1.97	13.16
Missouri River - 100 year				
Day	0.21	0.07	0.06	0.34
Night	0.44	0.15	0.12	0.71

8.3.4.5 Long Term Indirect Economic Losses. Several sectors of the economy are indirectly affected by flooding events. Thus, HAZUS-MH considers the long-term economic impacts of the region for five years after the flood event. Specifically, the model quantifies this information in terms of post-flood effects on the demand and supply of products, employment, income and tax revenues. This indirect economic impact is estimated both with and without additional outside aid, such as funding and/or services from FEMA or other non-profit, relief organizations. (FEMA 2003b)

According to the HAZUS-MH results, there was no impact on employment throughout St. Charles County due to either flood scenario. That is, jobs were neither created nor destroyed as a direct result of flood damage. However, there was a substantial effect on income across the region, detailed in Tables 8.24 and 8.25. Within these tables, positive values denote an income gain, whereas negative values represent a loss. The primary industries directly affected were construction, manufacturing, trade, and services. Most likely, other industries are affected but are not able to be quantified due to previously discussed limitations of the current software, such as losses connected with the transportation system.

Table 8.23 summarizes the income impact on St. Charles County if outside aid is available. Both scenarios totaled the same overall economic impact of a 2,000 dollars County expenditure over a five year time frame. However, the Missouri River 100-year flood did not cause enough damage to greatly impact the area's economy. On the other hand, the same scenario along the Mississippi River reaches caused long-term income effects for various industries. Immediately following the flood, St. Charles County experienced a surge of income due to impending construction projects, which diminished within the next few years. After the first two years following the Mississippi flood event, the region experiences a consistent negative impact on income across several industries.

Table 8.23. Indirect Income Impact on St. Charles County For Both Flood Scenarios (With Aid)

Industries	Indirect Economic Impact With Outside Aid ($)					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	TOTAL
Mississippi River - 100 year						
Agriculture	0	0	0	0	0	**0**
Mining	0	0	0	0	0	**0**
Construction	23,000	14,000	-1,000	-1,000	-1,000	**34,000**
Manufacturing	3,000	2,000	2,000	2,000	2,000	**11,000**
Transportation	0	-1,000	-1,000	-1,000	-1,000	**-4,000**
Trade	0	-1,000	5,000	5,000	5,000	**14,000**
Finance	-1,000	-3,000	-3,000	-3,000	-3,000	**-13,000**
Services	-2,000	-5,000	-7,000	-7,000	-7,000	**-28,000**
Government	-1,000	-2,000	-3,000	-3,000	-3,000	**-12,000**
Miscellaneous	0	0	0	0	0	**0**
TOTAL	**22,000**	**4,000**	**-8,000**	**-8,000**	**-8,000**	**2,000**
Missouri River - 100 year						
Agriculture	0	0	0	0	0	**0**
Mining	0	0	0	0	0	**0**
Construction	1,000	1,000	0	0	0	**2,000**
Manufacturing	0	0	0	0	0	**0**
Transportation	0	0	0	0	0	**0**
Trade	0	0	0	0	0	**0**
Finance	0	0	0	0	0	**0**
Services	0	0	0	0	0	**0**
Government	0	0	0	0	0	**0**
Miscellaneous	0	0	0	0	0	**0**
TOTAL	**1,000**	**1,000**	**0**	**0**	**0**	**2,000**

Note Positive values indicate economic gain and negative values indicate economic loss

The previous table summarized the indirect economic impact to the region if outside aid was available. As expected, if this funding is not available for whatever reason, the burden would lie solely on St. Charles County, resulting in a much more substantial impact. Specifically, the Mississippi River 100-year flood resulted in 691,000 dollars in income impact, with the vast majority being attributed to construction occurring within the first two years following the flood. Also, this scenario reported a negative impact on services provided throughout St. Charles County, no matter how minute. The Missouri River flooding scenario resulted in far less indirect income impact, totaling only 41,000 dollars. Still, the trends remain the same with the majority of the total resulting from necessary construction projects immediately following the recession of floodwaters.

Table 8.24. Indirect Income Impact to St. Charles County For Both Flood Scenarios (Without Aid)

Industries	Indirect Economic Impact Without Outside Aid ($)					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	TOTAL
Mississippi River - 100 year						
Agriculture	0	0	0	0	0	**0**
Mining	0	0	0	0	0	**0**
Construction	358,000	160,000	0	0	0	**518,000**
Manufacturing	69,000	34,000	4,000	4,000	4,000	**115,000**
Transportation	0	0	0	0	0	**0**
Trade	22,000	10,000	9,000	9,000	9,000	**59,000**
Finance	0	0	0	0	0	**0**
Services	-1,000	0	0	0	0	**-1,000**
Government	0	0	0	0	0	**0**
Miscellaneous	0	0	0	0	0	**0**
TOTAL	**448,000**	**204,000**	**13,000**	**13,000**	**13,000**	**691,000**
Missouri River - 100 year						
Agriculture	0	0	0	0	0	**0**
Mining	0	0	0	0	0	**0**
Construction	21,000	9,000	0	0	0	**30,000**
Manufacturing	4,000	2,000	0	0	0	**6,000**
Transportation	0	0	0	0	0	**0**
Trade	1,000	1,000	1,000	1,000	1,000	**5,000**
Finance	0	0	0	0	0	**0**
Services	0	0	0	0	0	**0**
Government	0	0	0	0	0	**0**
Miscellaneous	0	0	0	0	0	**0**
TOTAL	**26,000**	**12,000**	**1,000**	**1,000**	**1,000**	**41,000**

Note Positive values indicate economic gain and negative values indicate economic loss

8.3.5. Summary. As indicated by this output, the 100-year flood occurring along the Mississippi River would be more detrimental to St. Charles County than the same flood event for the Missouri River. In particular, the Mississippi River scenario had a greater impact concerning direct and induced damages, social impact, and direct and indirect losses.

Given the greater extent of the Mississippi River's floodplain, there are many more structures at risk to such a flooding event. In fact, 2,132 buildings reside within the 100-year floodplain, 935 of which were damaged to some extent as a direct result of this flood event. Furthermore, 253 structures were damaged beyond repair. By comparison, the Missouri River only has the potential to affect 52 structures with a 100-year flooding event, approximately half of which will actually be damaged to varying degrees. For both scenarios, very few essential facilities reside within any flood boundaries. In fact, only the Mississippi River scenario resulted in damages to such facilities. Specifically, just two schools are anticipated to incur damages totaling 448,910 dollars for building restoration and content replacement.

As previously discussed, HAZUS-MH is still very limited in its attempts to approximate damages to a region's lifeline system. When assessing the performance of the transportation system, the flood module only estimates damages associated with the bridge network, leaving all other transportation components unaccounted for until future versions are developed. Nonetheless, neither scenario returned any damages to the St. Charles County bridge inventory. However, it is reasonable to assume that these damage estimates would be much more realistic if all transportation system components were considered. HAZUS-MH does estimate damages, losses, and functionality for all components of the potable water and waste water facilities; however, these flood scenarios analyzed produced little to no damages to these systems. Specifically, the Mississippi River flood affected five of the 19 waste water facilities with two being classified as non-functional while waters remain at flood stage. The average damage of these facilities was 16.4 percent with a total loss of approximately 56.4 million dollars.

The flood module focuses only on building-related debris, excluding flood-induced debris such as vegetation, mud, or sediment. Thus, the Mississippi River flood scenario produced far more debris due to the fact that more buildings were affected within this floodplain. Specifically, this 100-year flood event resulted in 29,655 tons of debris whereas the same flood event along the Missouri River resulted in only 1,362 tons.

Due to the vast extent of the floodplain, the Mississippi River 100-year flood event had a much greater social impact on St. Charles County than the Missouri River 100-year flood event.

Specifically, the Missouri River flood scenario displaced a total of 429 people with 118 seeking short term shelter and the Mississippi River flood scenario displaced over 8,000 residents, 5,700 of which would require temporary shelter. Again, the estimate of people requiring short term shelter is based on various demographic factors such as income, age, etc. It is important to note that HAZUS-MH does not currently estimate casualties due to flooding.

The economic losses, both direct and indirect, resulting from the Mississippi River 100-year flood scenario greatly exceeds those associated with the same flood event occurring along the Missouri River. Specifically, the Missouri River flooding event resulted in a total of 48.66 million dollars in losses and the Mississippi River flood produced 559.35 million dollars in losses, nearly 11.5 times greater. These totals are comprised of building (including depreciation), lifeline, agricultural, and vehicle losses, as previously discussed within this section. Figure 8.5 illustrates the contribution of each of these for the Mississippi River 100-year flood event. As indicated by the figure, the majority of these losses can be attributed to building-related damages as well as the subsequent depreciation losses. Also, the Mississippi River flood scenario had a much greater long-term impact on the region, resulting in 691,000 in income impact, with the vast majority being attributed to construction occurring within the first two years following the flood. The Missouri River flooding scenario resulted in far less indirect income impact, totaling only 41,000 dollars.

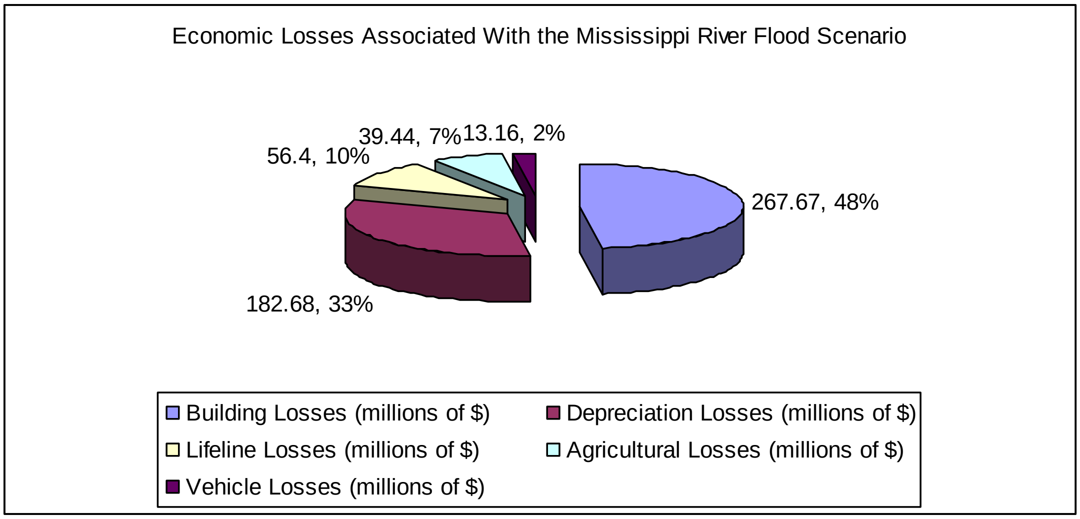


Figure 8.5. Economic Losses Associated With the Mississippi River Flood Scenario

8.4. COMPARISON OF HAZARDS

Due to the significant discrepancies in HAZUS-MH methodologies, it becomes much more difficult to make a reasonable comparison between the two very different hazards and their effects on St. Charles County. Specifically, the earthquake model was originally released in 1997 with seven subsequent releases, allowing for the advancement of the technology to more accurately estimate both direct and indirect losses. Conversely, the flood module was more recently developed in 2004 with only two newer versions and the expectation for further development to remove bugs and improve the overall capabilities of the software.

As previously established, the SCISZ magnitude 6.0 earthquake event would have the greatest impact on St. Charles County of the three scenarios analyzed. Similarly, the 100-year flood event occurring along the Mississippi River would be more detrimental to the region than the same flood event for the Missouri River. Thus, only these two prevailing scenarios will be compared within this section.

While the means of expressing building damage differs slightly between the two methodologies, the results of which can still be compared as illustrated in Table 8.25. The flood model estimates that 935 buildings will be at least moderately damaged by the Mississippi River scenario, 253 of which are considered a total loss. Lying within the confines of the Mississippi River floodplain, these affected structures only represent eight percent of the total number of buildings within St. Charles County. Even though the earthquake model considers the entire building inventory for the region, the SCISZ earthquake event still only affected 1,260 structures. However, this earthquake resulted in far more extensive damage to the same general building stock with nearly half of the impacted structures being damaged beyond repair. In fact, the SCISZ magnitude 6.0 earthquake completely destroyed over twice as many structures as the Mississippi River 100-year flood event. Once again, it is important to note that very few structures were extensively damaged for either scenario.

Table 8.25. Comparison of Building Damage Count by General Occupancy For Both Hazards

General Occupancy Classes	Number of Buildings					
	None	**Slight**	**Moderate**	**Extensive**	**Complete**	**Total**
SCISZ - M6.0						
Single Family Res.	83,779	487	33	0	464	84,763
Other Residential	7,507	156	9	0	73	7,745
Commercial	1,504	14	1	0	9	1,528
Industrial	363	3	0	0	5	371
Government	90	1	0	0	0	91
Education	65	1	0	0	0	66
Religion	145	2	0	0	1	148
Agriculture	58	1	0	0	0	59
TOTAL	**93,511**	**665**	**43**	**0**	**552**	**94,771**
Total Damaged Structures = 1,260						
Mississippi River - 100 year						
Single Family Res.	1,197	0	678	0	253	2,128
Other Residential	0	0	0	0	0	0
Commercial	0	0	4	0	0	4
Industrial	0	0	0	0	0	0
Government	0	0	0	0	0	0
Education	0	0	0	0	0	0
Religion	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0
TOTAL	**1,197**	**0**	**682**	**0**	**253**	**2,132**
Total Damaged Structures = 935						

For the SCISZ earthquake, the critical facilities were only slightly impacted and should be able to operate with only minor inconveniences immediately following the earthquake and functionality steadily increasing with time. On average, these facilities, including fire stations, hospitals, police stations, and schools, should operate at approximately 95 percent functionality. By comparison, very few essential facilities reside within any flood boundaries associated with the Mississippi River. Specifically, only two of the 92 schools are anticipated to incur any damage from a 100-year flooding event along these river reaches. These few schools are designated non-functional while waters remain at high flood stage with a restoration time of approximately 480 days.

HAZUS-MH is still very limited in its attempts to approximate damage to a region's lifeline system. When assessing the performance of the transportation system, the flood module only estimates damages associated with the bridge network, simply leaving all other transportation components unaccounted for until future versions are developed. Nonetheless, the Mississippi River 100-year flood scenario returned no damages to the St. Charles County bridge inventory. Meanwhile, the earthquake module assumes that several transportation components such as roadway segments, railroad tracts, and airport runways can only be impacted by ground failure; and therefore, ground failure maps should be included within the scenario definition. If ground failure maps are not provided as is the case with this earthquake scenario, damage estimates to these components will not be computed. However, bridges and transportation facilities are also vulnerable to ground shaking, and as such, were evaluated as part of the analysis. Even still, the SCISZ earthquake resulted in only minor damage to approximately one percent of the total bridges (216) within St. Charles County and no damage to any transportation facilities. While these damage results are very similar, it is reasonable to assume that these estimates would be much more realistic if all transportation system components were considered for both analyses.

Both hazards also returned similar results for damages associated with St. Charles County's utility system. The earthquake model analyzes the damage/performance of all utility system components susceptible to ground shaking that could ultimately result in disruption to the entire network. For the SCISZ earthquake event, the potable water and waste water facilities are only slightly to moderately damaged; however, the pipelines will suffer several leaks and more than twice as many breaks. When considering the impact of flooding on the St. Charles County utility system, the flood module estimates damages, losses, and functionality of all components of the potable water and waste water facilities. While no damages were returned for the potable water system, the Mississippi flood scenario affected five of the 19 waste water facilities with two being classified as non-functional while waters remain at high flood stage. The average damage to these facilities was 16.4 percent with a total loss of approximately 56.4 million dollars.

For the earthquake methodology, induced damages include the amount of debris and number of fires generated following such an event. The immediate aftermath of the SCISZ earthquake is rather substantial, producing 66,000 tons of debris and several fires. The flood module only estimates the debris generated as fires are not anticipated as a direct result of flooding. The Mississippi River flood scenario only resulted in approximately 29,500 tons of debris, less than half of that produced by the SCISZ earthquake. However, it is important to note that this estimate only includes building-related debris, excluding natural debris (vegetation, mud, or sediment), building contents, and lifeline debris. It is reasonable to assume that this estimate debris would be much greater if all debris was considered within the flood model.

The social impact on St. Charles County is also extensive for both hazards. This impact is quantified in terms of the number of displaced residents that will require temporary shelter and the number of people that will be injured or killed as a direct result of the natural disaster. Specifically, the Mississippi River flood scenario displaced over 8,000 residents, 5,700 of which would require short-term shelter. By comparison, the SCISZ earthquake event only displaced 589 households; however, only 123 people out of a total population of 283,883 will seek temporary shelter. Also, the SCISZ magnitude 6.0 earthquake caused several injuries, including seven deaths. For this scenario, the number of people affected varies from 121 to 161 depending on the time of day that the earthquake occurs, with more injuries resulting early in the morning due to limited reaction time. Currently, HAZUS-MH does not have the capabilities to estimate casualties due to flooding, but future versions of the software will include this application. Given these results, it is difficult to determine which hazard had a greater social impact on St. Charles County. While the Mississippi River flood would result in the overcrowding of the region's public shelters, the SCISZ earthquake would result in the congestion of local hospitals. Given the value placed on human life as opposed to material possessions, the SCISZ would be more detrimental to St. Charles County.

Once again, discrepancies between the two models complicate the comparison of economic losses, direct and indirect, resulting from both of the hazards. Specifically, the flood methodology considers additional economic losses uniquely associated with flooding such as building depreciation, agricultural losses, and vehicle losses, none of which are addressed within the earthquake methodology. These losses are quite substantial and as such should be included within the comparison although no equivalent exists for the earthquake losses. As indicated in Table 8.26, the Mississippi River 100-year flood scenario resulted in 559.35 million dollars in losses. The majority of these losses can be attributed to building-related damages as well as the subsequent depreciation losses. By comparison, the SCISZ earthquake event resulted in only 232.55 million dollars in total losses, less than half as much as those associated with the Mississippi River flood. It is important to note that even without including the losses uniquely associated with the flood methodology, the Mississippi River flood scenario still surpasses the SCISZ earthquake event with a total of 324.07 million dollars in direct and indirect losses.

Table 8.26. Comparison of Economic Losses For Both Hazards

Economic Losses (millions of dollars)	Mississippi River - 100 year	SCISZ - M6.0
Building	267.67	196.98
Depreciation	182.68	NA
Lifeline		
Transportation	0.00	8.79
Utility	56.40	26.78
Agricultural	39.44	NA
Vehicle	13.16	NA
TOTAL	**559.35**	**232.55**

When considering the long-term economic impacts on St. Charles County, HAZUS-MH calculates impacts on the region for 15 years after an earthquake but only five years following a flood. To be consistent, the forthcoming totals used for this comparison only account for the first five years following the natural disasters. This indirect economic impact is estimated both with and without additional outside aid, such as funding and/or services from FEMA or other non-profit, relief organizations. The model quantifies this long-term impact in terms of the post-disaster effects on the demand and supply of products, employment, income and tax revenues. Neither hazard had any impact, positive or negative on the region's employment. While the employment impact does not differ whether or not outside aid is available, the income impact on the region varies drastically depending on the availability of additional funding. For example, the SCISZ earthquake resulted in a total influx of 27 million dollars with outside aid and 52 million dollars without outside aid, because the burden lies completely on the County and its residents. It is important to note that these totals reflect all positive impact, indicating a surge in several industries attributed to the recovery efforts. Specifically, this income is evenly distributed across several industries such as construction, manufacturing, transportation, trade, finance, government, and other services. Dissimilarly, the Mississippi River 100-year flood scenario totaled an overall economic impact (with outside aid) of a 2,000 dollar income gain across the region for the same five year time frame. However, several industries experienced substantial losses, nearly equivalent to the gains. If outside funding is not available, this flood event still only resulted in 691,000 dollars in income impact, with the vast majority being attributed to construction occurring with the first two years following the flood. Either way, the SCISZ earthquake had a much more substantial long-term impact on St. Charles County without even taking into account the additional ten years included within the analysis.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1. CONCLUSIONS

Bounded by the Missouri River on the south and the Mississippi River on the north, St. Charles County is predominantly flat, low-lying terrain at great risk to periodic flooding. The county is also well within the area of influence for several local seismic zones, increasing the susceptibility to earthquake damage. Given the apparent risk to both flooding and earthquake, this study applied the latest HAZUS-MH edition to assess both hazards for St. Charles County. With this technology it is possible to compare the extent of damage or losses between various scenarios or between different hazards.

Of the three earthquake scenarios analyzed, the magnitude 6.0 earthquake within the SCISZ would have the greatest impact on St. Charles County. Specifically, this scenario surpassed the others in direct and induced damages, social impact, and direct and indirect economic losses. Similarly, the 100-year flood occurring along the Mississippi River would be much more detrimental to St. Charles County than the same flood event for the Missouri River, resulting in far more damages and losses.

While the SCISZ M6.0 earthquake event affected the entire region, the Mississippi River 100-year flood only impacted the portions residing within the calculated flood boundaries. Nonetheless, both hazards have the potential to greatly impact St. Charles County as indicated by the results. However, due to the significant discrepancies between the HAZUS-MH methodologies coupled with several incompatible results, it becomes much more difficult to make a reasonable comparison between these two very different hazards and their effects on St. Charles County. Even still, it was determined that the SCISZ M6.0 earthquake event resulted in slightly more damage to St. Charles County and all of its system components, creating a lasting surge across several industries. However, the Mississippi River 100-year flood scenario resulted in far more economic losses in addition to substantial damages to the same system components. Thus, the Mississippi River 100-year flood poses the greater threat to St. Charles County overall.

Finally, one should always be aware that numbers produced by software models such as HAZUS-MH are to be used with a certain degree of caution. Uncertainty within the results can be introduced from a number of sources including the use of national datasets to represent local conditions, simplifications within the model introduced to allow the model to have flexibility with inexperienced users, and errors introduced as part of the mathematical processing within the software code. This type of analysis is most appropriate as an initial loss estimation study to determine where more detailed data collection and analyses are warranted.

9.2. RECOMMENDATIONS

The nature of this study allows for constant further development. There are numerous possible scenarios, both earthquake and flood, that could be analyzed for St. Charles County. While there is historic earthquake activity and paleoliquefaction evidence supporting regional seismicity, the exact location of the next possible event is still unknown. In fact, a low probability, worst case earthquake scenario should be considered possible anywhere in the Midwest. Also, the most devastating flood witnessed within the St. Louis metropolitan area was the Great Flood of 1993, determined to have a recurrence interval of 175 years. However, it is plausible that an even greater flooding event could occur for the region.

As previously discussed, there are several levels of analysis available within HAZUS-MH. At Level 1, all data used for the analysis is provided by national data sets included within the software. This level of analysis provides limited results as the national databases tend to be lacking in both scope and detail. Results from an analysis using only default inventory can be improved with at least a minimum amount of locally developed input. This is the intended level of implementation (Level 2). Improved results are highly dependent on the quality and quantity of improved inventories. The scenarios analyzed in this thesis can be improved by the inclusion of any of the following inventory improvements, which will greatly impact the accuracy of the results:

- Development of landslide potential, surface rupture, and inundation maps
- Utilization of locally available data concerning the square footage of buildings in each occupancy class.
- Preparation of a detailed inventory for all essential facilities
- Compilation of information concerning high potential loss facilities and facilities housing hazardous materials.
- Collection of cost data to improve evaluation of losses and lack of function in various transportation and utility lifelines

Also, at Level 3, users may supply their own techniques through the third party models available to analyze special conditions. Most often, engineering and other expertise is necessary at this level. As expected, the total effort required as well as the degree of sophistication increases with the levels of analysis. For this preliminary study, advanced Level 1 analyses were performed. If so warranted, a Level 3 analysis could be completed by a qualified engineer to analyze a dam or levee break that would inherently affect St. Charles County.

At the time this study first commenced, HAZUS-MH MR2, the second maintenance release of the multi-hazard software program, was the latest version available. Since then, FEMA has released HAZUS-MH MR3, which has several improvements based on necessary upgrades as well as consumer feedback. Late in the process, this research was postponed in order to include results from this version of software. However, the multi-hazard software is a constant work in progress; and as such, will undoubtedly produce later versions of improved software. This same research should be performed utilizing any future methodology and the results of which should be compared to those within this report.

While HAZUS-MH provides individuals, businesses, and communities with the information and tools necessary to assesses potential losses due to natural hazards, few are utilizing this powerful program to aid in planning, construction practices, and disaster preparedness. Since St. Charles County has taken the first steps towards proactive planning to mitigate hazards and prevent losses resulting from disasters, the hope is that other counties within the St. Louis metropolitan area will soon follow. Future research should focus on performing appropriate HAZUS-MH analyses for these communities threatened by similar natural disasters.

APPENDIX A.

ST. CHARLES COUNTY OFFICIAL LETTER

The following letter exemplifies the cooperative relationship with St. Charles County for this multi-hazard research. Specifically, the director of the St. Charles Community Development Department offered the continual support of his staff by any means necessary for the completion of this pilot study. This working relationship should be maintained if future work is to be performed within this field of study.

St. Charles County Government

Community Development Department

Wayne Anthony, Director

April 25, 2007

Ronaldo Luna, Ph.D., P.E.
Department of Civil Architectural and Environmental Engineering
130 Butler-Carlton Hall
1870 Miner Circle
Rolla, MO 65409-0030

Dear Dr. Luna,

I have received your letter of April 18, 2007 and I have had further discussions with Jan Whipple of my staff regarding your research project and the selection of St. Charles County for the study. As I understand, Michael Gawedzinski, County GIS Manager has advised you that he would supply information as possible subject to their licensing procedures. Also, the Community Development Department will assist you in obtaining data that we may have available. Please continue to coordinate with Jan Whipple and Michael Gawenzinski regarding your needs.

I am advised that you plan to seek funding from the USGS National Earthquake Hazard Reduction Program to fund a portion of this Hazard Assessment study. I find that this study and its findings could provide important information that could be used in our disaster and land-use planning efforts. I support your funding request and look forward to seeing the results.

Please advise how we may continue to support your efforts.

Sincerely,

Wayne E. Anthony

CC: Jan Whipple
Michael Gawedzinski

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APPENDIX B.

SEISMIC HAZARD MAPS

This appendix is available in the included CD and contains all of the seismic hazard maps utilized within HAZUS-MH to characterize the ground shaking that will result from the earthquake scenarios evaluated within this study. Specifically, these hazard maps include peak ground acceleration (PGA), peak ground velocity (PGV), and spectral accelerations (SA) for relatively short (0.3 seconds) and long (1.0 seconds) periods. A set of maps is available for each earthquake scenario: a M7.7 NMSZ earthquake, a M7.1 WVSZ earthquake, and a M6.0 SCISZ earthquake.

APPENDIX C.

HAZUS-MH SCENARIO RESULTS

This appendix is available in the included CD and contains all of the results for each scenario analyzed. These results are first divided by natural hazard and then by category. Specifically, the categories include inventory for the entire County; damages associated with buildings and lifelines; direct economic losses associated with buildings, lifelines, agriculture, and vehicles; indirect economic losses associated with the long term effects the disaster imparts upon income and employment; casualties; and global reports that summarize all of the previously described results.

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VITA

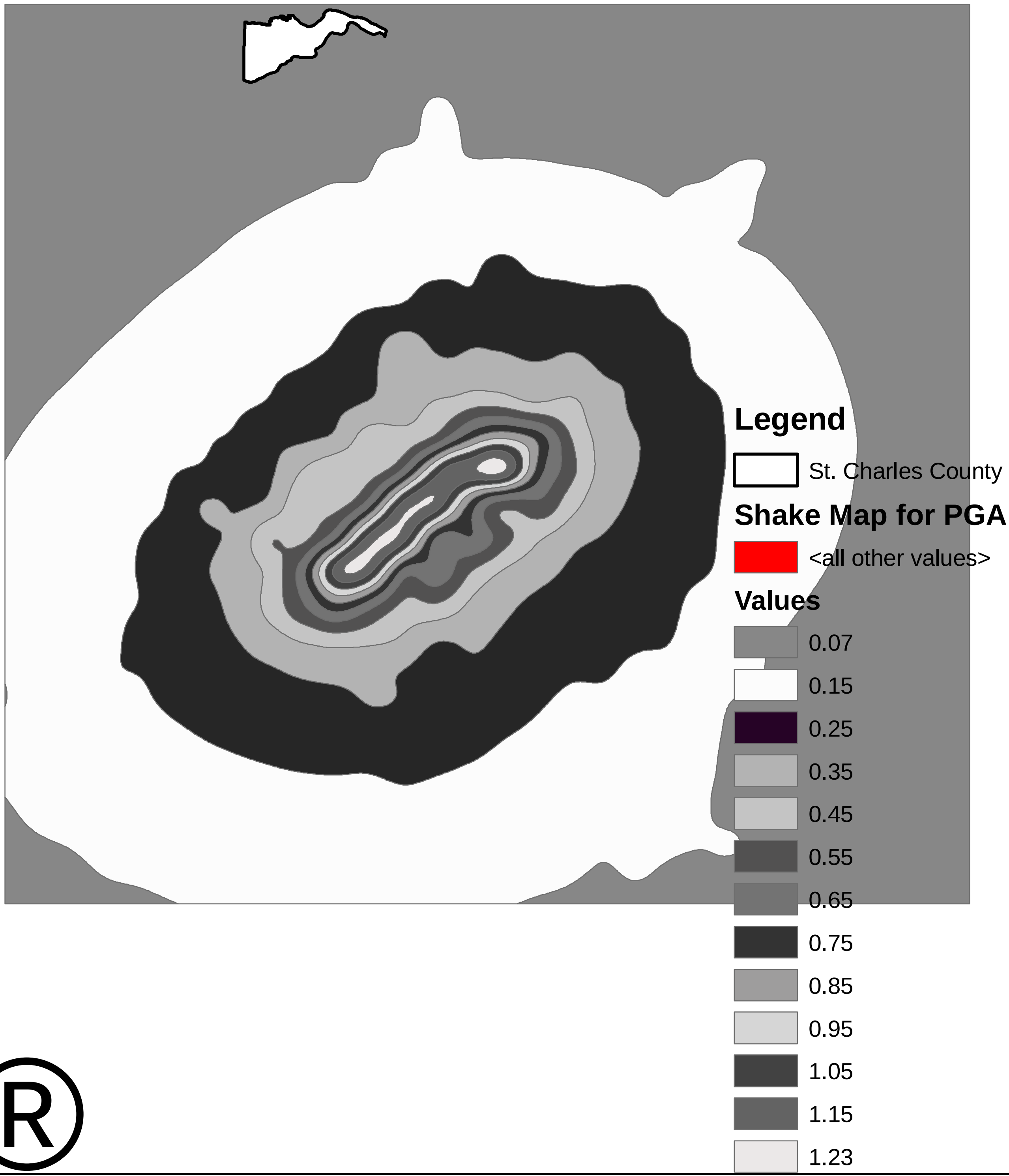
Amy L. Krauch was born on August 18, 1984 in Belleville, Illinois to parents Robert and Glenda Krauch. She attended elementary schools in the O'Fallon Public School District and graduated with honors from O'Fallon Township High School in May of 2002. The following August she entered the University of Missouri – Rolla. As summa cum laude, she received her Bachelors of Science degree in Geological Engineering in May of 2006. After being awarded the Chancellor's Fellowship, she went on to pursue her graduate degree at the same university while shifting focus to Geotechnical Engineering.

Throughout her education, Ms. Krauch has held many summer internships. Specifically, she worked for two summers with Shaw Environmental & Infrastructure, Inc. in St. Louis, Missouri and a single summer with Shannon & Wilson, Inc. in Fairbanks, Alaska. Just recently, she agreed to full-time employment with Shannon & Wilson, Inc. in the St. Louis, Missouri branch. She also holds both a teaching assistantship through the University as well as research assistantships supported by the Federal Emergency Management Agency (FEMA) and the National Science Foundation (NSF).

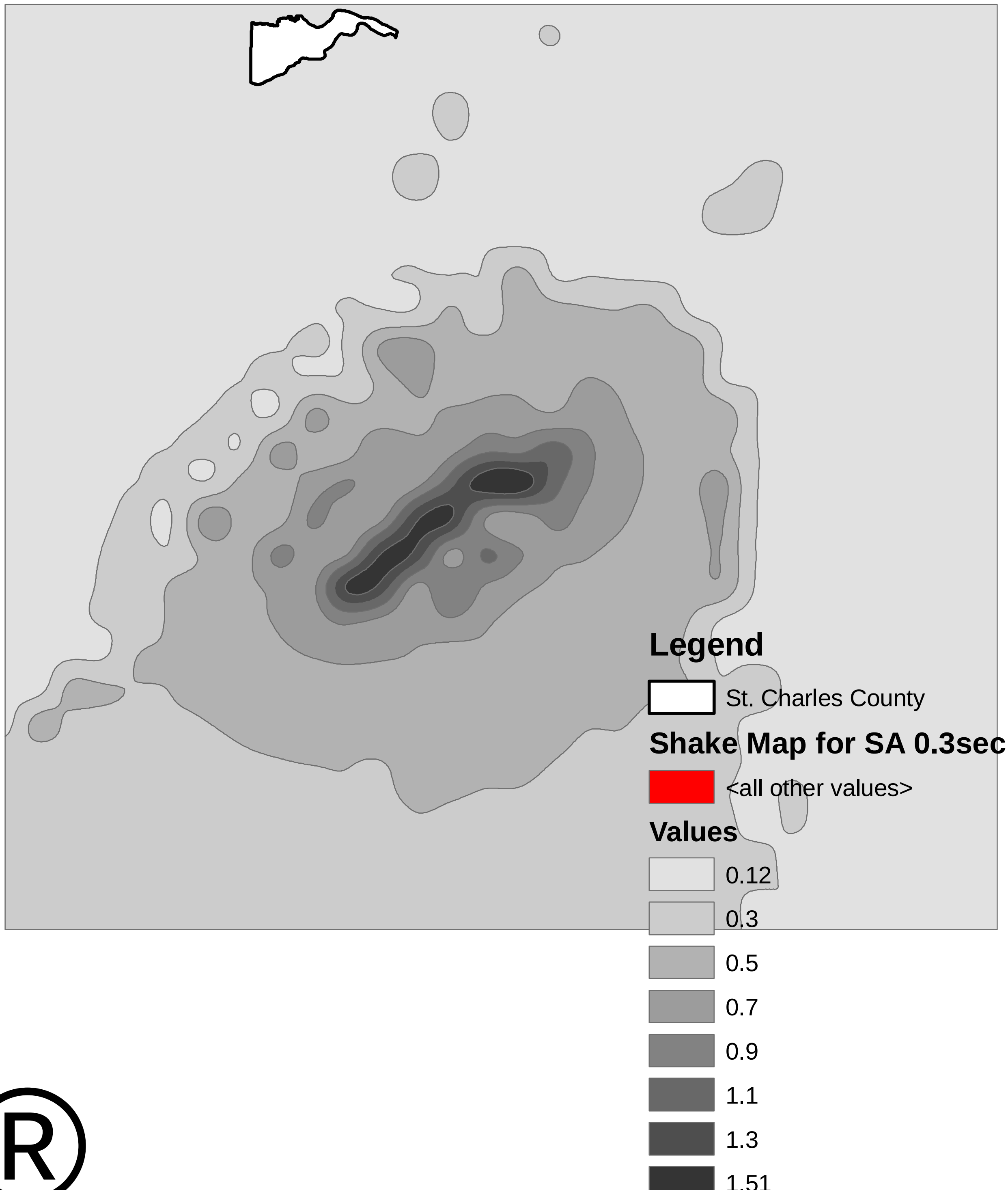
Ms. Krauch has been actively involved in several organizations on campus including, but not limited to: the UMR women's varsity soccer team, Delta Omicron Lambda, Tau Beta Pi, Sigma Gamma Epsilon, American Society of Civil Engineers, and Habitat for Humanity. She is listed as an Engineer-in-Training in the state of Missouri.

Ms. Krauch is engaged to be married in May of 2008 to Thomas W. Morris Jr., her college sweetheart.

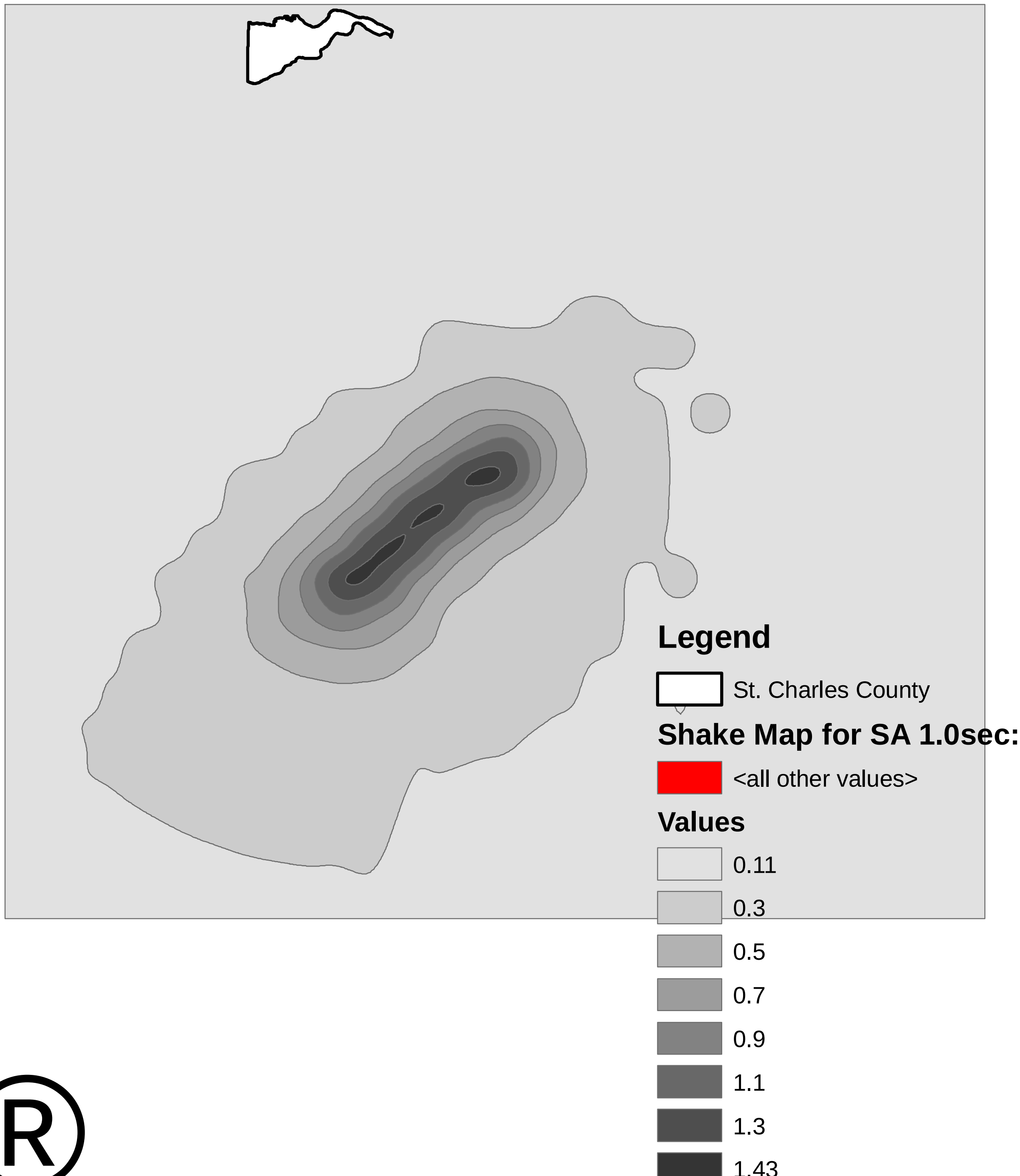
NMSZ M7.7 Earthquake
PGA Map



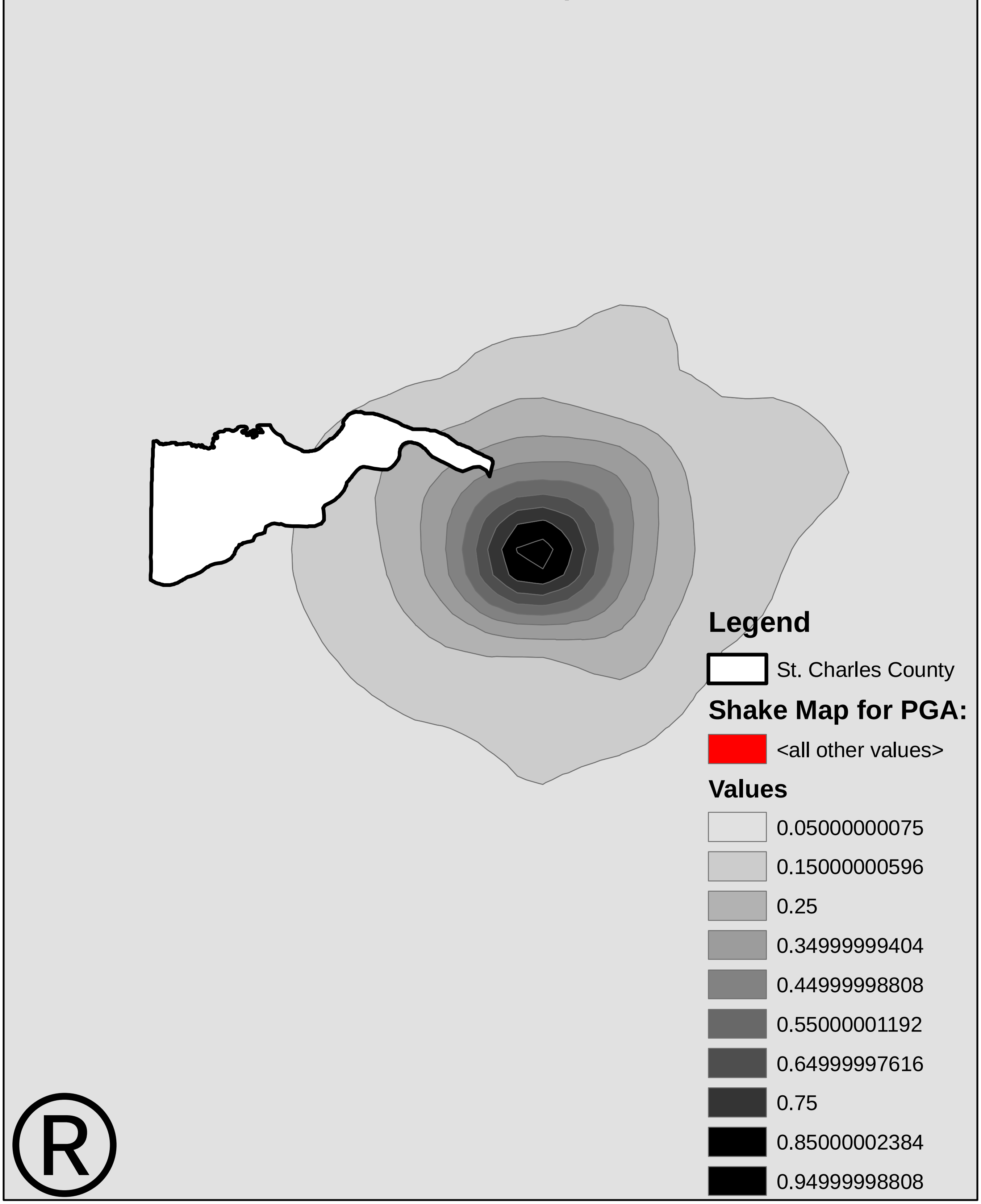
NMSZ M7.7 Earthquake
SA 0.3sec Map



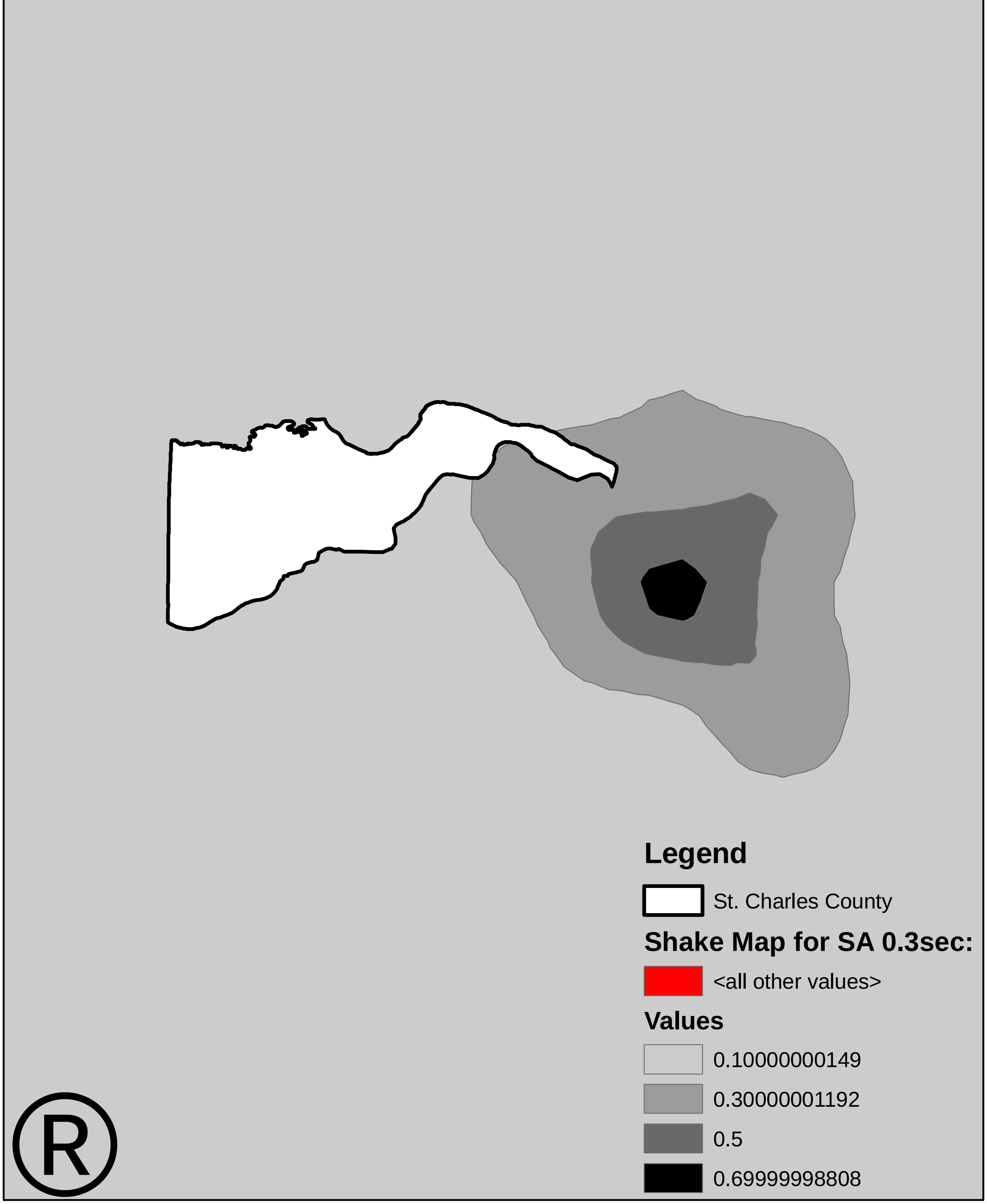
NMSZ M7.7 Earthquake
SA 1.0sec Map



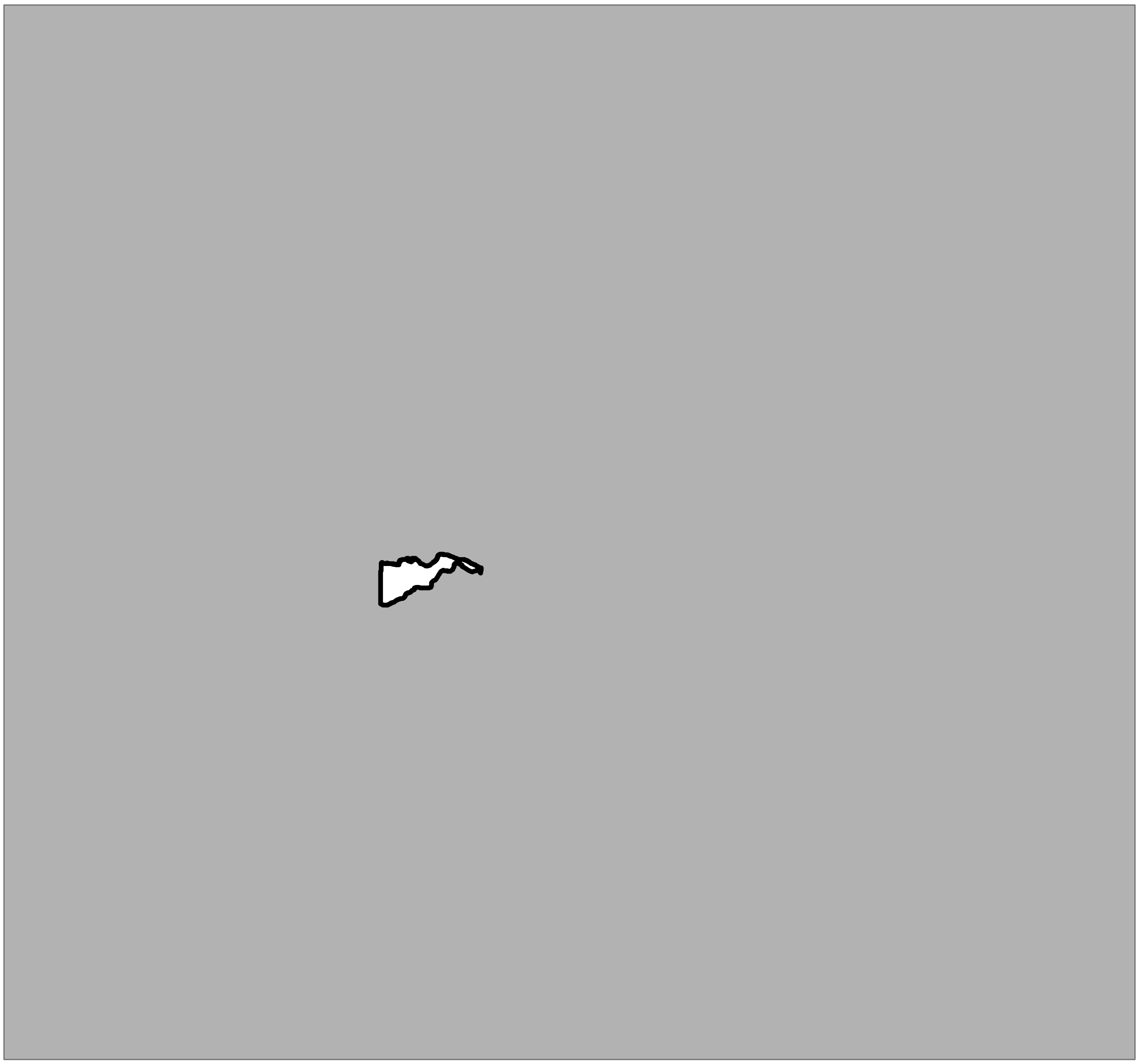
St. Louis M6.0 Earthquake
PGA Map



St. Louis M6.0 Earthquake
SA 0.3 sec Map



St. Louis M6.0 Earthquake
SA 1.0sec Map



Legend

St. Charles County

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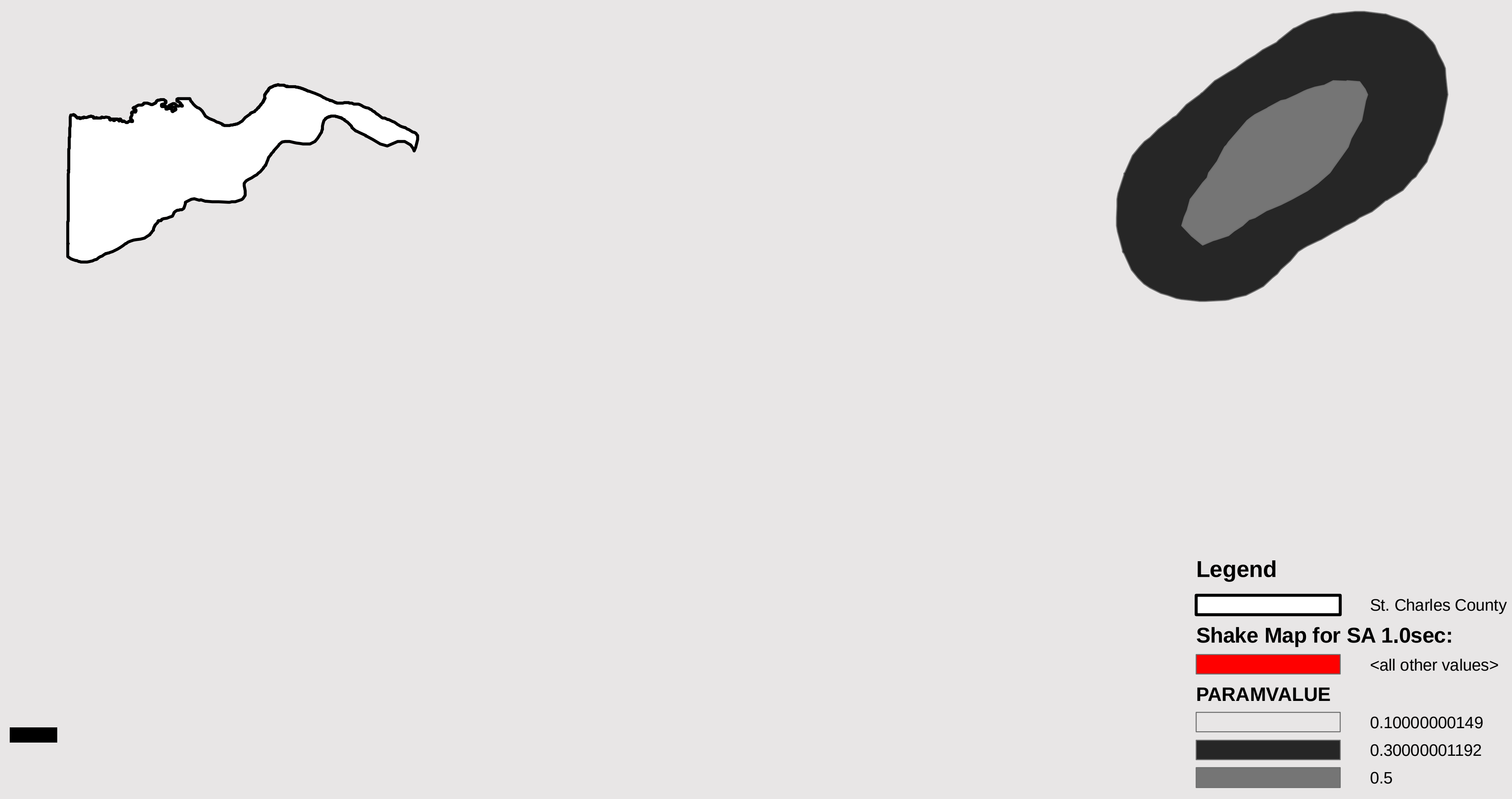
WVSZ M7.1 SA 1.0sec Map



WVSZ M7.1 Earthquake
PGA Map

Legend

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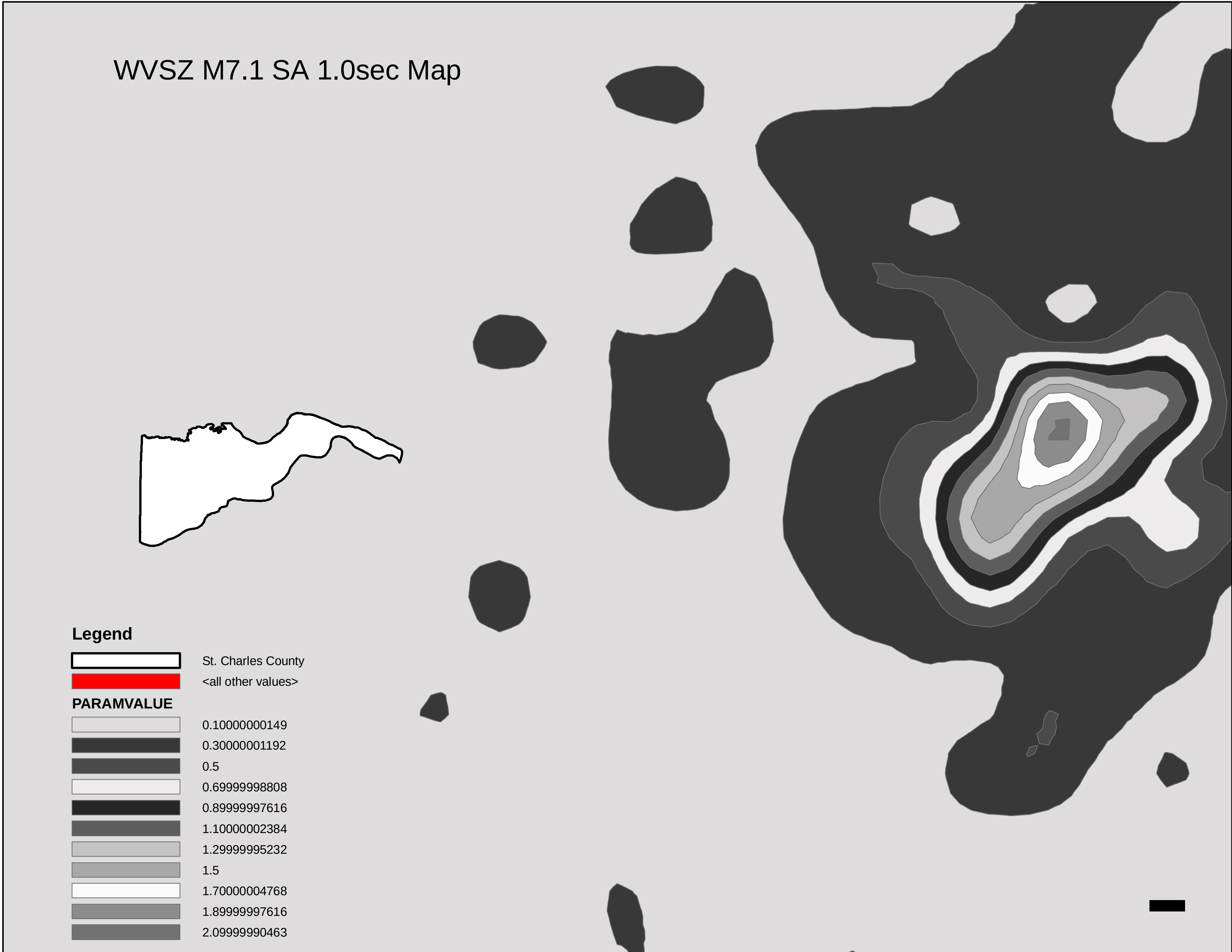
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Legend
St. Charles County
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NEW MADRID SEISMIC ZONE (NMSZ)

EARTHQUAKE HAZARD SCENARIO

Airport Runways Functionality

April 22, 2008

	# of Runways	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	11	100.00	100.00	100.00	100.00	100.00
Total	**11**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Region Total	**11**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage by Building Type for Low Design Level

April 22, 2008

	Average Damage State				
	None	**Slight**	**Moderate**	**Extensive**	**Complete**
Missouri					
Saint Charles					
Wood	1.00	0.00	0.00	0.00	0.00
Steel	1.00	0.00	0.00	0.00	0.00
Concrete	1.00	0.00	0.00	0.00	0.00
Precast	1.00	0.00	0.00	0.00	0.00
Reinforced Masonry	1.00	0.00	0.00	0.00	0.00
Unreinforced Masonry	1.00	0.00	0.00	0.00	0.00
Manufactured Home	1.00	0.00	0.00	0.00	0.00
Total	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**
Region Average	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage by Count by General Occupancy

April 22, 2008

	# of Buildings					
	None	**Slight**	**Moderate**	**Extensive**	**Complete**	**Total**
Missouri						
Saint Charles						
Government	*89*	*3*	*0*	*0*	*0*	*92*
Religion	*144*	*3*	*0*	*0*	*0*	*148*
Agriculture	*57*	*2*	*0*	*0*	*0*	*59*
Single Family	*83,771*	*916*	*74*	*1*	*0*	*84,762*
Education	*64*	*2*	*0*	*0*	*0*	*66*
Commercial	*1,486*	*38*	*5*	*0*	*0*	*1,528*
Industrial	*360*	*10*	*1*	*0*	*0*	*371*
Other Residential	*7,149*	*531*	*65*	*0*	*0*	*7,745*
Total	**93,120**	**1,504**	**145**	**1**	**0**	**94,771**
Region Total	**93,120**	**1,504**	**145**	**1**	**0**	**94,771**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage Count for Low Seismic Design Level

April 22, 2008

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
Missouri						
Saint Charles						
Wood	66,232	126	0	0	0	66,358
Steel	184	2	0	0	0	187
Concrete	58	0	0	0	0	59
Precast	59	0	0	0	0	60
Reinforced Masonry	2	0	0	0	0	2
Unreinforced Masonry	7,979	126	7	0	0	8,112
Manufactured Home	1,988	34	2	0	0	2,023
Total	**76,503**	**288**	**10**	**0**	**0**	**76,801**
Region Total	**76,503**	**288**	**10**	**0**	**0**	**76,801**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Stock Exposure By General Occupancy

April 22, 2008 *All values are in thousands of dollars*

	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Missouri								
Saint Charles	16,610,965	3,052,036	808,965	62,566	324,991	100,392	303,699	21,263,614
Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**
Region Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 2 AM

April 22, 2008

	Population	Injury Severity Level				
		Severity 1	Severity 2	Severity 3	Severity 4	total
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		0	0	0	0	0
Educational		0	0	0	0	0
Hotels		0	0	0	0	0
Industrial		0	0	0	0	0
Other-Residential		1	0	0	0	1
Single Family		2	0	0	0	2
Total Saint Charles	**283,883**	**3**	**0**	**0**	**0**	**3**
Total Missouri		**3**	**0**	**0**	**0**	**3**
Region Total		**3**	**0**	**0**	**0**	**3**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 2 PM

April 22, 2008

	Population	Severity 1 #	Severity 2 #	Severity 3 #	Severity 4 #	Total #
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		1	0	0	0	1
Educational		1	0	0	0	1
Hotels		0	0	0	0	0
Industrial		0	0	0	0	0
Other-Residential		0	0	0	0	0
Single Family		0	0	0	0	0
Total Saint Charles	283,883	**2**	**0**	**0**	**0**	**3**
Total Missouri		**2**	**0**	**0**	**0**	**3**
Region Total		**2**	**0**	**0**	**0**	**3**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 5 PM

April 22, 2008

	Population	Injury Severity Level: Severity 1	Severity 2	Severity 3	Severity 4	total
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		1	0	0	0	1
Educational		0	0	0	0	0
Hotels		0	0	0	0	0
Industrial		0	0	0	0	0
Other-Residential		0	0	0	0	0
Single Family		1	0	0	0	1
Total Saint Charles	**283,883**	**3**	**0**	**0**	**0**	**3**
Total Missouri		**3**	**0**	**0**	**0**	**3**
Region Total		**3**	**0**	**0**	**0**	**3**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report

April 22, 2008

	Injury Severity Level				
	Severity 1	**Severity 2**	**Severity 3**	**Severity 4**	**Total**
Missouri					
Saint Charles					
Casualties - 2am					
Other-Residential	1	0	0	0	1
Single Family	2	0	0	0	2
Commuting	0	0	0	0	0
Commercial	0	0	0	0	0
Hotels	0	0	0	0	0
Educational	0	0	0	0	0
Industrial	0	0	0	0	0
Total Casualties - 2am	**3**	**0**	**0**	**0**	**3**
Casualties - 2pm					
Hotels	0	0	0	0	0
Educational	1	0	0	0	1
Single Family	0	0	0	0	0
Commercial	1	0	0	0	1
Commuting	0	0	0	0	0
Other-Residential	0	0	0	0	0
Industrial	0	0	0	0	0
Total Casualties - 2pm	**2**	**0**	**0**	**0**	**3**
Casualties - 5pm					
Hotels	0	0	0	0	0
Educational	0	0	0	0	0
Industrial	0	0	0	0	0
Other-Residential	0	0	0	0	0
Commercial	1	0	0	0	1
Commuting	0	0	0	0	0
Single Family	1	0	0	0	1
Total Casualties - 5pm	**3**	**0**	**0**	**0**	**3**
Region Total	NA	NA	NA	NA	NA

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Communication Facility Functionality

April 22, 2008

	# of Facilities	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	4	99.50	99.90	99.90	99.90	99.90
Total	**4**	**99.50**	**99.90**	**99.90**	**99.90**	**99.90**
Region Total	**4**	**99.50**	**99.90**	**99.90**	**99.90**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Debris Summary Report

April 22, 2008 *All values are in thousands of tons.*

	Brick, Wood & Others	Concrete & Steel	Total
Missouri			
Saint Charles	5	1	6
Total	**5**	**1**	**6**
Region Total	**5**	**1**	**6**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Direct Economic Loss For Transportation

April 22, 2008

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Missouri								
Saint Charles								
Segments	0	0	0					0
Bridges	142	0	0					142
Tunnels	0	0	0					0
Facilities		80	0	73	282	0	1,467	1,903
Total	**142**	**80**	**0**	**73**	**282**	**0**	**1,467**	**2,044**
Total	**142**	**80**	**0**	**73**	**282**	**0**	**1,467**	**2,044**
Region Total	**142**	**80**	**0**	**73**	**282**	**0**	**1,467**	**2,044**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Direct Economic Loss For Utilities

April 22, 2008 *All values are in thousands of dollars*

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	612	7,748	0	0	674	2	9,036
Pipelines	58	46	0	49			154
Total	670	7,795	0	49	674	2	9,190
Total	**670**	**7,795**	**0**	**49**	**674**	**2**	**9,190**
Region Total	**670**	**7,795**	**0**	**49**	**674**	**2**	**9,190**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Electrical Power System Performance

April 22, 2008

	Total Households	# of households without power: At day 1 Count	At day 1 %	At day 3 Count	At day 3 %	At day 7 Count	At day 7 %	At day 30 Count	At day 30 %	At day 90 Count	At day 90 %
Missouri											
Saint Charles	101,663	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**
Region Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Fire Station Facilities Functionality

April 22, 2008

	Count	Functionality(%) At Day 1
Missouri		
Saint Charles	14	94.10
Total	**14**	**94.10**
Region Total	**14**	**94.10**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Fire Following Analysis Summary Report

April 22, 2008

	Number of Ignitions	Population Exposed	Value Exposed (thous. $)
Missouri			
Saint Charles	2	60	4,362
Total	**2**	**60**	**4,362**
Region Total	**2**	**60**	**4,362**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

HAZUS-MH: Earthquake Event Report

Region Name: St_Charles_County_NMSZ

Earthquake Scenario: NMSZ_EQ_M7.7

Print Date: April 22, 2008

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Missouri

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 591.73 square miles and contains 57 census tracts. There are over 101 thousand households in the region and has a total population of 283,883 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 94 thousand buildings in the region with a total building replacement value (excluding contents) of 21,263 (millions of dollars). Approximately 98.00 % of the buildings (and 78.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,678 and 1,519 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 94 thousand buildings in the region which have an aggregate total replacement value of 21,263 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 70% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 4 hospitals in the region with a total bed capacity of 546 beds. There are 92 schools, 14 fire stations, 15 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 97 dams identified within the region. Of these, 18 of the dams are classified as 'high hazard'. The inventory also includes 83 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 3,197.00 (millions of dollars). This inventory includes over 216 kilometers of highways, 216 bridges, 7,639 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	216	331.40
	Segments	68	855.00
	Tunnels	0	0.00
		Subtotal	**1,186.40**
Railways	Bridges	4	0.40
	Facilities	2	4.50
	Segments	32	79.60
	Tunnels	0	0.00
		Subtotal	**84.50**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	2	2.20
		Subtotal	**2.20**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	4	8.60
		Subtotal	**8.60**
Airport	Facilities	8	44.90
	Runways	11	352.10
		Subtotal	**397.00**
		Total	**1,678.80**

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	76.40
	Facilities	3	102.90
	Pipelines	0	0.00
		Subtotal	**179.30**
Waste Water	Distribution Lines	NA	45.80
	Facilities	19	1,303.40
	Pipelines	0	0.00
		Subtotal	**1,349.20**
Natural Gas	Distribution Lines	NA	30.60
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**30.60**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	1	113.30
		Subtotal	**113.30**
Communication	Facilities	4	0.40
		Subtotal	**0.40**
		Total	**1,672.80**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	NMSZ_EQ_M7.7
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	7.70
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

HAZUS estimates that about 146 buildings will be at least moderately damaged. This is over 0.00 % of the total number of buildings in the region. There are an estimated 0 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	57	0.06	2	0.11	0	0.14	0	0.22	0	0.00
Commercial	1,486	1.60	38	2.51	5	3.16	0	4.92	0	0.00
Education	64	0.07	2	0.12	0	0.12	0	0.19	0	0.00
Government	89	0.10	3	0.17	0	0.20	0	0.29	0	0.00
Industrial	360	0.39	10	0.64	1	0.91	0	1.33	0	0.00
Other Residential	7,149	7.68	531	35.32	65	44.47	0	2.65	0	0.00
Religion	144	0.15	3	0.23	0	0.25	0	0.41	0	0.00
Single Family	83,771	89.96	916	60.90	74	50.74	1	89.98	0	0.00
Total	**93,120**		**1,504**		**145**		**1**		**0**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	66,583	71.50	128	8.54	0	0.00	0	0.00	0	0.00
Steel	681	0.73	21	1.38	3	2.38	0	3.27	0	0.00
Concrete	190	0.20	2	0.14	0	0.10	0	0.00	0	0.00
Precast	188	0.20	4	0.27	1	0.54	0	0.85	0	0.00
RM	91	0.10	1	0.05	0	0.06	0	0.00	0	0.00
URM	20,629	22.15	843	56.09	79	53.99	1	95.89	0	0.00
MH	4,758	5.11	504	33.53	62	42.93	0	0.00	0	0.00
Total	**93,120**		**1,504**		**145**		**1**		**0**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 546 hospital beds available for use. On the day of the earthquake, the model estimates that only 526 hospital beds (96.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 99.00% of the beds will be back in service. By 30 days, 100.00% will be operational.

Table 6: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**At Least Moderate Damage > 50%**	**Complete Damage > 50%**	**With Functionality > 50% on day 1**
Hospitals	4	0	0	4
Schools	92	0	0	92
EOCs	0	0	0	0
PoliceStations	15	0	0	15
FireStations	14	0	0	14

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 % After Day 1	With Functionality > 50 % After Day 7
Highway	Segments	68	0	0	68	68
	Bridges	216	0	0	216	216
	Tunnels	0	0	0	0	0
Railways	Segments	32	0	0	32	32
	Bridges	4	0	0	4	4
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	2	0	0	2	2
Ferry	Facilities	0	0	0	0	0
Port	Facilities	4	0	0	4	4
Airport	Facilities	8	0	0	8	8
	Runways	11	0	0	11	11

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	3	0	0	3	3
Waste Water	19	0	0	19	19
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	1	0	0	1	1
Communication	4	0	0	4	4

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,820	13	3
Waste Water	2,292	10	3
Natural Gas	1,528	11	3
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	101,663	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 2 ignitions that will burn about 0.02 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 59 people and burn about 4 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 89.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 0 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 283,883) will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- · Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- · Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- · Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- · Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	1	0	0	0
	Single Family	2	0	0	0
	Total	**3**	**0**	**0**	**0**
2 PM	Commercial	1	0	0	0
	Commuting	0	0	0	0
	Educational	1	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	**2**	**0**	**0**	**0**
5 PM	Commercial	1	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	1	0	0	0
	Total	**3**	**0**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 36.08 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 24.85 (millions of dollars); 6 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 54 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	0.01	0.40	0.02	0.06	0.49
	Capital-Related	0.00	0.00	0.35	0.01	0.01	0.38
	Rental	0.10	0.08	0.33	0.01	0.01	0.54
	Relocation	0.01	0.00	0.01	0.00	0.00	0.02
	Subtotal	**0.11**	**0.09**	**1.09**	**0.05**	**0.09**	**1.44**
Capital Stock Loses							
	Structural	1.09	0.26	0.50	0.13	0.12	2.10
	Non_Structural	6.12	1.59	3.26	1.23	0.78	12.98
	Content	3.60	0.57	2.41	0.87	0.63	8.07
	Inventory	0.00	0.00	0.07	0.19	0.01	0.26
	Subtotal	**10.82**	**2.41**	**6.23**	**2.42**	**1.53**	**23.41**
	Total	**10.93**	**2.51**	**7.33**	**2.47**	**1.62**	**24.85**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	855.01	$0.00	0.00
	Bridges	331.41	$0.14	0.04
	Tunnels	0.00	$0.00	0.00
	Subtotal	**1186.40**	**0.10**	
Railways	Segments	79.57	$0.00	0.00
	Bridges	0.44	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	4.49	$0.08	1.79
	Subtotal	**84.50**	**0.10**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	2.25	$0.07	3.27
	Subtotal	**2.20**	**0.10**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	8.63	$0.28	3.27
	Subtotal	**8.60**	**0.30**	
Airport	Facilities	44.91	$1.47	3.27
	Runways	352.14	$0.00	0.00
	Subtotal	**397.00**	**1.50**	
	Total	**1678.80**	**2.00**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	102.90	$0.61	0.59
	Distribution Lines	76.40	$0.06	0.08
	Subtotal	**179.30**	**$0.67**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	1,303.40	$7.75	0.59
	Distribution Lines	45.80	$0.05	0.10
	Subtotal	**1,349.20**	**$7.79**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	30.60	$0.05	0.16
	Subtotal	**30.56**	**$0.05**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	113.30	$0.67	0.59
	Subtotal	**113.30**	**$0.67**	
Communication	Facilities	0.40	$0.00	0.58
	Subtotal	**0.41**	**$0.00**	
	Total	**1,672.77**	**$9.19**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	0	0.00
Second Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.01
Third Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.02
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.02
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.02
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.02

Appendix A: County Listing for the Region

Saint Charles,MO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Missouri					
	Saint Charles	283,883	16,610	4,652	21,263
Total State		**283,883**	**16,610**	**4,652**	**21,263**
Total Region		**283,883**	**16,610**	**4,652**	**21,263**

Highway Bridge Damage

April 22, 2008

		Average for Damage State				
	# of Bridges	None	Slight	Moderate	Extensive	
Missouri						
Saint Charles	216	0.99	0.01	0.00	0.00	0.00
Total	**216**	**0.99**	**0.01**	**0.00**	**0.00**	**0.00**
Region Average	**216**	**0.99**	**0.01**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Transportation Highway Bridge Functionality

April 22,2008

	# of bridges	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	216	99.50	99.70	99.80	99.80	99.90
Total	**216**	**99.50**	**99.70**	**99.80**	**99.80**	**99.90**
Region Total	**216**	**99.50**	**99.70**	**99.80**	**99.80**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Highway Road Functionality

April 22,2008

	Length (KM)	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	216	100.00	100.00	100.00	100.00	100.00
Total	**216**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Region Total	**216**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Hospital Functionality

April 22, 2008

	Total # of Beds	At Day 1		At day 3		At day 7		At day 30		At day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Missouri											
Saint Charles											
Large Hospital	276	266	96.40	266	96.50	274	99.30	276	99.90	276	99.90
Medium Hospital	270	260	96.40	261	96.50	268	99.30	270	99.90	270	99.90
Total	**546**	**526**	**96.40**	**527**	**96.50**	**542**	**99.30**	**545**	**99.90**	**545**	**99.90**
Total	**546**	**526**	**96.40**	**527**	**96.50**	**542**	**99.30**	**545**	**99.90**	**545**	**99.90**
Region Total	**546**	**526**	**96.40**	**527**	**96.50**	**542**	**99.30**	**545**	**99.90**	**545**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Income and Employment Impact
(without outside aid)

April 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Second Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Third Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Fourth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Fifth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Years 6 to 15											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Income and Employment Impact
(with outside aid)

April 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Second Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Third Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Fourth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Fifth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Years 6 to 15											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)

Totals only reflect data for those census tracts/blocks included in the user’s study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Police Station Facilities Functionality

April 22, 2008

	Count	Functionality(%) At Day 1
Missouri		
Saint Charles	15	94.10
Total	**15**	**94.10**
Region Total	**15**	**94.10**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Potable Water Pipeline Damage

April 22, 2008

	Pipeline Length (KM)	Total Number of Leaks	Total Number of Breaks
Missouri			
Saint Charles	3,820	13	3
Total	**3,820**	**13**	**3**
Region Total	**3,820**	**13**	**3**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Potable Water System Facility Damage

April 22, 2008

	# Facilities	Average for Damage State				
		None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	3	0.90	0.09	0.01	0.00	0.00
Total	**3**	**0.90**	**0.09**	**0.01**	**0.00**	**0.00**
Region Total	**3**	**0.90**	**0.09**	**0.01**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Potable Water System Performance

April 22, 2008

	Total Households	# of households without water: At day 1 Count	At day 1 %	At day 3 Count	At day 3 %	At day 7 Count	At day 7 %	At day 30 Count	At day 30 %	At day 90 Count	At day 90 %
Missouri											
Saint Charles	101,663	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**
Region Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	*Description*	*Range*
General Building Stock	Building Damage	< 0.1
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	< 0.1

Estimated Building Damage(Thousands of Buildings)

Description	*Residential*	*Commercial*	*Other*	*Total*
Minor	0 - 3	< 1.0	< 1.0	0 - 3
Major	< 1.0	< 1.0	< 1.0	< 1.0
Total	0 - 3	< 1.0	< 1.0	0 - 3

Estimated Casualties : Night Time

Severity Level	*Description*	*# Persons*
Level 1	Medical Aid	< 20
Level 2	Hospital Care	< 20
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	*Households*	*People*
Displaced Households	< 1.0	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, goetechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 7.70

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: < 1.0

Counties :
- Saint Charles,MO

Major Metro Area :

Time of report: April 22, 2008 2:03 pm

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	< 0.1
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	< 0.1

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	0 - 3	< 1.0	< 1.0	0 - 3
Major	< 1.0	< 1.0	< 1.0	< 1.0
Total	0 - 3	< 1.0	< 1.0	0 - 3

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	< 20
Level 2	Hospital Care	< 20
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	< 1.0	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
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Earthquake Information

Location :

Origin Time:

Magnitude : 7.70

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: < 1.0

Counties :
- Saint Charles,MO

Major Metro Area :

Time of report: April 22, 2008 2:03 pm

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	< 0.1
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	< 0.1

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	0 - 3	< 1.0	< 1.0	0 - 3
Major	< 1.0	< 1.0	< 1.0	< 1.0
Total	0 - 3	< 1.0	< 1.0	0 - 3

Estimated Casualties : Commute Time

Severity Level	Description	# Persons
Level 1	Medical Aid	< 20
Level 2	Hospital Care	< 20
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	< 1.0	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, goetechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 7.70

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: < 1.0

Counties :
- Saint Charles,MO

Major Metro Area :

Railroad Bridge Damage

April 22, 2008

	# Bridges	Average For Damage State: None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	4	1.00	0.00	0.00	0.00	0.00
Total	**4**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**
Region Total	**4**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Railroad Bridge Functionality

April 22, 2008

	# of Bridges	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	4	99.90	99.90	99.90	99.90	99.90
Total	**4**	**99.90**	**99.90**	**99.90**	**99.90**	**99.90**
Region Total	**4**	**99.90**	**99.90**	**99.90**	**99.90**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

School Functionality

April 22, 2008

	Count	Functionality (%)
Missouri		
Saint Charles	92	94.10
Total	**92**	**94.10**
Region Total	**92**	**94.10**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Shelter Summary Report

April 22, 2008

	# of Displaced Households	# of People Needing Short Term Shelter
Missouri		
Saint Charles	0	0
Total	**0**	**0**
Region Total	**0**	**0**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Transportation System Dollar Exposure

April 22, 2008

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Runway	Total
Missouri									
Saint Charles									
Segments	855,009	79,567	0						934,576
Bridges	331,413	445	0						331,858
Tunnels	0	0	0						0
Facilities		4,491	0	2,245	8,633	0	44,908	352,136	60,277
Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**
Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**
Region Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Utility System Dollar Exposure

April 22, 2008

All values are in thousands of dollars

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	102,897	1,303,362	0	0	113,300	412	1,519,971
Pipelines	76,400	45,840	0	30,560			152,799
Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**
Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**
Region Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Waste Water Facility Damage

April 22, 2008

	# of Facilities	Average for Damage State				
		None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	19	0.90	0.09	0.01	0.00	0.00
Total	**19**	**0.90**	**0.09**	**0.01**	**0.00**	**0.00**
Region Total	**19**	**0.90**	**0.09**	**0.01**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Waste Water Pipeline Damage

April 22, 2008

	Pipeline Length (KM)	Total Number of Leaks	Total Number of Breaks
Missouri			
Saint Charles	2,292	10	3
Total	**2,292**	**10**	**3**
Region Total	**2,292**	**10**	**3**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

SOUTH CENTRAL ILLINOIS SEISMIC ZONE (SCISZ)

EARTHQUAKE HAZARD SCENARIO

Waste Water Facility Damage

April 22, 2008

	# of Facilities	Average for Damage State: None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	19	0.82	0.14	0.04	0.00	0.00
Total	**19**	**0.82**	**0.14**	**0.04**	**0.00**	**0.00**
Region Total	**19**	**0.82**	**0.14**	**0.04**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Utility System Dollar Exposure

April 22, 2008 *All values are in thousands of dollars*

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	102,897	1,303,362	0	0	113,300	412	1,519,971
Pipelines	76,400	45,840	0	30,560			152,799
Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**
Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**
Region Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Transportation System Dollar Exposure

April 22, 2008

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Runway	Total
Missouri									
Saint Charles									
Segments	855,009	79,567	0						934,576
Bridges	331,413	445	0						331,858
Tunnels	0	0	0						0
Facilities		4,491	0	2,245	8,633	0	44,908	352,136	60,277
Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**
Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**
Region Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Shelter Summary Report

April 22, 2008

	# of Displaced Households	# of People Needing Short Term Shelter
Missouri		
Saint Charles	589	123
Total	**589**	**123**
Region Total	**589**	**123**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

School Functionality

April 22, 2008

	Count	Functionality (%)
Missouri		
Saint Charles	92	96.00
Total	**92**	**96.00**
Region Total	**92**	**96.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Railroad Bridge Functionality

April 22, 2008

	# of Bridges	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	4	99.50	99.50	99.50	99.60	99.80
Total	**4**	**99.50**	**99.50**	**99.50**	**99.60**	**99.80**
Region Total	**4**	**99.50**	**99.50**	**99.50**	**99.60**	**99.80**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Railroad Bridge Damage

April 22, 2008

	# Bridges	Average For Damage State				
		None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	4	1.00	0.00	0.00	0.00	0.00
Total	**4**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**
Region Total	**4**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	*Description*	*Range*
General Building Stock	Building Damage	0.10 - 0.30
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	0.10 - 0.40

Estimated Building Damage(Thousands of Buildings)

Description	*Residential*	*Commercial*	*Other*	*Total*
Minor	0 - 1	< 1.0	< 1.0	0 - 1
Major	0 - 1	< 1.0	< 1.0	0 - 1
Total	0 - 2	< 1.0	< 1.0	0 - 2

Estimated Casualties : Commute Time

Severity Level	*Description*	*# Persons*
Level 1	Medical Aid	40 - 180
Level 2	Hospital Care	10 - 50
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	*Households*	*People*
Displaced Households	300 - 1,200	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

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Earthquake Information

Location :

Origin Time:

Magnitude : 6.00

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: 60 - 200

Counties :
- Saint Charles,MO

Major Metro Area :

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.10 - 0.30
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	0.10 - 0.40

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	0 - 1	< 1.0	< 1.0	0 - 1
Major	0 - 1	< 1.0	< 1.0	0 - 1
Total	0 - 2	< 1.0	< 1.0	0 - 2

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	40 - 170
Level 2	Hospital Care	10 - 50
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	300 - 1,200	
Public Shelter		

Comments :

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Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 6.00

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: 60 - 200

Counties :
- Saint Charles,MO

Major Metro Area :

Time of report: April 22, 2008 12:55 pm

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.10 - 0.30
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	0.10 - 0.40

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	0 - 1	< 1.0	< 1.0	0 - 1
Major	0 - 1	< 1.0	< 1.0	0 - 1
Total	0 - 2	< 1.0	< 1.0	0 - 2

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	60 - 200
Level 2	Hospital Care	20 - 70
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	300 - 1,200	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, goetechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 6.00

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: 60 - 200

Counties :
- Saint Charles,MO

Major Metro Area :

Time of report: April 22, 2008 12:55 pm

Potable Water System Performance

April 22, 2008

	Total Households	# of households without water									
		At day 1		At day 3		At day 7		At day 30		At day 90	
		Count	%	Count	%	Count	%	Count	%	Count	%
Missouri											
Saint Charles	101,663	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**
Region Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Potable Water System Facility Damage

April 22, 2008

	# Facilities	Average for Damage State: None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	3	0.81	0.15	0.04	0.00	0.00
Total	**3**	**0.81**	**0.15**	**0.04**	**0.00**	**0.00**
Region Total	**3**	**0.81**	**0.15**	**0.04**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Potable Water Pipeline Damage

April 22, 2008

	Pipeline Length (KM)	Total Number of Leaks	Total Number of Breaks
Missouri			
Saint Charles	3,820	17	34
Total	**3,820**	**17**	**34**
Region Total	**3,820**	**17**	**34**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Police Station Facilities Functionality

April 22, 2008

	Count	Functionality(%) At Day 1
Missouri		
Saint Charles	15	96.60
Total	**15**	**96.60**
Region Total	**15**	**96.60**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Income and Employment Impact
(with outside aid)

April 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Second Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	(1)	0	(1)	0	(1)	0	0	(5)
Third Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(1)	(2)	0	(1)	0	(2)	0	0	(7)
Fourth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(1)	(2)	0	(1)	0	(2)	0	0	(7)
Fifth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(1)	(2)	0	(1)	0	(2)	0	0	(7)
Years 6 to 15											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(1)	(2)	0	(1)	0	(2)	0	0	(7)

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Study Region: St_Charles_County_SCISZ

Scenario: St_Louis_M6.0_EQ

Income and Employment Impact
(without outside aid)

April 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	(1)	0	(1)	0	(1)	0	0	(3)
Second Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(1)	(3)	(1)	(2)	(1)	(3)	(1)	0	(10)
Third Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(2)	(3)	(1)	(2)	(1)	(3)	(1)	0	(13)
Fourth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(2)	(3)	(1)	(2)	(1)	(3)	(1)	0	(13)
Fifth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(2)	(3)	(1)	(2)	(1)	(3)	(1)	0	(13)
Years 6 to 15											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	(2)	(3)	(1)	(2)	(1)	(3)	(1)	0	(13)

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Hospital Functionality

April 22, 2008

	Total # of Beds	At Day 1 # of Beds	At Day 1 %	At day 3 # of Beds	At day 3 %	At day 7 # of Beds	At day 7 %	At day 30 # of Beds	At day 30 %	At day 90 # of Beds	At day 90 %
Missouri											
Saint Charles											
Large Hospital	276	271	98.10	271	98.10	275	99.60	276	99.90	276	99.90
Medium Hospital	270	256	94.83	256	94.83	260	96.30	261	96.63	261	96.73
Total	**546**	**527**	**96.50**	**527**	**96.50**	**535**	**98.00**	**537**	**98.30**	**537**	**98.30**
Total	**546**	**527**	**96.50**	**527**	**96.50**	**535**	**98.00**	**537**	**98.30**	**537**	**98.30**
Region Total	**546**	**527**	**96.47**	**527**	**96.47**	**535**	**97.95**	**537**	**98.27**	**537**	**98.32**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Highway Road Functionality

April 22,2008

	Length (KM)	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	216	99.40	99.60	99.80	99.90	100.00
Total	**216**	**99.40**	**99.60**	**99.80**	**99.90**	**100.00**
Region Total	**216**	**99.40**	**99.60**	**99.80**	**99.90**	**100.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Transportation Highway Bridge Functionality

April 22,2008

	# of bridges	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	216	99.20	99.40	99.40	99.50	99.70
Total	**216**	**99.20**	**99.40**	**99.40**	**99.50**	**99.70**
Region Total	**216**	**99.20**	**99.40**	**99.40**	**99.50**	**99.70**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Highway Bridge Damage

April 22, 2008

	# of Bridges	Average for Damage State				
		None	Slight	Moderate	Extensive	
Missouri						
Saint Charles	216	0.99	0.01	0.00	0.00	0.00
Total	**216**	**0.99**	**0.01**	**0.00**	**0.00**	**0.00**
Region Average	**216**	**0.99**	**0.01**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

HAZUS-MH: Earthquake Event Report

Region Name: St_Charles_County_SCISZ

Earthquake Scenario: St_Louis_M6.0_EQ

Print Date: April 22, 2008

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Missouri

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 591.73 square miles and contains 57 census tracts. There are over 101 thousand households in the region and has a total population of 283,883 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 94 thousand buildings in the region with a total building replacement value (excluding contents) of 21,263 (millions of dollars). Approximately 98.00 % of the buildings (and 78.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,678 and 1,519 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 94 thousand buildings in the region which have an aggregate total replacement value of 21,263 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 70% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 4 hospitals in the region with a total bed capacity of 546 beds. There are 92 schools, 14 fire stations, 15 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 97 dams identified within the region. Of these, 18 of the dams are classified as 'high hazard'. The inventory also includes 83 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 3,197.00 (millions of dollars). This inventory includes over 216 kilometers of highways, 216 bridges, 7,639 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	216	331.40
	Segments	68	855.00
	Tunnels	0	0.00
		Subtotal	**1,186.40**
Railways	Bridges	4	0.40
	Facilities	2	4.50
	Segments	32	79.60
	Tunnels	0	0.00
		Subtotal	**84.50**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	2	2.20
		Subtotal	**2.20**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	4	8.60
		Subtotal	**8.60**
Airport	Facilities	8	44.90
	Runways	11	352.10
		Subtotal	**397.00**
		Total	**1,678.80**

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	76.40
	Facilities	3	102.90
	Pipelines	0	0.00
		Subtotal	**179.30**
Waste Water	Distribution Lines	NA	45.80
	Facilities	19	1,303.40
	Pipelines	0	0.00
		Subtotal	**1,349.20**
Natural Gas	Distribution Lines	NA	30.60
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**30.60**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	1	113.30
		Subtotal	**113.30**
Communication	Facilities	4	0.40
		Subtotal	**0.40**
		Total	**1,672.80**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	St_Louis_M6.0_EQ
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	6.00
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

HAZUS estimates that about 595 buildings will be at least moderately damaged. This is over 1.00 % of the total number of buildings in the region. There are an estimated 552 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	58	0.06	1	0.09	0	0.12	0	0.00	0	0.07
Commercial	1,504	1.61	14	2.13	1	2.44	0	0.00	9	1.55
Education	65	0.07	1	0.13	0	0.14	0	0.00	0	0.05
Government	90	0.10	1	0.15	0	0.17	0	0.00	0	0.09
Industrial	363	0.39	3	0.44	0	0.56	0	0.00	5	0.89
Other Residential	7,507	8.03	156	23.51	9	21.40	0	0.00	73	13.23
Religion	145	0.16	2	0.26	0	0.30	0	0.00	1	0.13
Single Family	83,779	89.59	487	73.30	33	74.87	0	0.00	464	83.99
Total	**93,511**		**664**		**43**		**0**		**552**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	66,303	70.90	47	7.14	0	0.00	0	0.00	361	65.42
Steel	698	0.75	2	0.26	0	0.19	0	0.00	6	1.00
Concrete	190	0.20	1	0.12	0	0.07	0	0.00	1	0.23
Precast	189	0.20	2	0.32	0	0.82	0	0.00	1	0.24
RM	91	0.10	0	0.05	0	0.09	0	0.00	0	0.08
URM	20,931	22.38	470	70.74	35	79.70	0	0.00	117	21.19
MH	5,109	5.46	142	21.36	8	19.13	0	0.00	65	11.84
Total	**93,511**		**664**		**43**		**0**		**552**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 546 hospital beds available for use. On the day of the earthquake, the model estimates that only 522 hospital beds (96.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 97.00% of the beds will be back in service. By 30 days, 97.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	4	0	0	4
Schools	92	0	0	92
EOCs	0	0	0	0
PoliceStations	15	0	0	15
FireStations	14	0	0	14

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	68	0	0	68	68
	Bridges	216	0	0	216	216
	Tunnels	0	0	0	0	0
Railways	Segments	32	0	0	32	32
	Bridges	4	0	0	4	4
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	2	0	0	2	2
Ferry	Facilities	0	0	0	0	0
Port	Facilities	4	0	0	4	4
Airport	Facilities	8	0	0	8	8
	Runways	11	0	0	11	11

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	3	0	0	3	3
Waste Water	19	0	0	19	19
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	1	0	0	1	1
Communication	4	0	0	4	4

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,820	17	34
Waste Water	2,292	13	27
Natural Gas	1,528	14	29
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	101,663	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 4 ignitions that will burn about 0.05 sq. mi 0.01 % of the region's total area.) The model also estimates that the fires will displace about 173 people and burn about 13 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 45.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 588 households to be displaced due to the earthquake. Of these, 123 people (out of a total population of 283,883) will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- · Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- · Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- · Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- · Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	1	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	1	0	0	0
	Other-Residential	19	5	0	1
	Single Family	97	28	3	6
	Total	**117**	**33**	**4**	**7**
2 PM	Commercial	39	12	2	4
	Commuting	0	0	0	0
	Educational	15	5	1	2
	Hotels	0	0	0	0
	Industrial	8	3	0	1
	Other-Residential	4	1	0	0
	Single Family	18	5	1	1
	Total	**83**	**26**	**4**	**7**
5 PM	Commercial	34	11	2	3
	Commuting	1	1	2	0
	Educational	2	1	0	0
	Hotels	0	0	0	0
	Industrial	5	2	0	1
	Other-Residential	7	2	0	0
	Single Family	39	11	1	2
	Total	**88**	**27**	**5**	**7**

Economic Loss

The total economic loss estimated for the earthquake is 232.67 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 196.98 (millions of dollars); 6 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 64 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	0.03	2.60	0.38	0.24	3.24
	Capital-Related	0.00	0.01	2.54	0.22	0.04	2.82
	Rental	2.45	0.99	1.43	0.10	0.06	5.03
	Relocation	0.28	0.03	0.07	0.00	0.02	0.41
	Subtotal	**2.73**	**1.06**	**6.64**	**0.72**	**0.35**	**11.50**
Capital Stock Loses							
	Structural	18.15	2.01	4.29	2.03	0.81	27.29
	Non_Structural	65.72	13.03	18.50	11.94	3.41	112.60
	Content	19.68	3.58	10.21	7.57	2.28	43.30
	Inventory	0.00	0.00	0.34	1.90	0.05	2.29
	Subtotal	**103.55**	**18.62**	**33.33**	**23.44**	**6.54**	**185.48**
	Total	**106.28**	**19.68**	**39.98**	**24.15**	**6.89**	**196.98**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	855.01	$4.20	0.49
	Bridges	331.41	$0.76	0.23
	Tunnels	0.00	$0.00	0.00
	Subtotal	**1186.40**	**5.00**	
Railways	Segments	79.57	$0.07	0.08
	Bridges	0.44	$0.00	0.09
	Tunnels	0.00	$0.00	0.00
	Facilities	4.49	$0.03	0.77
	Subtotal	**84.50**	**0.10**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	2.25	$0.04	1.66
	Subtotal	**2.20**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	8.63	$1.98	22.91
	Subtotal	**8.60**	**2.00**	
Airport	Facilities	44.91	$1.71	3.81
	Runways	352.14	$0.11	0.03
	Subtotal	**397.00**	**1.80**	
	Total	**1678.80**	**8.90**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	102.90	$1.60	1.56
	Distribution Lines	76.40	$0.37	0.49
	Subtotal	**179.30**	**$1.98**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	1,303.40	$19.31	1.48
	Distribution Lines	45.80	$0.29	0.64
	Subtotal	**1,349.20**	**$19.60**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	30.60	$0.31	1.03
	Subtotal	**30.56**	**$0.31**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	113.30	$4.88	4.31
	Subtotal	**113.30**	**$4.88**	
Communication	Facilities	0.40	$0.01	2.23
	Subtotal	**0.41**	**$0.01**	
	Total	**1,672.77**	**$26.78**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	(1)	-0.03
Second Year			
	Employment Impact	0	0.00
	Income Impact	(5)	-0.10
Third Year			
	Employment Impact	0	0.00
	Income Impact	(7)	-0.14
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(7)	-0.14
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(7)	-0.14
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(7)	-0.14

Appendix A: County Listing for the Region

Saint Charles,MO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Missouri					
	Saint Charles	283,883	16,610	4,652	21,263
Total State		**283,883**	**16,610**	**4,652**	**21,263**
Total Region		**283,883**	**16,610**	**4,652**	**21,263**

Fire Following Analysis Summary Report

April 22, 2008

	Number of Ignitions	Population Exposed	Value Exposed (thous. $)
Missouri			
Saint Charles	4	174	13,494
Total	**4**	**174**	**13,494**
Region Total	**4**	**174**	**13,494**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Fire Station Facilities Functionality

April 22, 2008

	Count	Functionality(%) At Day 1
Missouri		
Saint Charles	14	95.20
Total	**14**	**95.20**
Region Total	**14**	**95.20**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Electrical Power System Performance

April 22, 2008

	Total Households	# of households without power									
		At day 1		At day 3		At day 7		At day 30		At day 90	
		Count	%	Count	%	Count	%	Count	%	Count	%
Missouri											
Saint Charles	101,663	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**
Region Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Direct Economic Loss For Utilities

April 22, 2008

All values are in thousands of dollars

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	1,603	19,306	0	0	4,880	9	25,798
Pipelines	372	295	0	315			982
Total	1,975	19,601	0	315	4,880	9	26,780
Total	**1,975**	**19,601**	**0**	**315**	**4,880**	**9**	**26,780**
Region Total	**1,975**	**19,601**	**0**	**315**	**4,880**	**9**	**26,780**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Direct Economic Loss For Transportation

April 22, 2008 | *All values are in thousands of dollars*

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Missouri								
Saint Charles								
Segments	4,205	66	0					4,271
Bridges	762	0	0					763
Tunnels	0	0	0					0
Facilities		34	0	37	1,978	0	1,710	3,760
Total	**4,967**	**101**	**0**	**37**	**1,978**	**0**	**1,710**	**8,794**
Total	**4,967**	**101**	**0**	**37**	**1,978**	**0**	**1,710**	**8,794**
Region Total	**4,967**	**101**	**0**	**37**	**1,978**	**0**	**1,710**	**8,794**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Debris Summary Report

April 22, 2008

All values are in thousands of tons.

	Brick, Wood & Others	Concrete & Steel	Total
Missouri			
Saint Charles	30	36	66
Total	**30**	**36**	**66**
Region Total	**30**	**36**	**66**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Communication Facility Functionality

April 22, 2008

	# of Facilities	Functionality (%)				
		At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	4	96.50	99.40	99.60	99.90	99.90
Total	**4**	**96.50**	**99.40**	**99.60**	**99.90**	**99.90**
Region Total	**4**	**96.50**	**99.40**	**99.60**	**99.90**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Study Region : St_Charles_County_SCISZ

Scenario : St_Louis_M6.0_EQ

Casualties Summary Report

April 22, 2008

	Injury Severity Level				
	Severity 1	Severity 2	Severity 3	Severity 4	Total
Missouri					
Saint Charles					
Casualties - 2am					
Other-Residential	19	5	0	1	25
Single Family	97	28	3	6	133
Commuting	0	0	0	0	0
Commercial	1	0	0	0	1
Hotels	0	0	0	0	0
Educational	0	0	0	0	0
Industrial	1	0	0	0	2
Total Casualties - 2am	**117**	**33**	**4**	**7**	**161**
Casualties - 2pm					
Hotels	0	0	0	0	0
Educational	15	5	1	2	22
Single Family	18	5	1	1	24
Commercial	39	12	2	4	57
Commuting	0	0	0	0	0
Other-Residential	4	1	0	0	5
Industrial	8	3	0	1	12
Total Casualties - 2pm	**83**	**26**	**4**	**7**	**121**
Casualties - 5pm					
Hotels	0	0	0	0	0
Educational	2	1	0	0	2
Industrial	5	2	0	1	7
Other-Residential	7	2	0	0	10
Commercial	34	11	2	3	50
Commuting	1	1	2	0	3
Single Family	39	11	1	2	54
Total Casualties - 5pm	**88**	**27**	**5**	**7**	**127**
Region Total	NA	NA	NA	NA	NA

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 5 PM

April 22, 2008

	Population	Injury Severity Level				
		Severity 1	**Severity 2**	**Severity 3**	**Severity 4**	**total**
Missouri						
Saint Charles						
Commuting		1	1	2	0	3
Commercial		34	11	2	3	50
Educational		2	1	0	0	2
Hotels		0	0	0	0	0
Industrial		5	2	0	1	7
Other-Residential		7	2	0	0	10
Single Family		39	11	1	2	54
Total Saint Charles	**283,883**	**88**	**27**	**5**	**7**	**127**
Total Missouri		**88**	**27**	**5**	**7**	**127**
Region Total		**88**	**27**	**5**	**7**	**127**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 2 PM

April 22, 2008

	Population	Severity 1 #	Severity 2 #	Severity 3 #	Severity 4 #	Total #
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		39	12	2	4	57
Educational		15	5	1	2	22
Hotels		0	0	0	0	0
Industrial		8	3	0	1	12
Other-Residential		4	1	0	0	5
Single Family		18	5	1	1	24
Total Saint Charles	283,883	**83**	**26**	**4**	**7**	**121**
Total Missouri		**83**	**26**	**4**	**7**	**121**
Region Total		**83**	**26**	**4**	**7**	**121**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Study Region : St_Charles_County_SCISZ

Scenario : St_Louis_M6.0_EQ

Casualties Summary Report At 2 AM

April 22, 2008

	Population	Injury Severity Level				
		Severity 1	**Severity 2**	**Severity 3**	**Severity 4**	**total**
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		1	0	0	0	1
Educational		0	0	0	0	0
Hotels		0	0	0	0	0
Industrial		1	0	0	0	2
Other-Residential		19	5	0	1	25
Single Family		97	28	3	6	133
Total Saint Charles	**283,883**	**117**	**33**	**4**	**7**	**161**
Total Missouri		**117**	**33**	**4**	**7**	**161**
Region Total		**117**	**33**	**4**	**7**	**161**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Stock Exposure By General Occupancy

April 22, 2008 *All values are in thousands of dollars*

	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Missouri								
Saint Charles	16,610,965	3,052,036	808,965	62,566	324,991	100,392	303,699	21,263,614
Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**
Region Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage Count for Low Seismic Design Level

April 22, 2008

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
Missouri						
Saint Charles						
Wood	65,952	46	0	0	359	66,358
Steel	185	0	0	0	2	187
Concrete	58	0	0	0	0	59
Precast	59	0	0	0	0	60
Reinforced Masonry	2	0	0	0	0	2
Unreinforced Masonry	8,008	58	2	0	44	8,112
Manufactured Home	1,983	15	1	0	25	2,023
Total	**76,247**	**119**	**3**	**0**	**430**	**76,801**
Region Total	**76,247**	**119**	**3**	**0**	**430**	**76,801**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage by Count by General Occupancy

April 22, 2008

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
Missouri						
Saint Charles						
Government	*90*	*1*	*0*	*0*	*0*	*92*
Religion	*145*	*2*	*0*	*0*	*1*	*148*
Agriculture	*58*	*1*	*0*	*0*	*0*	*59*
Single Family	*83,779*	*487*	*33*	*0*	*464*	*84,762*
Education	*65*	*1*	*0*	*0*	*0*	*66*
Commercial	*1,504*	*14*	*1*	*0*	*9*	*1,528*
Industrial	*363*	*3*	*0*	*0*	*5*	*371*
Other Residential	*7,507*	*156*	*9*	*0*	*73*	*7,745*
Total	**93,511**	**664**	**43**	**0**	**552**	**94,771**
Region Total	**93,511**	**664**	**43**	**0**	**552**	**94,771**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage by Building Type for Low Design Level

April 22, 2008

	Average Damage State				
	None	**Slight**	**Moderate**	**Extensive**	**Complete**
Missouri					
Saint Charles					
Wood	1.00	0.00	0.00	0.00	0.00
Steel	1.00	0.00	0.00	0.00	0.00
Concrete	1.00	0.00	0.00	0.00	0.00
Precast	1.00	0.00	0.00	0.00	0.00
Reinforced Masonry	1.00	0.00	0.00	0.00	0.00
Unreinforced Masonry	1.00	0.00	0.00	0.00	0.00
Manufactured Home	1.00	0.00	0.00	0.00	0.00
Total	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**
Region Average	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Airport Runways Functionality

April 22, 2008

	# of Runways	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	11	100.00	100.00	100.00	100.00	100.00
Total	**11**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Region Total	**11**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Waste Water Pipeline Damage

April 22, 2008

	Pipeline Length (KM)	Total Number of Leaks	Total Number of Breaks
Missouri			
Saint Charles	2,292	13	27
Total	**2,292**	**13**	**27**
Region Total	**2,292**	**13**	**27**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

WABASH VALLEY SEISMIC ZONE (WVSZ)

EARTHQUAKE HAZARD SCENARIO

Waste Water Facility Damage

April 22, 2008

	# of Facilities	Average for Damage State				
		None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	19	0.97	0.03	0.00	0.00	0.00
Total	**19**	**0.97**	**0.03**	**0.00**	**0.00**	**0.00**
Region Total	**19**	**0.97**	**0.03**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Utility System Dollar Exposure

April 22, 2008

All values are in thousands of dollars

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	102,897	1,303,362	0	0	113,300	412	1,519,971
Pipelines	76,400	45,840	0	30,560			152,799
Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**
Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**
Region Total	**179,297**	**1,349,202**	**0**	**30,560**	**113,300**	**412**	**1,672,770**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Transportation System Dollar Exposure

April 22, 2008

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Runway	Total
Missouri									
Saint Charles									
Segments	855,009	79,567	0						934,576
Bridges	331,413	445	0						331,858
Tunnels	0	0	0						0
Facilities		4,491	0	2,245	8,633	0	44,908	352,136	60,277
Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**
Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**
Region Total	**1,186,422**	**84,503**	**0**	**2,245**	**8,633**	**0**	**44,908**	**352,136**	**1,678,848**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Shelter Summary Report

April 22, 2008

	# of Displaced Households	# of People Needing Short Term Shelter
Missouri		
Saint Charles	0	0
Total	**0**	**0**
Region Total	**0**	**0**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

School Functionality

April 22, 2008

	Count	Functionality (%)
Missouri		
Saint Charles	92	96.60
Total	**92**	**96.60**
Region Total	**92**	**96.60**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Railroad Bridge Functionality

April 22, 2008

	# of Bridges	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	4	99.90	99.90	99.90	99.90	99.90
Total	**4**	**99.90**	**99.90**	**99.90**	**99.90**	**99.90**
Region Total	**4**	**99.90**	**99.90**	**99.90**	**99.90**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Railroad Bridge Damage

April 22, 2008

	# Bridges	Average For Damage State: None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	4	1.00	0.00	0.00	0.00	0.00
Total	**4**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**
Region Total	**4**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	< 0.1
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	< 0.1

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	0 - 1	< 1.0	< 1.0	0 - 1
Major	< 1.0	< 1.0	< 1.0	< 1.0
Total	0 - 1	< 1.0	< 1.0	0 - 1

Estimated Casualties : Commute Time

Severity Level	Description	# Persons
Level 1	Medical Aid	< 20
Level 2	Hospital Care	< 20
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	< 1.0	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, goetechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 7.10

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: < 1.0

Counties :
- Saint Charles,MO

Major Metro Area :

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	< 0.1
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	< 0.1

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	0 - 1	< 1.0	< 1.0	0 - 1
Major	< 1.0	< 1.0	< 1.0	< 1.0
Total	0 - 1	< 1.0	< 1.0	0 - 1

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	< 20
Level 2	Hospital Care	< 20
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	< 1.0	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, goetechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 7.10

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: < 1.0

Counties :
- Saint Charles,MO

Major Metro Area :

Time of report: April 22, 2008 3:05 pm

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	< 0.1
	Building Contents	< 0.1
	Business Interruption	< 0.1
Infrastructure	Lifelines Damage	
	Total	< 0.1

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	0 - 1	< 1.0	< 1.0	0 - 1
Major	< 1.0	< 1.0	< 1.0	< 1.0
Total	0 - 1	< 1.0	< 1.0	0 - 1

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	< 20
Level 2	Hospital Care	< 20
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	< 1.0	
Public Shelter		

Comments :

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, goetechnical, and observed ground motion data.

Earthquake Information

Location :

Origin Time:

Magnitude : 7.10

Epicenter Latitude/Longitude :
/

Depth & Type :/U

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation :

Information Sources:

Comments :

Population and Building Exposure (2002 D&B) (2000 Census)

Population: 283,883

Building Exposure : ($ Millions)

Residential	16,610
Commerical	3,052
Other	1,600
Total	21,262

State: < 1.0

Counties :
- Saint Charles,MO

Major Metro Area :

Time of report: April 22, 2008 3:04 pm

Potable Water System Performance

April 22, 2008

	Total Households	# of households without water: At day 1 Count	%	At day 3 Count	%	At day 7 Count	%	At day 30 Count	%	At day 90 Count	%
Missouri											
Saint Charles	101,663	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**
Region Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Potable Water System Facility Damage

April 22, 2008

	# Facilities	Average for Damage State				
		None	Slight	Moderate	Extensive	Complete
Missouri						
Saint Charles	3	0.97	0.03	0.00	0.00	0.00
Total	**3**	**0.97**	**0.03**	**0.00**	**0.00**	**0.00**
Region Total	**3**	**0.97**	**0.03**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Potable Water Pipeline Damage

April 22, 2008

	Pipeline Length (KM)	Total Number of Leaks	Total Number of Breaks
Missouri			
Saint Charles	3,820	9	2
Total	**3,820**	**9**	**2**
Region Total	**3,820**	**9**	**2**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Police Station Facilities Functionality

April 22, 2008

	Count	Functionality(%) At Day 1
Missouri		
Saint Charles	15	96.60
Total	**15**	**96.60**
Region Total	**15**	**96.60**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Income and Employment Impact
(with outside aid)

April 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Second Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Third Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Fourth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Fifth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Years 6 to 15											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Income and Employment Impact
(without outside aid)

April 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Second Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	0
Third Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Fourth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Fifth Year											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)
Years 6 to 15											
Employment Impact	0	0	0	0	0	0	0	0	0	0	0
Income Impact	0	0	0	0	0	0	0	0	0	0	(1)

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Hospital Functionality

April 22, 2008

	Total # of Beds	At Day 1		At day 3		At day 7		At day 30		At day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Missouri											
Saint Charles											
Large Hospital	276	271	98.10	271	98.10	275	99.60	276	99.90	276	99.90
Medium Hospital	270	265	98.10	265	98.10	269	99.60	270	99.90	270	99.90
Total	**546**	**536**	**98.10**	**536**	**98.10**	**544**	**99.60**	**545**	**99.90**	**545**	**99.90**
Total	**546**	**536**	**98.10**	**536**	**98.10**	**544**	**99.60**	**545**	**99.90**	**545**	**99.90**
Region Total	**546**	**536**	**98.10**	**536**	**98.10**	**544**	**99.60**	**545**	**99.90**	**545**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Highway Road Functionality

April 22,2008

	Length (KM)	Functionality (%)				
		At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	216	100.00	100.00	100.00	100.00	100.00
Total	**216**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Region Total	**216**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Transportation Highway Bridge Functionality

April 22,2008

	# of bridges	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	216	99.60	99.80	99.80	99.80	99.90
Total	**216**	**99.60**	**99.80**	**99.80**	**99.80**	**99.90**
Region Total	**216**	**99.60**	**99.80**	**99.80**	**99.80**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Highway Bridge Damage

April 22, 2008

		Average for Damage State				
	# of Bridges	None	Slight	Moderate	Extensive	
Missouri						
Saint Charles	216	0.99	0.01	0.00	0.00	0.00
Total	**216**	**0.99**	**0.01**	**0.00**	**0.00**	**0.00**
Region Average	**216**	**0.99**	**0.01**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

HAZUS-MH: Earthquake Event Report

Region Name: St_Charles_County_WVSZ

Earthquake Scenario: Edited_WVSZ_M7.1_EQ

Print Date: April 22, 2008

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Missouri

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 591.73 square miles and contains 57 census tracts. There are over 101 thousand households in the region and has a total population of 283,883 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 94 thousand buildings in the region with a total building replacement value (excluding contents) of 21,263 (millions of dollars). Approximately 98.00 % of the buildings (and 78.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,678 and 1,519 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 94 thousand buildings in the region which have an aggregate total replacement value of 21,263 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 70% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 4 hospitals in the region with a total bed capacity of 546 beds. There are 92 schools, 14 fire stations, 15 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 97 dams identified within the region. Of these, 18 of the dams are classified as 'high hazard'. The inventory also includes 83 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 3,197.00 (millions of dollars). This inventory includes over 216 kilometers of highways, 216 bridges, 7,639 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	216	331.40
	Segments	68	855.00
	Tunnels	0	0.00
		Subtotal	**1,186.40**
Railways	Bridges	4	0.40
	Facilities	2	4.50
	Segments	32	79.60
	Tunnels	0	0.00
		Subtotal	**84.50**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	2	2.20
		Subtotal	**2.20**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	4	8.60
		Subtotal	**8.60**
Airport	Facilities	8	44.90
	Runways	11	352.10
		Subtotal	**397.00**
		Total	**1,678.80**

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	76.40
	Facilities	3	102.90
	Pipelines	0	0.00
		Subtotal	**179.30**
Waste Water	Distribution Lines	NA	45.80
	Facilities	19	1,303.40
	Pipelines	0	0.00
		Subtotal	**1,349.20**
Natural Gas	Distribution Lines	NA	30.60
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**30.60**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	1	113.30
		Subtotal	**113.30**
Communication	Facilities	4	0.40
		Subtotal	**0.40**
		Total	**1,672.80**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	Edited_WVSZ_M7.1_EQ
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	7.10
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

HAZUS estimates that about 43 buildings will be at least moderately damaged. This is over 0.00 % of the total number of buildings in the region. There are an estimated 0 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	58	0.06	1	0.09	0	0.12	0	0.00	0	0.00
Commercial	1,513	1.61	14	2.13	1	2.43	0	0.00	0	0.00
Education	65	0.07	1	0.13	0	0.14	0	0.00	0	0.00
Government	91	0.10	1	0.15	0	0.17	0	0.00	0	0.00
Industrial	368	0.39	3	0.44	0	0.55	0	0.00	0	0.00
Other Residential	7,578	8.06	158	23.62	9	21.53	0	0.00	0	0.00
Religion	146	0.16	2	0.26	0	0.30	0	0.00	0	0.00
Single Family	84,240	89.56	489	73.19	33	74.75	0	0.00	0	0.00
Total	**94,059**		**668**		**44**		**0**		**0**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	66,664	70.87	47	7.10	0	0.00	0	0.00	0	0.00
Steel	704	0.75	2	0.26	0	0.18	0	0.00	0	0.00
Concrete	191	0.20	1	0.12	0	0.07	0	0.00	0	0.00
Precast	190	0.20	2	0.32	0	0.82	0	0.00	0	0.00
RM	91	0.10	0	0.05	0	0.09	0	0.00	0	0.00
URM	21,045	22.37	472	70.67	35	79.57	0	0.00	0	0.00
MH	5,173	5.50	144	21.47	8	19.27	0	0.00	0	0.00
Total	**94,059**		**668**		**44**		**0**		**0**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 546 hospital beds available for use. On the day of the earthquake, the model estimates that only 535 hospital beds (98.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 100.00% of the beds will be back in service. By 30 days, 100.00% will be operational.

Table 6: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**At Least Moderate Damage > 50%**	**Complete Damage > 50%**	**With Functionality > 50% on day 1**
Hospitals	4	0	0	4
Schools	92	0	0	92
EOCs	0	0	0	0
PoliceStations	15	0	0	15
FireStations	14	0	0	14

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	68	0	0	68	68
	Bridges	216	0	0	216	216
	Tunnels	0	0	0	0	0
Railways	Segments	32	0	0	32	32
	Bridges	4	0	0	4	4
	Tunnels	0	0	0	0	0
	Facilities	2	0	0	2	2
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	2	0	0	2	2
Ferry	Facilities	0	0	0	0	0
Port	Facilities	4	0	0	4	4
Airport	Facilities	8	0	0	8	8
	Runways	11	0	0	11	11

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	3	0	0	3	3
Waste Water	19	0	0	19	19
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	1	0	0	1	1
Communication	4	0	0	4	4

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,820	9	2
Waste Water	2,292	7	2
Natural Gas	1,528	7	2
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	101,663	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 1 ignitions that will burn about 0.01 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 22 people and burn about 1 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 94.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 0 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 283,883) will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	1	0	0	0
	Total	**1**	**0**	**0**	**0**
2 PM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	**1**	**0**	**0**	**0**
5 PM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	**1**	**0**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 12.98 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 9.04 (millions of dollars); 5 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 58 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	0.00	0.10	0.00	0.03	0.14
	Capital-Related	0.00	0.00	0.09	0.00	0.01	0.10
	Rental	0.05	0.04	0.10	0.00	0.00	0.19
	Relocation	0.00	0.00	0.00	0.00	0.00	0.01
	Subtotal	**0.05**	**0.04**	**0.30**	**0.01**	**0.04**	**0.44**
Capital Stock Loses							
	Structural	0.54	0.09	0.16	0.03	0.05	0.87
	Non_Structural	2.40	0.59	1.09	0.40	0.28	4.77
	Content	1.32	0.21	0.83	0.28	0.24	2.88
	Inventory	0.00	0.00	0.02	0.06	0.00	0.08
	Subtotal	**4.26**	**0.89**	**2.10**	**0.77**	**0.57**	**8.61**
	Total	**4.31**	**0.93**	**2.40**	**0.78**	**0.61**	**9.04**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	855.01	$0.00	0.00
	Bridges	331.41	$0.10	0.03
	Tunnels	0.00	$0.00	0.00
	Subtotal	**1186.40**	**0.10**	
Railways	Segments	79.57	$0.00	0.00
	Bridges	0.44	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	4.49	$0.03	0.77
	Subtotal	**84.50**	**0.00**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	2.25	$0.04	1.66
	Subtotal	**2.20**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	8.63	$0.14	1.66
	Subtotal	**8.60**	**0.10**	
Airport	Facilities	44.91	$0.75	1.66
	Runways	352.14	$0.00	0.00
	Subtotal	**397.00**	**0.70**	
	Total	**1678.80**	**1.10**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	102.90	$0.19	0.18
	Distribution Lines	76.40	$0.04	0.05
	Subtotal	**179.30**	**$0.23**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	1,303.40	$2.39	0.18
	Distribution Lines	45.80	$0.03	0.07
	Subtotal	**1,349.20**	**$2.42**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	30.60	$0.03	0.11
	Subtotal	**30.56**	**$0.03**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	113.30	$0.21	0.18
	Subtotal	**113.30**	**$0.21**	
Communication	Facilities	0.40	$0.00	0.19
	Subtotal	**0.41**	**$0.00**	
	Total	**1,672.77**	**$2.88**	

Table 15. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	0	0.00
Second Year			
	Employment Impact	0	0.00
	Income Impact	0	0.00
Third Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.01
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.01
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.01
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	0	-0.01

Appendix A: County Listing for the Region

Saint Charles,MO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Missouri					
	Saint Charles	283,883	16,610	4,652	21,263
Total State		**283,883**	**16,610**	**4,652**	**21,263**
Total Region		**283,883**	**16,610**	**4,652**	**21,263**

Fire Following Analysis Summary Report

April 22, 2008

	Number of Ignitions	Population Exposed	Value Exposed (thous. $)
Missouri			
Saint Charles	1	22	1,799
Total	**1**	**22**	**1,799**
Region Total	**1**	**22**	**1,799**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Fire Station Facilities Functionality

April 22, 2008

	Count	Functionality(%) At Day 1
Missouri		
Saint Charles	14	96.60
Total	**14**	**96.60**
Region Total	**14**	**96.60**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Electrical Power System Performance

April 22, 2008

	Total Households	# of households without power: At day 1 Count	At day 1 %	At day 3 Count	At day 3 %	At day 7 Count	At day 7 %	At day 30 Count	At day 30 %	At day 90 Count	At day 90 %
Missouri											
Saint Charles	101,663	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**
Region Total	**101,663**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Direct Economic Loss For Utilities

April 22, 2008

All values are in thousands of dollars

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	188	2,385	0	0	207	1	2,782
Pipelines	39	31	0	33			102
Total	227	2,416	0	33	207	1	2,884
Total	**227**	**2,416**	**0**	**33**	**207**	**1**	**2,884**
Region Total	**227**	**2,416**	**0**	**33**	**207**	**1**	**2,884**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Direct Economic Loss For Transportation

April 22, 2008

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Missouri								
Saint Charles								
Segments	0	0	0					0
Bridges	95	0	0					95
Tunnels	0	0	0					0
Facilities		34	0	37	143	0	745	960
Total	**95**	**34**	**0**	**37**	**143**	**0**	**745**	**1,055**
Total	**95**	**34**	**0**	**37**	**143**	**0**	**745**	**1,055**
Region Total	**95**	**34**	**0**	**37**	**143**	**0**	**745**	**1,055**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Debris Summary Report

April 22, 2008

All values are in thousands of tons.

	Brick, Wood & Others	Concrete & Steel	Total
Missouri			
Saint Charles	3	0	3
Total	**3**	**0**	**3**
Region Total	**3**	**0**	**3**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Communication Facility Functionality

April 22, 2008

	# of Facilities	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	4	99.80	99.90	99.90	99.90	99.90
Total	**4**	**99.80**	**99.90**	**99.90**	**99.90**	**99.90**
Region Total	**4**	**99.80**	**99.90**	**99.90**	**99.90**	**99.90**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report

April 22, 2008

	Injury Severity Level				
	Severity 1	**Severity 2**	**Severity 3**	**Severity 4**	**Total**
Missouri					
Saint Charles					
Casualties - 2am					
Other-Residential	0	0	0	0	0
Single Family	1	0	0	0	1
Commuting	0	0	0	0	0
Commercial	0	0	0	0	0
Hotels	0	0	0	0	0
Educational	0	0	0	0	0
Industrial	0	0	0	0	0
Total Casualties - 2am	**1**	**0**	**0**	**0**	**1**
Casualties - 2pm					
Hotels	0	0	0	0	0
Educational	0	0	0	0	0
Single Family	0	0	0	0	0
Commercial	0	0	0	0	0
Commuting	0	0	0	0	0
Other-Residential	0	0	0	0	0
Industrial	0	0	0	0	0
Total Casualties - 2pm	**1**	**0**	**0**	**0**	**1**
Casualties - 5pm					
Hotels	0	0	0	0	0
Educational	0	0	0	0	0
Industrial	0	0	0	0	0
Other-Residential	0	0	0	0	0
Commercial	0	0	0	0	0
Commuting	0	0	0	0	0
Single Family	0	0	0	0	0
Total Casualties - 5pm	**1**	**0**	**0**	**0**	**1**
Region Total	NA	NA	NA	NA	NA

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 5 PM

April 22, 2008

	Population	Injury Severity Level				
		Severity 1	Severity 2	Severity 3	Severity 4	total
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		0	0	0	0	0
Educational		0	0	0	0	0
Hotels		0	0	0	0	0
Industrial		0	0	0	0	0
Other-Residential		0	0	0	0	0
Single Family		0	0	0	0	0
Total Saint Charles	**283,883**	**1**	**0**	**0**	**0**	**1**
Total Missouri		**1**	**0**	**0**	**0**	**1**
Region Total		**1**	**0**	**0**	**0**	**1**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 2 PM

April 22, 2008

	Population	Severity 1 #	Severity 2 #	Severity 3 #	Severity 4 #	Total #
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		0	0	0	0	0
Educational		0	0	0	0	0
Hotels		0	0	0	0	0
Industrial		0	0	0	0	0
Other-Residential		0	0	0	0	0
Single Family		0	0	0	0	0
Total Saint Charles	283,883	**1**	**0**	**0**	**0**	**1**
Total Missouri		**1**	**0**	**0**	**0**	**1**
Region Total		**1**	**0**	**0**	**0**	**1**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Casualties Summary Report At 2 AM

April 22, 2008

	Population	Injury Severity Level: Severity 1	Severity 2	Severity 3	Severity 4	total
Missouri						
Saint Charles						
Commuting		0	0	0	0	0
Commercial		0	0	0	0	0
Educational		0	0	0	0	0
Hotels		0	0	0	0	0
Industrial		0	0	0	0	0
Other-Residential		0	0	0	0	0
Single Family		1	0	0	0	1
Total Saint Charles	**283,883**	**1**	**0**	**0**	**0**	**1**
Total Missouri		**1**	**0**	**0**	**0**	**1**
Region Total		**1**	**0**	**0**	**0**	**1**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Stock Exposure By General Occupancy

April 22, 2008

All values are in thousands of dollars

	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Missouri								
Saint Charles	16,610,965	3,052,036	808,965	62,566	324,991	100,392	303,699	21,263,614
Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**
Region Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage Count for Low Seismic Design Level

April 22, 2008

	# of Buildings					
	None	**Slight**	**Moderate**	**Extensive**	**Complete**	**Total**
Missouri						
Saint Charles						
Wood	66,311	46	0	0	0	66,358
Steel	187	0	0	0	0	187
Concrete	59	0	0	0	0	59
Precast	59	0	0	0	0	60
Reinforced Masonry	2	0	0	0	0	2
Unreinforced Masonry	8,051	58	2	0	0	8,112
Manufactured Home	2,008	15	1	0	0	2,023
Total	**76,677**	**120**	**3**	**0**	**0**	**76,801**
Region Total	**76,677**	**120**	**3**	**0**	**0**	**76,801**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage by Count by General Occupancy

April 22, 2008

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
Missouri						
Saint Charles						
Government	*91*	*1*	*0*	*0*	*0*	*92*
Religion	*146*	*2*	*0*	*0*	*0*	*148*
Agriculture	*58*	*1*	*0*	*0*	*0*	*59*
Single Family	*84,240*	*489*	*33*	*0*	*0*	*84,762*
Education	*65*	*1*	*0*	*0*	*0*	*66*
Commercial	*1,513*	*14*	*1*	*0*	*0*	*1,528*
Industrial	*368*	*3*	*0*	*0*	*0*	*371*
Other Residential	*7,578*	*158*	*9*	*0*	*0*	*7,745*
Total	**94,059**	**668**	**44**	**0**	**0**	**94,771**
Region Total	**94,059**	**668**	**44**	**0**	**0**	**94,771**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Building Damage by Building Type for Low Design Level

April 22, 2008

	Average Damage State				
	None	**Slight**	**Moderate**	**Extensive**	**Complete**
Missouri					
Saint Charles					
Wood	1.00	0.00	0.00	0.00	0.00
Steel	1.00	0.00	0.00	0.00	0.00
Concrete	1.00	0.00	0.00	0.00	0.00
Precast	1.00	0.00	0.00	0.00	0.00
Reinforced Masonry	1.00	0.00	0.00	0.00	0.00
Unreinforced Masonry	1.00	0.00	0.00	0.00	0.00
Manufactured Home	1.00	0.00	0.00	0.00	0.00
Total	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**
Region Average	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Airport Runways Functionality

April 22, 2008

	# of Runways	Functionality (%) At day 1	At day 3	At day 7	At day 30	At day 90
Missouri						
Saint Charles	11	100.00	100.00	100.00	100.00	100.00
Total	**11**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Region Total	**11**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Waste Water Pipeline Damage

April 22, 2008

	Pipeline Length (KM)	Total Number of Leaks	Total Number of Breaks
Missouri			
Saint Charles	2,292	20	5
Total	**2,292**	**20**	**5**
Region Total	**2,292**	**20**	**5**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

MISSISSIPPI RIVER

FLOOD HAZARD SCENARIO

Vehicle Dollar Exposure (Day)

March 22, 2008

All values are in dollars.

	Cars	Light Trucks	Heavy Trucks	Total
Missouri				
Saint Charles	$243,718,091	$102,490,731	$189,722,220	$535,931,041
Total	**$243,718,091**	**$102,490,731**	**$189,722,220**	**$535,931,041**
Study Region Total	**$243,718,091**	**$102,490,731**	**$189,722,220**	**$535,931,041**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

HAZUS-MH: Flood Event Report

Region Name: St_Charles_County_Flood_Hazard

Flood Scenario: Edited Mississippi Reaches 2

Print Date: Saturday, March 22, 2008

Disclaimer:

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.

Table of Contents

General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Missouri

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 560 square miles and contains 5,655 census blocks. There are over 102 thousand households in the region and has a total population of 283,883 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 108,003 buildings in the region with a total building replacement value (excluding contents) of 21,264 million dollars (2006 dollars). Approximately 93.24% of the buildings (and 78.12% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

HAZUS estimates that there are 108,003 buildings in the region which have an aggregate total replacement value of 21,264 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	16,610,965	78.1%
Commercial	3,052,036	14.4%
Industrial	808,965	3.8%
Agricultural	62,566	0.3%
Religion	324,991	1.5%
Government	100,392	0.5%
Education	303,699	1.4%
Total	**21,263,614**	**100.00%**

Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	4,624,889	78.3%
Commercial	748,712	12.7%
Industrial	314,524	5.3%
Agricultural	21,511	0.4%
Religion	81,512	1.4%
Government	21,744	0.4%
Education	93,946	1.6%
Total	**5,906,838**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 4 hospitals in the region with a total bed capacity of 546 beds. There are 92 schools, 14 fire stations, 15 police stations and no emergency operation centers.

Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	St_Charles_County_Flood_Hazard
Scenario Name:	Edited Mississippi Reaches 2
Return Period Analyzed:	100
Analysis Options Analyzed:	0

Building Damage

General Building Stock Damage

HAZUS estimates that about 936 buildings will be at least moderately damaged. This is over 8% of the total number of buildings in the study case. There are an estimated 253 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	4	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	0	0.00	45	4.83	113	12.12	260	27.90	261	28.00	253	27.15
Total	**1**		**49**		**113**		**260**		**261**		**253**	

Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		Substantially	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Concrete	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ManufHousing	0	0.00	0	0.00	0	0.00	0	0.00	2	2.56	76	97.44
Masonry	0	0.00	6	4.32	17	12.23	42	30.22	47	33.81	27	19.42
Steel	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Wood	0	0.00	41	5.72	96	13.39	218	30.40	212	29.57	150	20.92

Essential Facility Damage

Before the flood analyzed in this study case, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Fire Stations	14	0	0	0
Hospitals	4	0	0	0
Police Stations	15	0	0	0
Schools	92	2	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 29,655 tons of debris will be generated. Of the total amount, Finishes comprises 47% of the total, Structure comprises 29% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 1,186 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 2,696 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 5,697 people (out of a total population of 283,883) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the flood is 267.67 million dollars, which represents 8.00 % of the total replacement value of the scenario buildings.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 265.75 million dollars. 1% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 58.37% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	102.40	18.36	5.76	4.03	130.54
	Content	53.50	46.11	12.14	19.69	131.45
	Inventory	0.00	1.11	2.38	0.26	3.76
	Subtotal	**155.90**	**65.58**	**20.28**	**23.99**	**265.75**
Business Interruption						
	Income	0.00	0.32	0.00	0.06	0.38
	Relocation	0.27	0.06	0.00	0.00	0.33
	Rental Income	0.05	0.04	0.00	0.00	0.09
	Wage	0.01	0.30	0.01	0.81	1.12
	Subtotal	**0.34**	**0.71**	**0.01**	**0.86**	**1.93**
ALL	**Total**	**156.24**	**66.30**	**20.29**	**24.85**	**267.67**

Appendix A: County Listing for the Region

Missouri

- Saint Charles

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Missouri				
Saint Charles	283,883	16,610,965	4,652,649	21,263,614
Total	**283,883**	**16,610,965**	**4,652,649**	**21,263,614**
Total Study Region	**283,883**	**16,610,965**	**4,652,649**	**21,263,614**

Utility System Dollar Exposure

March 22, 2008

All values are in thousands of dollars.

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	$102897.00	$1303362.00	$0.00	$0.00	$113300.00	$412.00	$1,519,971.00
Pipelines	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	**$102,897.00**	**$1,303,362.00**	**$0.00**	**$0.00**	**$113,300.00**	**$412.00**	**$1,519,971.00**
Total	**$102,897.00**	**$1,303,362.00**	**$0.00**	**$0.00**	**$113,300.00**	**$412.00**	**$1,519,971.00**
Study Region Total	**$102,897.00**	**$1,303,362.00**	**$0.00**	**$0.00**	**$113,300.00**	**$412.00**	**$1,519,971.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Transportation System Dollar Exposure

March 22, 2008

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Missouri								
Saint Charles								
Segments	855,009.03	79,567.00	0.00	0.00	0.00	0.00	352,136.40	1,286,712.43
Bridges	331,413.33	444.96	0.00	0.00	0.00	0.00	0.00	331,858.29
Tunnels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Facilities	0.00	4,490.80	0.00	2,245.40	8,632.80	0.00	44,908.00	60,277.00
Total	**1,186,422.36**	**84,502.76**	**0.00**	**2,245.40**	**8,632.80**	**0.00**	**397,044.40**	**1,678,847.72**
Total	**1,186,422.36**	**84,502.76**	**0.00**	**2,245.40**	**8,632.80**	**0.00**	**397,044.40**	**1,678,847.72**
Study Region Total	**1,186,422.36**	**84502.76**	**0.00**	**2,245.40**	**8,632.80**	**0.00**	**397,044.40**	**1,678,847.72**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Shelter Summary Report

March 22, 2008

	# of Displaced People	# of People Needing Short Term Shelter
Missouri		
Saint Charles	8,087	5,697
Total	**8,087**	**5,697**
Scenario Total	**8,087**	**5,697**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

School Damage and Functionality

March 22, 2008

Dollar values are in thousands.

	Count of Schools	Total Building Damage ($)	Total Content Damage ($)	Non-Functional Schools	Average Restoration Time
Missouri					
Saint Charles					
Grade Schools (Primary and High Schools)	2	64.79	384.12	0	480
Total	**2**	**64.79**	**384.12**	**0**	**480**
Total	**2**	**64.79**	**384.12**	**0**	**480**
Scenario Total	**2**	**64.79**	**384.12**	**0**	**480**

If this report displays all zeros, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box ask you to replace the existing results.

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard

Scenario: Edited Mississippi Reaches 2

Return Period: 100

Quick Assessment Report

March 22, 2008

Study Region :	St_Charles_County_Flood_Hazard
Scenario :	Edited Mississippi Reaches 2
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	560
Number of Census Blocks	5,655
Number of Buildings	
Residential	100,707
Total	108,003
Number of People in the Region (x 1000)	284
Building Exposure ($ Millions)	
Residential	16,611
Total	21,264

Scenario Results

Shelter Requirements

Displaced Population (# Households)	2,696
Short Term Shelter (# People)	5,697

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	155.90
Total Property (Capital Stock) Losses ($ Millions)	265.75
Business Interruptions (Income) Losses ($ Millions)	1.93

Disclaimer:

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific flood. These results can be improved by using enhanced inventory data and flood hazard information.

Income and Employment Impact (without outside aid)

March 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	0.358	0.069	0.000	0.022	0.000	-0.001	0.000	0.000	0.447
Second Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	0.160	0.034	0.000	0.010	0.000	0.000	0.000	0.000	0.204
Third Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	0.000	0.004	0.000	0.009	0.000	0.000	0.000	0.000	0.013
Fourth Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	0.000	0.004	0.000	0.009	0.000	0.000	0.000	0.000	0.013
Fifth Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	0.000	0.004	0.000	0.009	0.000	0.000	0.000	0.000	0.013

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Income and Employment Impact (with outside aid)

March 22, 2008

Income impact in millions of dollars
Employment impact in number of employees
Positive values denote a gain, negative values denote a loss

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
First Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	0.023	0.003	0.000	0.000	-0.001	-0.002	-0.001	0.000	0.022
Second Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	0.014	0.002	-0.001	-0.001	-0.003	-0.005	-0.002	0.000	0.003
Third Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	-0.001	0.002	-0.001	0.005	-0.003	-0.007	-0.003	0.000	-0.009
Fourth Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	-0.001	0.002	-0.001	0.005	-0.003	-0.007	-0.003	0.000	-0.009

Income and Employment Impact (with outside aid)

	Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Government	Miscellaneous	Total
Fifth Year											
Employment Impact	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Income Impact	0.000	0.000	-0.001	0.002	-0.001	0.005	-0.003	-0.007	-0.003	0.000	-0.009

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Direct Economic Losses For Vehicles (Night)

March 22, 2008

All values are in dollars.

	Car	Light Truck	Heavy Truck	Total Loss
Missouri				
Saint Charles	$8,491,462	$2,699,484	$1,972,400	$13,163,346
Total	**$8,491,462**	**$2,699,484**	**$1,972,400**	**$13,163,346**
Scenario Total	**$8,491,462**	**$2,699,484**	**1,972,400**	**$13,163,346**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Direct Economic Losses For Vehicles (Day)

March 22, 2008

All values are in dollars.

	Cars	Light Trucks	Heavy Trucks	Total Loss
Missouri				
Saint Charles	$5,340,142	$1,727,999	$1,311,058	$8,379,199
Total	**$5,340,142**	**$1,727,999**	**$1,311,058**	**$8,379,199**
Scenario Total	**$5,340,142**	**$1,727,999**	**$1,311,058**	**$8,379,199**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Direct Economic Losses for Utilities

March 22, 2008

All values are in thousands of dollars.

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	$0.00	$56372.59	$0.00	$0.00	$0.00	$0.00	$56,372.59
Pipelines	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	**$0.00**	**$56,372.59**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$56,372.59**
Total	**$0.00**	**$56,372.59**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$56,372.59**
Scenario Total	**$0.00**	**$56,372.59**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$56,372.59**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Direct Economic Losses for Buildings

March 22, 2008

All values are in thousands of dollars

	Capital Stock Losses				Income Losses				
	Cost Building Damage	Cost Contents Damage	Inventory Loss	Building Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Missouri									
Saint Charles	130,541	131,447	3,759	2.2	334	382	1,116	93	267,672
Total	**130,541**	**131,447**	**3,759**	**2.2**	**334**	**382**	**1,116**	**93**	**267,672**
Scenario Total	**130,541**	**131,447**	**3,759**	**2.2**	**334**	**382**	**1,116**	**93**	**267,672**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard

Scenario: Edited Mississippi Reaches 2

Return Period: 100

Direct Economic Loss For Agriculture Products

March 22, 2008

	Crop Loss Day 0	Crop Loss Day 3	Crop Loss Day 7	Crop Loss Day 14	Total
Missouri					
Saint Charles					
CORN	0.00	5,140,605.50	6,854,140.66	6,854,140.66	18,848,886.83
SOYBEANS	0.00	4,987,443.08	6,649,924.11	6,649,924.11	18,287,291.30
WHEAT	0.00	628,094.05	837,458.74	837,458.74	2,303,011.52
Total	**0.00**	**10,756,142.63**	**14,341,523.51**	**14,341,523.51**	**39,439,189.64**
Total	**0.00**	**10,756,142.63**	**14,341,523.51**	**14,341,523.51**	**39,439,189.64**
Scenario Total	**0.00**	**10,756,142.63**	**14,341,523.51**	**14,341,523.51**	**39,439,189.64**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Direct Economic Loss For Transportation

March 22, 2008

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Missouri								
Saint Charles								
Segments	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Bridges	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Tunnels	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Facilities	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Scenario Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Direct Economic Annualized Losses for Buildings

March 22, 2008 *All values are in thousands of dollars*

	Capital Stock Losses				Income Losses				
	Cost Building Damage	Cost Contents Damage	Inventory Loss	Building Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Missouri									
Saint Charles	130,541	131,447	3,759	2.2	334	382	1,116	93	267,672
Total	**130,541**	**131,447**	**3,759**	**2.2**	**334**	**382**	**1,116**	**93**	**267,672**
Scenario Total	**130,541**	**131,447**	**3,759**	**2.2**	**334**	**382**	**1,116**	**93**	**267,672**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Depreciated Direct Economic Losses for Buildings

March 22, 2008

All values are in thousands of dollars

	Capital Stock Losses		
	Cost Building Damage	Cost Contents Damage	Total Loss
Missouri			
Saint Charles	91,954	90,724	182,678
Total	**91,954**	**90,724**	**182,678**
Scenario Total	**91,954**	**90,724**	**182,678**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Debris Summary Report

March 22, 2008

All values are in tons.

	Finishes	Structures	Foundations	Total
Missouri				
Saint Charles	14,068	8,502	7,085	29,655
Total	**14,068**	**8,502**	**7,085**	**29,655**
Scenario Total	**14,068**	**8,502**	**7,085**	**29,655**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Building Stock Exposure by General Occupancy

March 22, 2008

All values are in thousands of dollars

	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Missouri								
Saint Charles	16,610,965	3,052,036	808,965	62,566	324,991	100,392	303,699	21,263,614
Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**
Study Region Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Building Stock Exposure by Building Type

March 22, 2008

All values are in thousands of dollars

	Wood	Steel	Concrete	Masonry	Manuf. Housing	Total
Missouri						
Saint Charles	13,312,476	916,757	1,385,539	5,442,224	206,892	21,263,888
Total	**13,312,476**	**916,757**	**1,385,539**	**5,442,224**	**206,892**	**21,263,888**
Study Region Total	**13,312,476**	**916,757**	**1,385,539**	**5,442,224**	**206,892**	**21,263,888**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Building Damage Count by General Occupancy

March 22, 2008

	Count of Buildings (#) by Range of Damage (%)							
	None	**1-10**	**11-20**	**21-30**	**31-40**	**41-50**	**Substantial**	**Total**
Missouri								
Saint Charles								
Government	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0
Commercial	0	0	4	0	0	0	0	4
Religion	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0
Residential	1,197	0	45	113	260	261	253	2,129
Agriculture	0	1	0	0	0	0	0	1
Total	**1,197**	**1**	**49**	**113**	**260**	**261**	**253**	**2,134**
Total	**1,197**	**1**	**49**	**113**	**260**	**261**	**253**	**2,134**
Scenario Total	**1,197**	**1**	**49**	**113**	**260**	**261**	**253**	**2,134**

Special Notice Regarding Building Count:

Unlike the earthquake and hurricane models, the flood model performs its analysis at the census block level. This means that the analysis starts with a small number of buildings within each census block and applies a series of distributions necessary for analyzing the potential damage. The application of these distributions and the small number of buildings make the flood model more sensitive to rounding errors that introduces uncertainty into the building count results. Please use these results with suitable caution.

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Building Damage Count by General Building Type

March 22, 2008

	# of Buildings							
	None	**1-10**	**11-20**	**21-30**	**31-40**	**41-50**	**Substantial**	**Total**
Missouri								
Saint Charles								
ManufHousing	211	0	0	0	0	2	76	289
Masonry	205	0	6	17	42	47	27	344
Wood	781	0	41	96	218	212	150	1,498
Steel	0	0	1	0	0	0	0	1
Concrete	0	0	0	0	0	0	0	0
Total	**1,197.00**	**0.00**	**48.00**	**113.00**	**260.00**	**261.00**	**253.00**	**2,132.00**
Total	**1,197**	**0**	**48**	**113**	**260**	**261**	**253**	**2,132**
Scenario Total	**1,197**	**0**	**48**	**113**	**260**	**261**	**253**	**2,132**

<u>Special Notice Regarding Building Count:</u>

Unlike the earthquake and hurricane models, the flood model performs its analysis at the census block level. This means that the analysis starts with a small number of buildings within each census block and applies a series of distributions necessary for analyzing the potential damage. The application of these distributions and the small number of buildings make the flood model more sensitive to rounding errors that introduces uncertainty into the building count results. Please use these results with suitable caution.

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Building Damage By General Occupancy

March 22, 2008

All values are in thousands of square feet

	Total Square Footage	Square Footage Distribution by Damage Percent Range						
		None	1-10	11-20	21-30	31-40	41-50	Substantial
Missouri								
Saint Charles								
Government	23.20	1.59	6.32	14.33	0.11	0.85	0.00	0.00
Industrial	283.10	33.78	14.23	100.79	41.36	35.81	37.98	19.16
Commercial	826.31	92.90	119.26	362.17	102.85	57.97	41.37	49.78
Religion	78.13	5.86	8.89	56.58	1.60	0.56	0.77	3.88
Education	109.25	20.22	71.65	7.98	1.69	1.27	1.11	5.32
Residential	4,413.32	2,105.75	14.19	184.13	373.84	594.29	578.78	562.34
Agriculture	37.40	4.22	5.57	11.23	7.67	3.53	2.13	3.05
Total	**5,770.71**	**2,264.33**	**240.11**	**737.21**	**529.12**	**694.29**	**662.14**	**643.52**
Total	**5,770.71**	**2,264.33**	**240.11**	**737.21**	**529.12**	**694.29**	**662.14**	**643.52**
Scenario Total	**5,770.71**	**2,264.33**	**240.11**	**737.21**	**529.12**	**694.29**	**662.14**	**643.52**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Building Damage by Building Type

March 22, 2008 *All values are in thousands of square feet*

	Average Damage (%) Within Each Damage Range						
	None	1-10	11-20	21-30	31-40	41-50	Substantial
Missouri							
Saint Charles							
ManufHousing	251.0	0.0	0.0	0.0	0.0	3.0	120.0
Masonry	456.0	74.0	168.0	93.0	140.0	127.0	96.0
Wood	1,408.0	22.0	221.0	275.0	460.0	432.0	297.0
Steel	31.0	47.0	158.0	30.0	15.0	13.0	12.0
Concrete	16.0	36.0	62.0	13.0	5.0	5.0	2.0
Total	**2,162.0**	**179.0**	**609.0**	**411.0**	**620.0**	**580.0**	**527.0**
Total	**2,162.0**	**179.0**	**609.0**	**411.0**	**620.0**	**580.0**	**527.0**
Scenario Total	**2,162.0**	**179.0**	**609.0**	**411.0**	**620.0**	**580.0**	**527.0**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Agriculture Products Dollar Exposure

March 22, 2008

	Average Total Yield	Units
Missouri		
Saint Charles		
BROMEGRASS-ALFALFA	0.00	AUM
BROMEGRASS-ALFALFA HAY	9,519,200,620.30	Ton
CORN	13,204,968,811.33	BU
GRAIN SORGHUM	8,914,312,141.51	BU
KENTUCKY BLUEGRASS	0.00	AUM
ORCHARDGRASS-ALFALFA HAY	6,776,881,685.13	Ton
SMOOTH BROMEGRASS	0.00	AUM
SOYBEANS	16,805,520,723.84	BU
TALL FESCUE	0.00	AUM
WHEAT	5,527,252,322.87	BU
WHEAT, WINTER	7,853,900,418.31	BU
Total	**68,602,036,723.28**	
Total	**68,602,036,723.28**	
Study Region Total	**68,602,036,723.28**	

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

Vehicle Dollar Exposure (Night)

March 22, 2008 *All values are in dollars.*

	Cars	Light Trucks	Heavy Trucks	Total
Missouri				
Saint Charles	$425,011,878	$178,730,179	$330,850,272	$934,592,329
Total	**$425,011,878**	**$178,730,179**	**$330,850,272**	**$934,592,329**
Study Region Total	**$425,011,878**	**$178,730,179**	**$330,850,272**	**$934,592,329**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Mississippi Reaches 2
Return Period: 100

MISSOURI RIVER

FLOOD HAZARD SCENARIO

Debris Summary Report

March 18, 2008

All values are in tons.

	Finishes	Structures	Foundations	Total
Missouri				
Saint Charles	781	326	255	1,362
Total	**781**	**326**	**255**	**1,362**
Scenario Total	**781**	**326**	**255**	**1,362**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Building Stock Exposure by General Occupancy

March 18, 2008 *All values are in thousands of dollars*

	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Missouri								
Saint Charles	16,610,965	3,052,036	808,965	62,566	324,991	100,392	303,699	21,263,614
Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**
Study Region Total	**16,610,965**	**3,052,036**	**808,965**	**62,566**	**324,991**	**100,392**	**303,699**	**21,263,614**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Building Stock Exposure by Building Type

March 18, 2008

All values are in thousands of dollars

	Wood	Steel	Concrete	Masonry	Manuf. Housing	Total
Missouri						
Saint Charles	13,312,476	916,757	1,385,539	5,442,224	206,892	21,263,888
Total	**13,312,476**	**916,757**	**1,385,539**	**5,442,224**	**206,892**	**21,263,888**
Study Region Total	**13,312,476**	**916,757**	**1,385,539**	**5,442,224**	**206,892**	**21,263,888**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Building Damage Count by General Occupancy

March 18, 2008

	Count of Buildings (#) by Range of Damage (%)							
	None	1-10	11-20	21-30	31-40	41-50	Substantial	Total
Missouri								
Saint Charles								
Agriculture	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0
Residential	29	0	0	2	8	8	5	52
Total	**29**	**0**	**0**	**2**	**8**	**8**	**5**	**52**
Total	**29**	**0**	**0**	**2**	**8**	**8**	**5**	**52**
Scenario Total	**29**	**0**	**0**	**2**	**8**	**8**	**5**	**52**

Special Notice Regarding Building Count:

Unlike the earthquake and hurricane models, the flood model performs its analysis at the census block level. This means that the analysis starts with a small number of buildings within each census block and applies a series of distributions necessary for analyzing the potential damage. The application of these distributions and the small number of buildings make the flood model more sensitive to rounding errors that introduces uncertainty into the building count results. Please use these results with suitable caution.

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Building Damage Count by General Building Type

March 18, 2008

	# of Buildings							
	None	**1-10**	**11-20**	**21-30**	**31-40**	**41-50**	**Substantial**	**Total**
Missouri								
Saint Charles								
Concrete	0	0	0	0	0	0	0	0
ManufHousing	0	0	0	0	0	0	0	0
Masonry	4	0	0	0	0	1	0	5
Steel	0	0	0	0	0	0	0	0
Wood	25	0	0	2	8	7	5	47
Total	**29.00**	**0.00**	**0.00**	**2.00**	**8.00**	**8.00**	**5.00**	**52.00**
Total	**29**	**0**	**0**	**2**	**8**	**8**	**5**	**52**
Scenario Total	**29**	**0**	**0**	**2**	**8**	**8**	**5**	**52**

Special Notice Regarding Building Count:

Unlike the earthquake and hurricane models, the flood model performs its analysis at the census block level. This means that the analysis starts with a small number of buildings within each census block and applies a series of distributions necessary for analyzing the potential damage. The application of these distributions and the small number of buildings make the flood model more sensitive to rounding errors that introduces uncertainty into the building count results. Please use these results with suitable caution.

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Building Damage By General Occupancy

March 18, 2008

All values are in thousands of square feet

	Total Square Footage	Square Footage Distribution by Damage Percent Range						
		None	1-10	11-20	21-30	31-40	41-50	Substantial
Missouri								
Saint Charles								
Agriculture	9.60	1.83	1.66	2.83	1.35	0.58	0.75	0.60
Commercial	50.53	5.92	4.57	25.93	7.75	4.81	1.16	0.39
Education	0.36	0.01	0.33	0.01	0.00	0.00	0.00	0.00
Government	0.61	0.11	0.07	0.42	0.00	0.00	0.00	0.00
Industrial	34.68	4.91	1.01	10.57	4.22	3.93	4.96	5.07
Religion	17.03	2.40	1.04	13.51	0.04	0.01	0.02	0.01
Residential	221.83	94.89	3.36	8.94	19.90	32.83	37.35	24.56
Total	**334.65**	**110.08**	**12.05**	**62.22**	**33.28**	**42.16**	**44.25**	**30.62**
Total	**334.65**	**110.08**	**12.05**	**62.22**	**33.28**	**42.16**	**44.25**	**30.62**
Scenario Total	**334.65**	**110.08**	**12.05**	**62.22**	**33.28**	**42.16**	**44.25**	**30.62**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Building Damage by Building Type

March 18, 2008

All values are in thousands of square feet

	Average Damage (%) Within Each Damage Range						
	None	**1-10**	**11-20**	**21-30**	**31-40**	**41-50**	**Substantial**
Missouri							
Saint Charles							
Concrete	2.0	1.0	6.0	0.0	0.0	0.0	0.0
ManufHousing	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Masonry	20.0	2.0	11.0	1.0	4.0	6.0	3.0
Steel	3.0	2.0	14.0	2.0	1.0	0.0	0.0
Wood	64.0	1.0	11.0	10.0	18.0	22.0	13.0
Total	**89.0**	**6.0**	**42.0**	**13.0**	**23.0**	**28.0**	**16.0**
Total	**89.0**	**6.0**	**42.0**	**13.0**	**23.0**	**28.0**	**16.0**
Scenario Total	**89.0**	**6.0**	**42.0**	**13.0**	**23.0**	**28.0**	**16.0**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Agriculture Products Dollar Exposure

March 18, 2008

	Average Total Yield	Units
Missouri		
Saint Charles		
BROMEGRASS-ALFALFA	0.00	AUM
BROMEGRASS-ALFALFA HAY	9,519,200,620.30	Ton
CORN	13,204,968,811.33	BU
GRAIN SORGHUM	8,914,312,141.51	BU
KENTUCKY BLUEGRASS	0.00	AUM
ORCHARDGRASS-ALFALFA HAY	6,776,881,685.13	Ton
SMOOTH BROMEGRASS	0.00	AUM
SOYBEANS	16,805,520,723.84	BU
TALL FESCUE	0.00	AUM
WHEAT	5,527,252,322.87	BU
WHEAT, WINTER	7,853,900,418.31	BU
Total	**68,602,036,723.28**	
Total	**68,602,036,723.28**	
Study Region Total	**68,602,036,723.28**	

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Depreciated Direct Economic Losses for Buildings

March 18, 2008 *All values are in thousands of dollars*

	Capital Stock Losses		
	Cost Building Damage	Cost Contents Damage	Total Loss
Missouri			
Saint Charles	5,529	6,336	11,865
Total	**5,529**	**6,336**	**11,865**
Scenario Total	**5,529**	**6,336**	**11,865**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Direct Economic Losses For Vehicles (Day)

March 18, 2008

All values are in dollars.

	Cars	Light Trucks	Heavy Trucks	Total Loss
Missouri				
Saint Charles	$210,284	$73,068	$55,834	$339,186
Total	**$210,284**	**$73,068**	**$55,834**	**$339,186**
Scenario Total	**$210,284**	**$73,068**	**$55,834**	**$339,186**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Direct Economic Losses for Utilities

March 18, 2008

All values are in thousands of dollars.

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Missouri							
Saint Charles							
Facilities	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Pipelines	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Scenario Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Direct Economic Loss For Transportation

March 18, 2008 *All values are in thousands of dollars*

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Missouri								
Saint Charles								
Segments	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Bridges	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Tunnels	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Facilities	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Scenario Total	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Direct Economic Losses for Buildings

March 18, 2008

All values are in thousands of dollars

	Capital Stock Losses				Income Losses				
	Cost Building Damage	Cost Contents Damage	Inventory Loss	Building Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Missouri									
Saint Charles	7,963	9,660	435	1.0	8	17	91	4	18,178
Total	**7,963**	**9,660**	**435**	**1.0**	**8**	**17**	**91**	**4**	**18,178**
Scenario Total	**7,963**	**9,660**	**435**	**1.0**	**8**	**17**	**91**	**4**	**18,178**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Direct Economic Loss For Agriculture Products

March 18, 2008

	Crop Loss Day 0	Crop Loss Day 3	Crop Loss Day 7	Crop Loss Day 14	Total
Missouri					
Saint Charles					
CORN	0.00	1,979,952.63	2,639,936.84	2,639,936.84	7,259,826.32
SOYBEANS	0.00	1,897,200.54	2,529,600.72	2,529,600.72	6,956,401.99
WHEAT	0.00	1,004,651.66	1,339,535.54	1,339,535.54	3,683,722.74
Total	**0.00**	**4,881,804.83**	**6,509,073.11**	**6,509,073.11**	**17,899,951.05**
Total	**0.00**	**4,881,804.83**	**6,509,073.11**	**6,509,073.11**	**17,899,951.05**
Scenario Total	**0.00**	**4,881,804.83**	**6,509,073.11**	**6,509,073.11**	**17,899,951.05**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Direct Economic Annualized Losses for Buildings

March 18, 2008

All values are in thousands of dollars

	Capital Stock Losses				Income Losses				
	Cost Building Damage	Cost Contents Damage	Inventory Loss	Building Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Missouri									
Saint Charles	7,963	9,660	435	1.0	8	17	91	4	18,178
Total	**7,963**	**9,660**	**435**	**1.0**	**8**	**17**	**91**	**4**	**18,178**
Scenario Total	**7,963**	**9,660**	**435**	**1.0**	**8**	**17**	**91**	**4**	**18,178**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: St_Charles_County_Flood_Hazard
Scenario: Edited Missouri River Reaches 2
Return Period: 100

Direct Economic Losses For Vehicles (Night)

March 18, 2008

All values are in dollars.

	Car	Light Truck	Heavy Truck	Total Loss
Missouri				
Saint Charles	$438,213	$150,565	$117,956	$706,734
Total	**$438,213**	**$150,565**	**$117,956**	**$706,734**
Scenario Total	**$438,213**	**$150,565**	**117,956**	**$706,734**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.