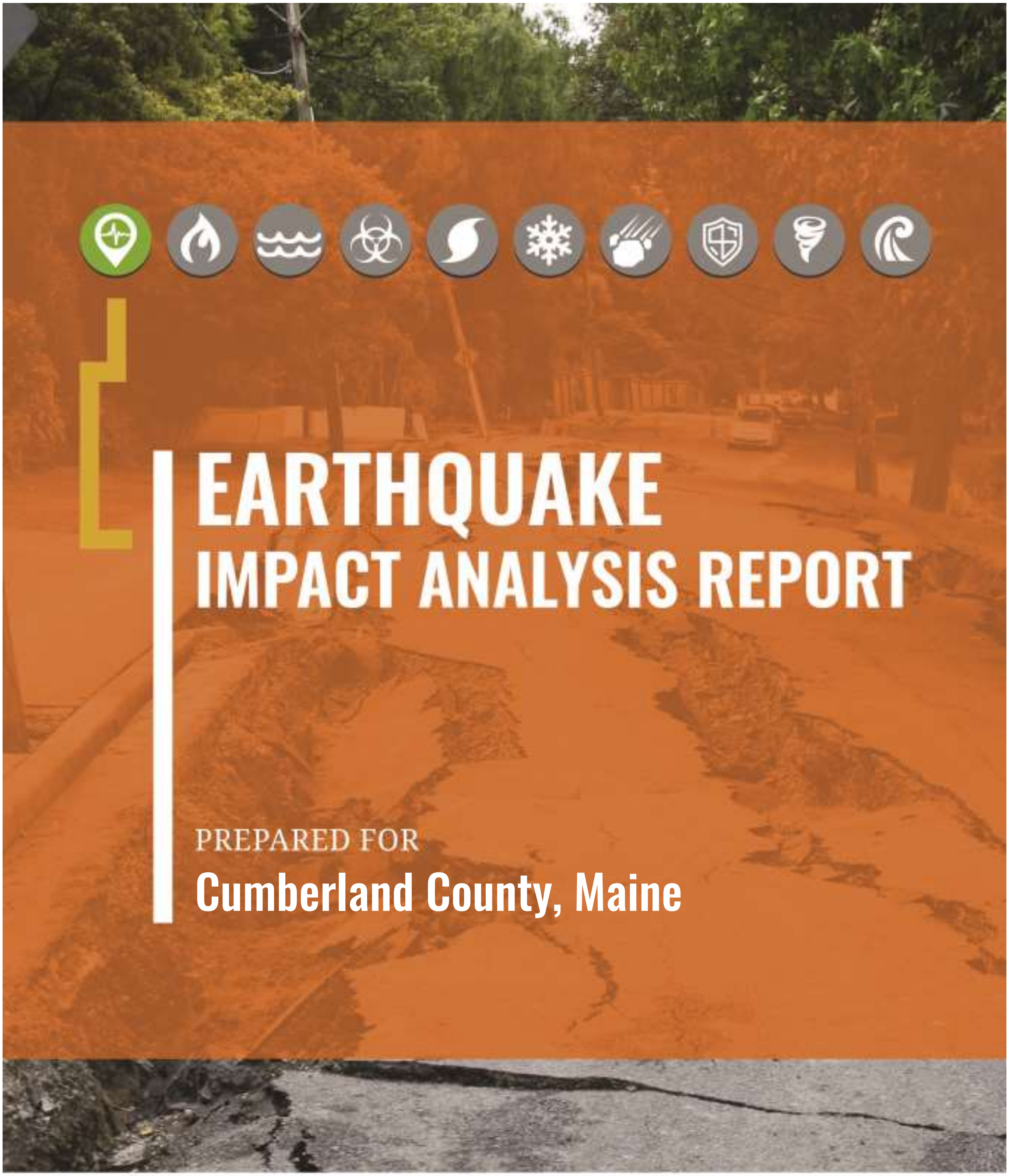

EARTHQUAKE
IMPACT ANALYSIS REPORT

PREPARED FOR

Cumberland County, Maine

THIS REPORT DEVELOPED BY

The Northeast States Emergency Consortium

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UTILIZING FEMA'S HAZUS MH PROGRAM

OVERVIEW

Earthquake Threat Level for Cumberland County, Maine

MODERATE

- Cumberland County, Maine experiences earthquakes infrequently, but New England has been known to experience 6.0 or greater magnitude.
- Typically, the region experiences about 40 - 50 earthquakes per year, some of which are felt.
- **When earthquakes do hit New England, they can cause significant damage.**

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I. INTRODUCTION

The first step in preparing for and mitigating any disaster is to estimate its potential impact on an area or region. The purpose of this study is to provide emergency managers and other government decision makers with an estimate of the potential impact of a moderate to large size earthquake affecting Cumberland County, Maine.

METHODOLOGY The methodology used to produce the results contained in this report is called HAZUS-MH (referred to as HAZUS) which was developed by the Federal Emergency Management Agency (FEMA) in cooperation with the National Institute of Building Sciences (NIBS). HAZUS uses Geographic Information System (GIS) software to calculate, map and display earthquake loss data. HAZUS uses mathematical formulas and information about building stock, geologic conditions, potential earthquakes, economic data and other information to estimate losses.

DATA COMPILATION This report utilizes default data contained in the HAZUS software compiled from available national databases. This data has been augmented using available state and county data. These default databases describe in general terms the building inventory and economic and social structure of Cumberland County, Maine. The default data provide a preliminary estimate of earthquake losses and impacts. More accurate estimates require detailed information about local geology, buildings, utilities, transportation systems and other specific information. This data is usually available from local and state agencies and departments and typically can be added to the HAZUS data base by local and state emergency personnel. In some cases, however, technical assistance from geologists, engineers and GIS experts may be required.

ESTIMATION It is imperative to point out that this HAZUS impact analysis is not a precise prediction, but rather a rough estimate of potential damage, human and economic impacts that may result from a single future hypothetical earthquake occurring in a specific location. While this estimate is based on current scientific and engineering knowledge, there can be large uncertainties in the results especially for individual buildings and facilities. More refined building specific results typically require detailed engineering studies and specific examinations beyond the scope and intent of HAZUS.

DISCLAIMER* *The estimates of social and economic impacts contained in this report are based on HAZUS-MH Version 4.2 that utilizes 2010 census data and 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 ground motion data.

II. EXECUTIVE SUMMARY OF IMPACT

The following is an Executive Summary of the estimated potential impact of a probabilistic earthquake occurring every 2500 years and affecting Cumberland County, Maine.

Estimated Direct Losses

Calculated by estimating the damage to buildings caused by earthquake ground shaking.

General Building Stock	$1,158,646,000
Transportation System	$35,145,000
Lifeline Utilities	$449,994,000
Combined Estimated Losses	$1,643,785,000

Essential Facilities

By averaging probabilities, we have calculated how the functionality of essential facilities will be impacted.

Emergency Operations Centers (EOC's)	74.30%
Police Stations	75.90%
Fire Stations	71.80%
Hospitals and Medical Care Facilities	65.96%
Schools	65.90%
Highway Bridges	99.80%
Highways	100%
Airport Facilities	85.25%
Airport Runways	100.0%

Estimated Debris

Calculated by estimating the total amount of debris generated.

Generated (Tons)	212

Estimated Social Impact

By averaging probabilities, we have calculated how many individuals and households will be affected.

Casualties	266
Displaced Households	655
People Requiring Shelter	354
Households Without Power	0
Households Without Water	0

III. THE EARTHQUAKE HISTORY OF CUMBERLAND COUNTY, MAINE

Both historically and in recent times, earthquakes have been felt in Cumberland County, Maine which have been centered throughout the Northeast United States and Southern Canada. One of the largest earthquakes to occur in the Northeast occurred in 1638 just north of Concord, New Hampshire (6.5), in 1755 off Cape Ann, Massachusetts (6.0), in 1940 near Ossipee, New Hampshire (5.8), and in 1944 near Massena New York (5.9). Since the 1980s, moderate size earthquakes with a magnitude of 4.5 to 6.0 have occurred in Central New Hampshire, northern New York State and central New Brunswick. Typically the region experiences about 40-50 earthquakes per year, some of which are felt. For additional information on the earthquake history of Maine see Appendix B.

The Study Earthquake

The scenario earthquake used for this study is a probabilistic 2500 year earthquake with a scenario magnitude of 6. The location and magnitude for this event is based on scenarios developed by Professor John Ebel, Boston College, Weston Observatory (See Appendix C). Figure 1 illustrates the location of the study earthquake and Figure 2 the ground shaking caused by the event.

It is important to note that this event does not represent the largest earthquake that could affect Cumberland County, Maine. In fact, the United States Geological Survey (USGS) has indicated that an earthquake with a magnitude of up to 7.0 could occur at any time anywhere on the east coast of the United States.

The Study Area

The area chosen for this study was Cumberland County, Maine with a land area of approximately 835 square miles and a 2010 US Census population of 281,674. The study area includes 66 census tracts which are the basic units of analysis for the HAZUS Methodology.

Figure 1 illustrates the location of the study area.

IV. DIRECT ECONOMIC IMPACT

General Building Stock

HAZUS estimates losses to the general building stock using default national inventories. This report was compiled based on HAZUS default data and has been augmented using available state and county data. Damage to the general building stock is not evaluated on a building by building basis. Rather, the methodology estimates losses based on the general character of the building stock (e.g. occupancy, age, height, floor area, type and class) in each census tract. Damage estimates are then converted into dollar losses. The direct losses to the general building stock were estimated to be $1,158,646,000. HAZUS estimates the total value of the building stock exposure for Cumberland County, Maine to be $38,909,008,000.

Therefore, these losses represent approximately 2.98 percent of the total value of the building stock. These total losses include direct building damage (structural, non-structural, contents and inventory) and income losses (relocation, income, wages and rental). Direct losses are $938,355,000 or 80.98 percent of the total losses with income losses of $220,291,000 accounting for the remaining 19.0 percent. Table 1 contains additional information on direct economic losses for buildings. Figure 3 is a map of Economic Losses to Buildings by census tracts.

Transportation Systems

The HAZUS default database of transportation facilities was created with data obtained from sources such as the Federal Highway Administration, the Federal Aviation Administration and the Census Bureau's Topographically Integrated Encoding and Referencing (TIGER) Files. Total losses to the transportation system are estimated at $35,145,000. The direct losses and post-earthquake probability of functionality by transportation mode were estimated to be as follows:

MODE	LOSS	RANGE OF PROBABILITY OF FUNCTIONALITY (%)
Highway Bridges	$471,000	99.8 - 99.9
Highway Roads	$0	100
Rail Tracks	$0	100
Rail Facilities	$452,000	86.1
Light Rail Facilities	*$N/A*	*N/A*

MODE	LOSS	RANGE OF PROBABILITY OF FUNCTIONALITY (%)
Bus Facilities	$1,015,000	84.4 - 86.1
Port Facilities	$18,076,000	84.6 - 90
Ferry Facilities	$0	100
Airport Runways	$0	100
Airport Facilities	$15,121,000	84.4 – 86.1

Facilities in italics have no HAZUS default data and therefore have no values for losses and functionality.

Table 2 contains additional information on direct economic losses for transportation systems. Figure 4 is a map of probability of functionality of highway bridges on the day of the earthquake.

Lifeline Utilities

The HAZUS methodology estimates losses for selected types of lifeline utilities. Lifeline utilities are vital to the function of a community or state. Damage to these systems can be devastating in terms of the health and safety of the citizens. Total direct losses to lifeline utilities were estimated at $449,994,000.

The direct total losses (facilities, pipelines and distribution lines) and post-earthquake facility functionality by type of utility were estimated to be as follows:

TYPE	LOSS	RANGE OF PROBABILITY OF FUNCTIONALITY (%)
Water Pipelines[1]	$547,000	N/A
Waste Water	$248,344,000	40.0 – 52.3
Oil	*$N/A*	*N/A*
Natural Gas Pipelines[1]	$102,000	67.5
Electric Power	$200,770,000	66.2 - 83.7
Communications	$232,000	77.8 – 89.8

[1] For more information on pipelines, see the Fire Following Earthquake section on page 12.

Facilities in italics have no HAZUS default data and therefore have no values for losses and functionality.

HAZUS estimated that no households or people would be without electric power and no households would be without potable water immediately following the earthquake.

Table 3 contains additional information on direct economic losses for utilities. Table 4 contains additional information about electric power and potable water system performance.

Essential Facilities

The HAZUS methodology estimates losses for selected types of essential facilities. These include hospitals, police stations, fire stations, emergency operating centers and schools. Schools are included because of the critical role they often play as emergency shelters. Estimated losses to essential facilities are expressed in terms of their ability to function immediately following the earthquake. The average range of probability of functionality for essential facilities was estimated as follows:

FACILITY	RANGE OF PROBABILITY OF FUNCTIONALITY (%)
Emergency Operations Centers (EOC's)	54.3 – 94.8
Police Stations	48.4 – 94.8
Fire Stations	42.5 – 92.8
Hospitals and Medical Care Facilities	48.4 - 81
Schools	47.7 – 96.5

Tables 5, 6, 7, 8 & 9 contain additional information about the functionality of hospitals, schools, emergency operations centers, police stations and fire stations respectively.

HIGH POTENTIAL LOSS FACILITIES HAZUS defines high potential loss facilities as dams and nuclear facilities. High potential loss facilities tend to be unique and complex facilities that require in-depth analysis by structural and geotechnical engineers to assess their vulnerability to earthquakes. For this reason, HAZUS is limited to providing information about the location of the study area's high potential loss facilities and estimated ground shaking. For the Cumberland County, Maine study, Figure 5 is a map of all dams in Cumberland County, Maine in relation to earthquake ground shaking.

Direct Social Impact

CASUALTIES HAZUS utilizes casualty statistics from previous earthquakes to estimate the number of casualties expected from this earthquake. Estimates of casualties are broken down into four severity levels as follows:

- Severity Level 1 - Injury requires basic medical aid without hospitalization
- Severity Level 2 - Injury requires medical hospitalization non-life threatening
- Severity Level 3 - Injury poses immediate life-threatening condition if not treated
- Severity Level 4 - Instantaneously killed or mortally injured.

Casualty estimates are based primarily on building damage, occupancy, time of day. Casualties are estimated for three times of day 2:00 AM, 2:00 PM and 5:00 PM. These three times were selected to evaluate the impact of population distributions primarily at home, at work and commuting. Casualty estimates range from a high of 266 at 2pm to a low of 118 at 2am. The greatest number of casualties occur at 2pm when most people are likely to be at work or school. Conversely, the fewest number of casualties occur at 2am when most people are likely to be at home.

Table 10 contains a detailed breakdown of casualties by time of day, location and severity.

DISPLACED HOUSEHOLDS AND SHELTERING NEEDS Earthquakes can cause loss of habitability of buildings which contain housing units. Loss of habitability is calculated directly from damage to residential occupancy inventory and loss of electric power and water.

The HAZUS methodology estimates the number of displaced households and the number of those households expected to seek shelter based on the number of non-functioning or inhabitable units. HAZUS estimated that 655 displaced households would result in approximately 354 people requiring emergency shelter. Individuals whose housing becomes uninhabitable will likely seek alternative shelter. Many will stay with friends and relatives. Others will stay in hotels. Some will stay in public shelters. In addition, observations from past disasters show that approximately 80% of the pre-disaster homeless population will seek public shelter in time of disaster.

Finally, data from recent earthquakes indicate that approximately one-third of those seeking public shelter came from residences with no or insignificant structural damage. This perceived structural damage coupled with seasonal variations in Cumberland County, Maine could result in a 50% increase in the estimate of people seeking shelter.

Table 11 contains a summary of estimated displaced households and shelter needs.

Induced Physical Damage

FIRE FOLLOWING EARTHQUAKE Fire following earthquake can cause severe losses as evidenced in the 1907 San Francisco Earthquake, the 1994 Northridge Earthquake and the 1995 Kobe Japan Earthquake. A lack of water to fight the fires due to broken water mains can further exacerbate the problem.

While HAZUS does not currently calculate the number of earthquake generated fires, it does estimate 30 broken water mains, and 122 leaks in the water distribution system. It also estimates 15 broken natural gas lines. These numbers are estimated based on the distribution of intensity of earthquake ground shaking and its impact on underground water and gas lines. These estimates can provide some insight as to the potential of fire following earthquake due to broken gas lines and the availability of water to fight fires flowing the earthquake. It should be pointed out that a more complete fire following earthquake model requires extensive input and analysis beyond the present scope of HAZUS.

Table 4 includes a summary of number of broken and leaking underground water and gas lines.

HAZARDOUS SUBSTANCES HAZUS defines hazardous substances as chemicals, reagents, or substances which exhibit physical or health hazards, whether the materials are in a usable or waste state.

The default database was developed using the EPA Toxic Release Inventory (TRI) Database of hazardous material sites. The HAZUS default database contains only those substances that are considered highly toxic, flammable or explosive. In addition it is limited to those facilities where large quantities are stored. Estimating earthquake losses related to the release of hazardous substances would require in-depth analysis by structural, and geotechnical engineers, health physicists, and chemical experts to assess their vulnerability to earthquakes. For this reason HAZUS is limited to providing geographic information about the location of the study area’s hazardous substances and estimated ground shaking. There are no hazardous materials facilities in the HAZUS default database for Cumberland County. It is recommended that this section is updated using available county data.

DEBRIS HAZUS includes a model that estimates two types of debris caused by earthquake ground shaking. The first type of debris is reinforced concrete and steel that tend to fall in large pieces. These large pieces of debris will need to be broken down into smaller pieces before they can be disposed of. It is likely that cranes and other heavy equipment would be required to remove this type of debris. It is estimated that 96 tons of concrete and steel debris will be generated from the earthquake.

The second type of debris include brick, wood, glass, furniture, equipment, plaster walls and other materials that are smaller in size and more easily removed with a bulldozer or hand held tools. It is estimated that the earthquake will generate 116 tons of brick wood glass and other small pieces of debris. The combined total debris is estimated to be 212 tons. This amount of debris would require an estimated 8.5 twenty-five ton truck loads to remove.

Table 12 contains a summary of the debris generated by the earthquake broken down by type of debris and county.

V. FIGURES, TABLES, AND APPENDICES

FIGURES

Figure 1: The Study Earthquake Scenario
Figure 2: Earthquake Ground Shaking
Figure 3: Economic Losses to Buildings
Figure 4: Highway Bridges Functionality
Figure 5: Dams of Cumberland County, Maine

TABLES

Table 1: Direct Economic Losses for Buildings
Table 2: Direct Economic Losses for Transportation
Table 3: Direct Economic Losses for Utilities
Table 4: Utility System Damage and Performance
Table 5: Hospital Functionality
Table 6: School Functionality
Table 7: Emergency Operations Center (EOC's) Functionality
Table 8: Police Station Functionality
Table 9: Fire Station Functionality
Table 10: Casualties Summary Report
Table 11: Shelter Summary Report
Table 12: Debris Summary Report

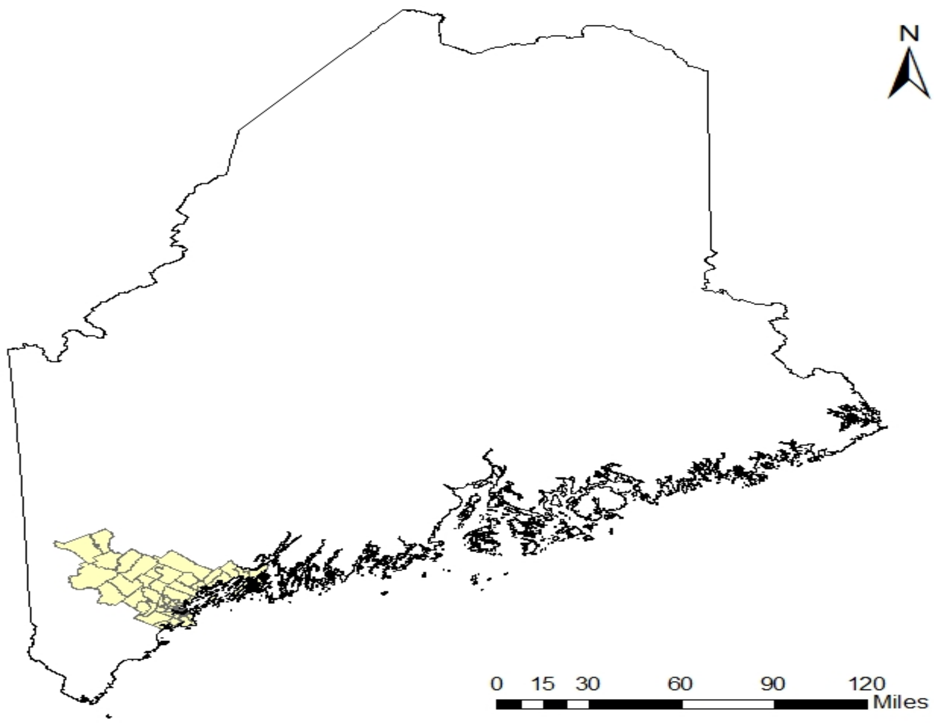
APPENDICES

Appendix A: USGS Earthquake Hazard Map
Appendix B: Earthquake History of Maine
Appendix C: New England Scenario Earthquakes to be used in HAZUS

Earthquake Scenario

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

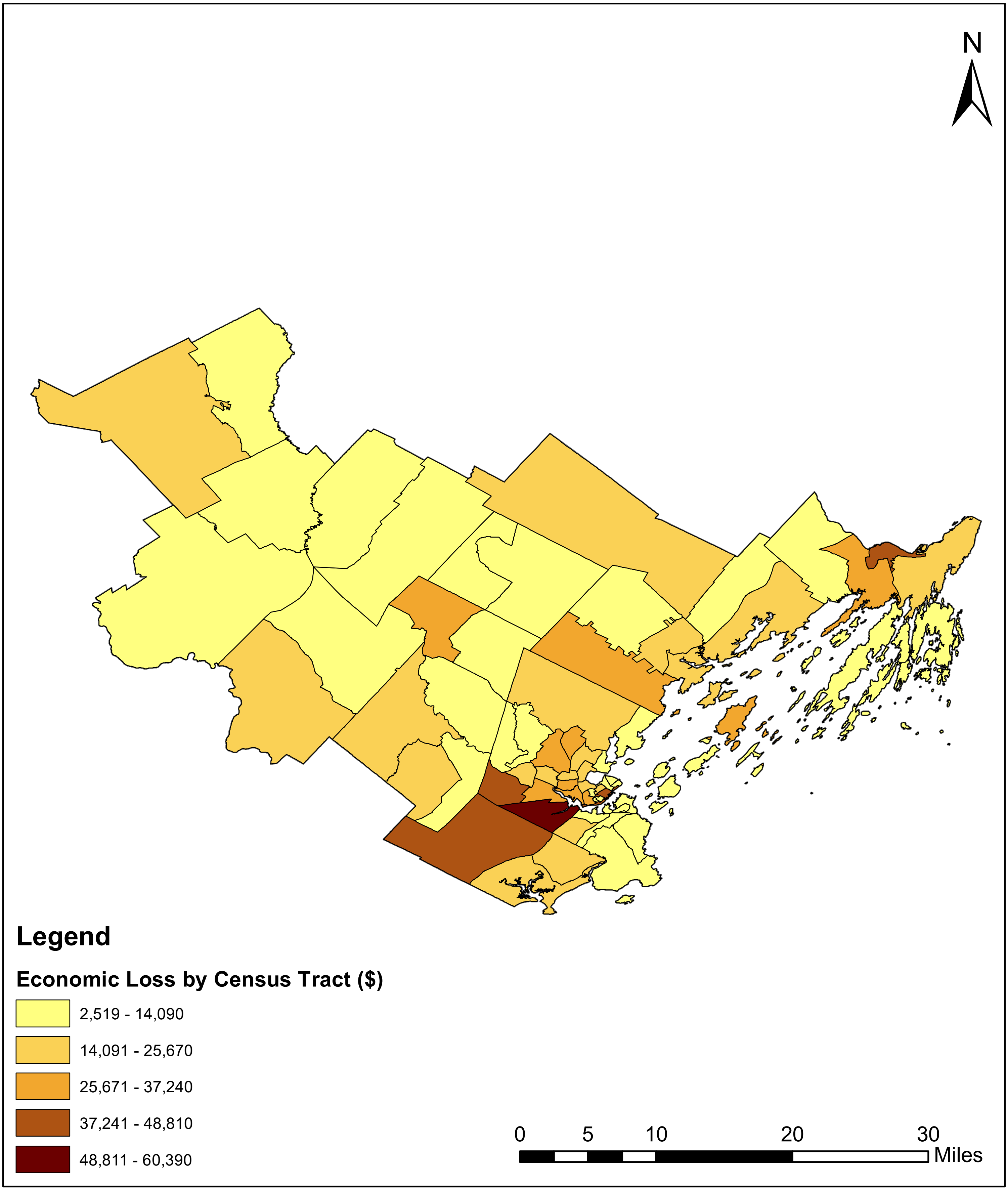
Cumberland County, Maine
2500 Year Probabilistic Earthquake Event



Scenario Name	prob2500
Type of Earthquake	Probabilistic
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	2,500.00
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

Economic Losses for Buildings
2500 Year Probabilistic Earthquake Event
Cumberland County, Maine

Figure 3



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Direct Economic Losses For Buildings

June 24, 2020

All values are in thousands of dollars

	Capital Stock Losses					Income Losses				
	Cost Structural Damage	Cost Non-struct. Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Maine										
Cumberland	118,618	545,074	267,797	6,866	1.71	74,277	43,457	58,723	43,834	1,158,646
Total	**118,618**	**545,074**	**267,797**	**6,866**	**1.71**	**74,277**	**43,457**	**58,723**	**43,834**	**1,158,646**
Region Total	**118,618**	**545,074**	**267,797**	**6,866**	**1.71**	**74,277**	**43,457**	**58,723**	**43,834**	**1,158,646**

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 : mastercumberland1

Scenario : prob2500

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Direct Economic Loss For Transportation

June 24, 2020

All values are in thousands of dollars

	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Maine								
Cumberland								
Segments	0	0	0					0
Bridges	471	10	0					481
Tunnels	0	0	0					0
Facilities		452	0	1,015	18,076	0	15,121	34,664
Total	**471**	**462**	**0**	**1,015**	**18,076**	**0**	**15,121**	**35,145**
Total	**471**	**462**	**0**	**1,015**	**18,076**	**0**	**15,121**	**35,145**
Region Total	**471**	**462**	**0**	**1,015**	**18,076**	**0**	**15,121**	**35,145**

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.

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Direct Economic Loss For Utilities

June 24, 2020

All values are in thousands of dollars

	Potable Water	Waste Water	Oil Systems	Natural Gas	Electric Power	Communication	Total
Maine							
Cumberland							
Facilities	0	248,069	0	102	200,770	232	449,173
Pipelines	547	275	0	0			822
Total	547	248,344	0	102	200,770	232	449,994
Total	**547**	**248,344**	**0**	**102**	**200,770**	**232**	**449,994**
Region Total	**547**	**248,344**	**0**	**102**	**200,770**	**232**	**449,994**

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.

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	0	0	0	0	0
Waste Water	24	0	0	4	24
Natural Gas	1	0	0	1	1
Oil Systems	0	0	0	0	0
Electrical Power	5	0	0	5	5
Communication	28	0	0	28	28

Expected Utility System Pipeline Damage (Site Specific)

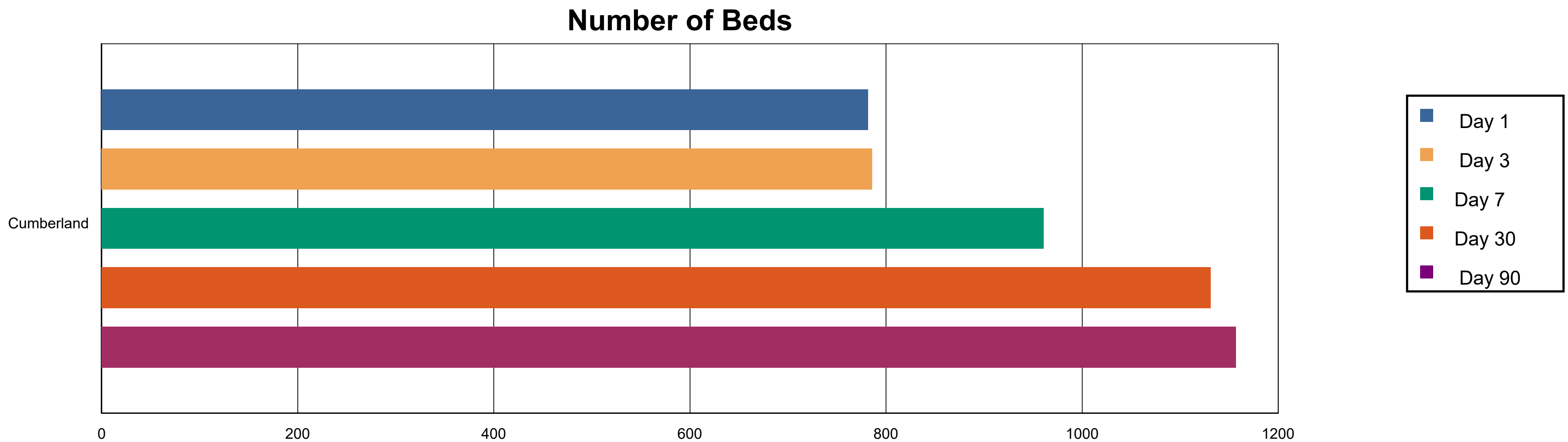
System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	7,018	122	30
Waste Water	4,211	61	15
Natural Gas	103	0	0
Oil	0	0	0

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	117,339	0	0	0	0	0
Electric Power		0	0	0	0	0

Hospital Functionality

June 24, 2020



		At Day 1		At day 3		At day 7		At day 30		At day 90	
	Total # of Beds	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Maine											
Cumberland											
Large Hospital	867	601	69.30	603	69.60	712	82.10	827	95.40	846	97.60
Medium Hospital	293	189	64.57	190	65.00	243	83.10	284	97.00	288	98.40
Small Hospital	25	16	64.00	16	64.30	20	78.00	24	94.00	24	96.90

		At Day 1		At day 3		At day 7		At day 30		At day 90	
	Total # of Beds	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Total	1,185	782	66.00	786	66.30	961	81.10	1,131	95.50	1,157	97.60
Total	1,185	782	66.00	786	66.30	961	81.10	1,131	95.50	1,157	97.60
Region Total	1,185	782	65.96	786	66.30	961	81.07	1,131	95.47	1,157	97.63

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

June 24, 2020

	Count	Functionality (%)
Maine		
Cumberland	119	74.10
Cumberland	10	57.60
Total	**129**	**65.90**
Region Total	**129**	**65.90**

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.

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Emergency Operation Center Functionality

June 24, 2020

	Count	Functionality(%) At Day 1
Maine		
Cumberland	29	74.30
Total	**29**	**74.30**
Region Total	**29**	**74.30**

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.

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Police Station Facilities Functionality

June 24, 2020

	Count	Functionality(%) At Day 1
Maine		
Cumberland	21	75.90
Total	**21**	**75.90**
Region Total	**21**	**75.90**

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.

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Fire Station Facilities Functionality

June 24, 2020

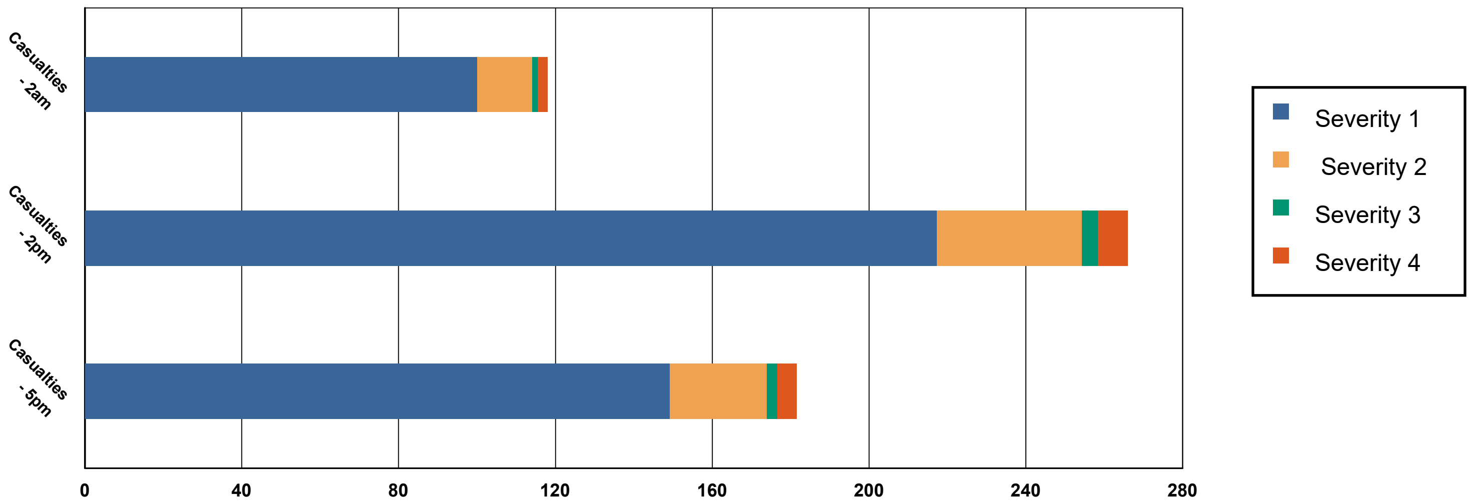
	Count	Functionality(%) At Day 1
Maine		
Cumberland	32	71.80
Total	**32**	**71.80**
Region Total	**32**	**71.80**

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.

Casualties Summary Report

June 24, 2020

Region Total Casualties



	Injury Severity Level				
	Severity 1	Severity 2	Severity 3	Severity 4	Total
Maine					
Cumberland					
Casualties - 2am					
Commuting	0	0	0	0	0
Commercial	3	0	0	0	3
Educational	0	0	0	0	0
Hotels	0	0	0	0	0
Industrial	2	0	0	0	2
Other-Residential	62	10	1	2	75
Single Family	34	3	0	0	37
Total Casualties - 2am	**100**	**14**	**1**	**2**	**118**
Casualties - 2pm					
Commuting	0	0	0	0	0
Commercial	141	24	3	5	173
Educational	44	8	1	2	55
Hotels	0	0	0	0	0
Industrial	14	2	0	0	17
Other-Residential	12	2	0	0	14
Single Family	6	1	0	0	7

	Injury Severity Level				
	Severity 1	Severity 2	Severity 3	Severity 4	Total
Maine					
Cumberland					
Total Casualties - 2pm	**217**	**37**	**4**	**8**	**266**
Casualties - 5pm					
Commuting	0	0	0	0	0
Commercial	98	17	2	3	120
Educational	6	1	0	0	7
Hotels	0	0	0	0	0
Industrial	9	1	0	0	11
Other-Residential	24	4	0	1	29
Single Family	13	1	0	0	14
Total Casualties - 5pm	**149**	**25**	**3**	**5**	**182**
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.

RiskMAP
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Shelter Summary Report

June 24, 2020

	# of Displaced Households	# of People Needing Short Term Shelter
Maine		
Cumberland	655	354
Total	**655**	**354**
Region Total	**655**	**354**

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 : mastercumberland1

Scenario : prob2500

Debris Summary Report

June 24, 2020

All values are in thousands of tons.

	Brick, Wood & Others	Concrete & Steel	Total
Maine			
Cumberland	116	96	212
Total	**116**	**96**	**212**
Region Total	**116**	**96**	**212**

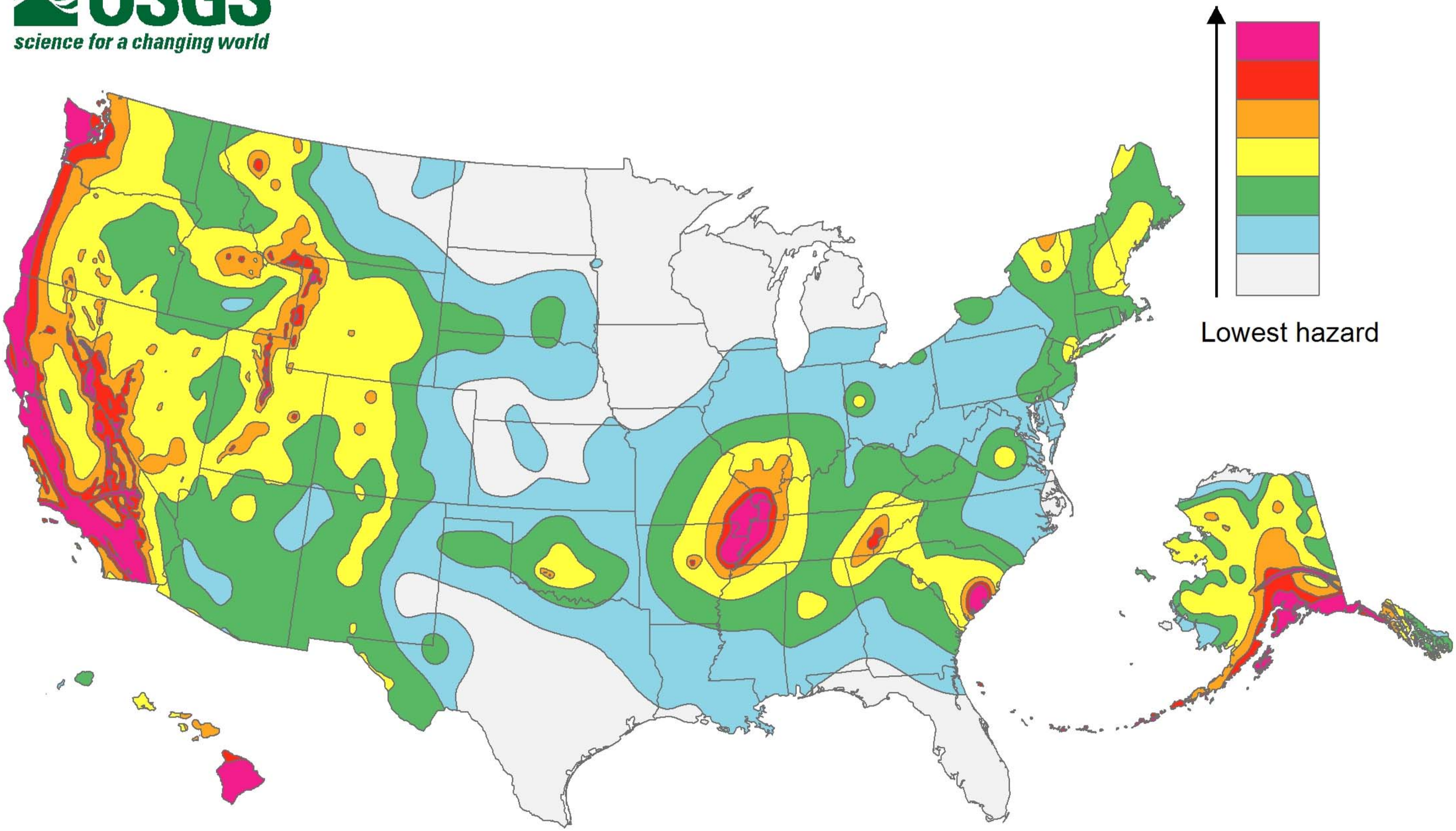
Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation.

Study Region : mastercumberland1

Scenario : prob2500

Appendix A

USGS Earthquake Hazard Map

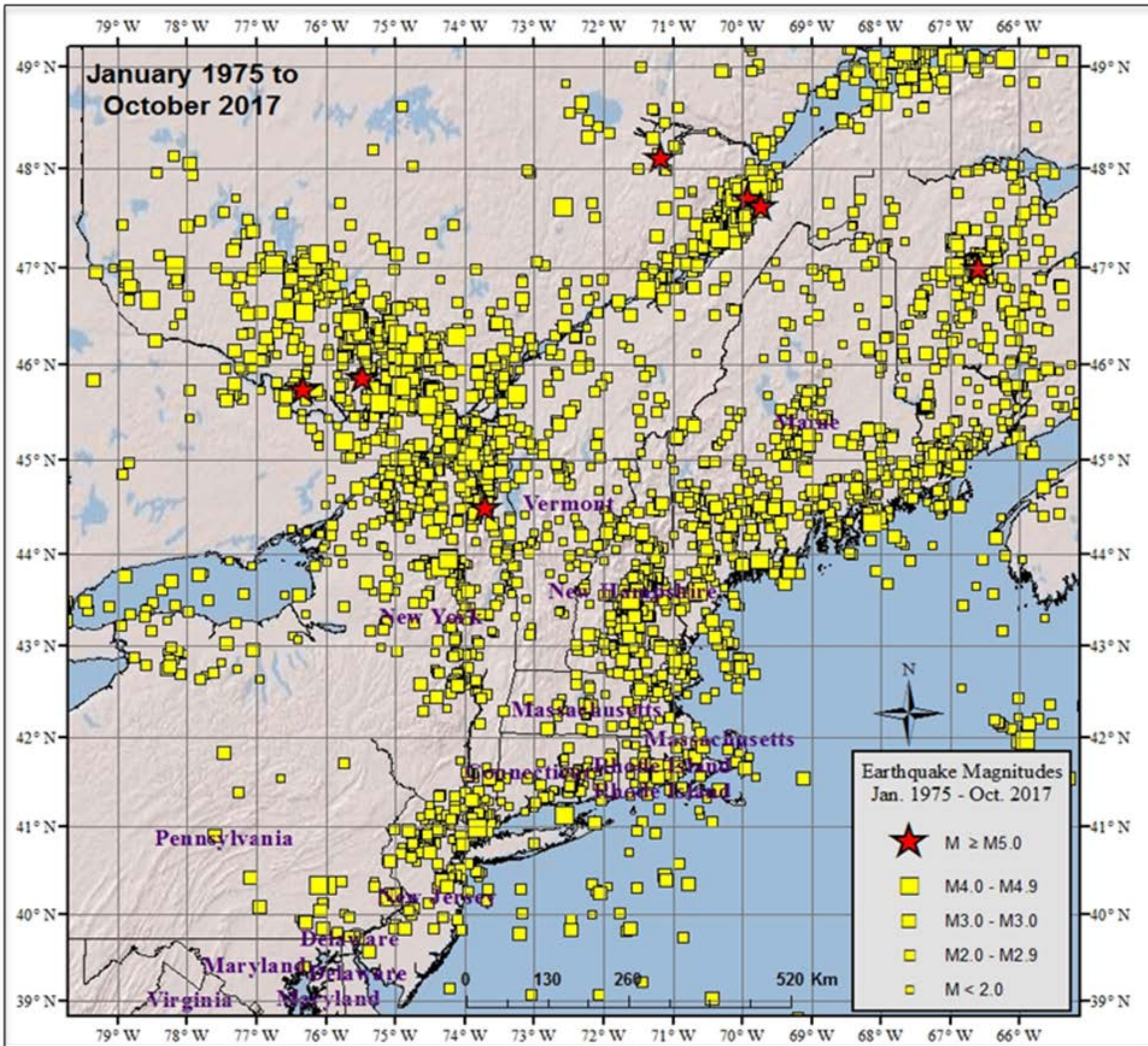


NESEC

Northeast States Emergency Consortium
www.nesec.org

Earthquake History of Maine

Although European missionaries and colonists began establishing settlements in Maine in the 1600s, the first earthquake likely centered in Maine was not recorded until January 23, 1766 when a small shake was reported felt in Portland. Through 2016 over 450 felt earthquakes are known to have been centered somewhere in Maine, with earthquake epicenters in almost all parts of the state. The first significant earthquake in Maine occurred on May 22, 1817 when the central and eastern parts of the state were rocked by a strong shake. This earthquake, also felt strongly in eastern New Brunswick, is thought to have been about magnitude 4.5 to 5.0 and to have been centered somewhere in the area of Passamaquoddy Bay. Another widely felt earthquake took place on January 16, 1855.



Map of Earthquakes of the Northeastern US and Southeastern Canada 1975 to 2017

This seismic event was felt throughout western Maine and New Hampshire, with an estimated epicenter somewhere near Otisfield, Maine and a magnitude about 5.0. It reportedly moved objects on shelves and rang bells in the epicentral area. On December 23, 1857, an earthquake was felt throughout southcentral Maine and caused some minor damage to plaster and a few chimneys at Lewiston. The epicenter was probably somewhere west of Lewiston, and the magnitude of the event was about 4.5.

The strongest known earthquake centered in the state of Maine occurred on March 21, 1904. With an epicenter somewhere between Bar Harbor and Passamaquoddy Bay, this earthquake was felt from Nova Scotia to Vermont and Connecticut and had an estimated magnitude of about .5.9. Damage to chimneys and masonry walls was reported at a number of towns in eastern Maine as well as at towns around Passamaquoddy Bay in New Brunswick. On July 15, 1905, an earthquake of estimated magnitude 4.5 was felt from southern New Hampshire to central Maine. The epicenter of this event is thought to have been near Sabbatus. An earthquake of similar magnitude struck southern Maine on August 21, 1918. The epicenter is thought to have been somewhere near Bridgeton and Norway. Starting on February 8, 1928 with an event of magnitude about 4.5, a swarm of earthquakes was felt in central Maine at the towns of Milo and Dover-Foxcroft. The swarm lasted several days. Another earthquake shock of about magnitude 4.3 centered in this same area took place on January 14, 1943. On April 26, 1957, there was an earthquake of about magnitude 3.8 that was centered just east of Portland, which did some minor damage in that city and nearby towns.

Number of Felt Earthquakes in the Northeast States			
State	**Years of Earthquake Record**	**Number of Felt Earthquakes**	**Years with Damaging Earthquakes**
Connecticut	1678-2016	115	1791
Maine	1766-2016	454	1973, 1904
Massachusetts	1668-2016	408	1727, 1755
New Hampshire	1638-2016	320	1638, 1940
New Jersey	1738-2016	98	1884
New York	1737-2016	551	1737, 1929, 1944, 1983, 2002
Rhode Island	1766-2016	34	
Vermont	1843-2016	50	
Total Number of Felt Earthquakes		2030	

Even in more recent times, Maine has experienced notable earthquakes. On June 14, 1973, a magnitude 4.7 earthquake was centered at the Maine-New Hampshire-Quebec border region. It caused some minor damage near its epicenter and was felt throughout all of New England and eastern New York. On October 2, 2006, a magnitude 4.2 earthquake was centered at Bar Harbor. This event, which was felt throughout southern and central Maine, caused several rock falls in Acadia National

Park, which blocked a couple of roads and damaged some hiking trails. On October 16, 2012, a magnitude 4.0 earthquake centered near Hollis Center was felt from Bangor to Connecticut.

Earthquakes Outside of Maine Having Notable State Impacts

Several strong earthquakes centered outside of Maine have had notable impacts in the state. The October 29, 1727 magnitude 5.6 earthquake at Newbury, MA was felt throughout the coastal communities of Maine. The November 18, 1755 magnitude 6.2 earthquake, which likely had an epicenter east of Cape Ann, MA, damaged chimneys along south coastal Maine from the New Hampshire border to Portland. Strong earthquakes in the Charlevoix seismic zone in Quebec on October 17, 1860 (magnitude 6.0), October 20, 1870 (magnitude 5.9) and March 1, 1925 (magnitude 6.2) cracked some plaster and chimneys in the northern part of the state, and all three events were felt throughout Maine. On October 22, 1869, a strong earthquake with a magnitude about 5.9 centered in New Brunswick was felt strongly throughout the state of Maine. The November 18, 1929 magnitude 7.2 earthquake that was centered south of Newfoundland and that caused a damaging tsunami there was also felt throughout Maine. A magnitude 5.8 earthquake on January 9, 1982 from central New Brunswick caused some minor damage in towns in northeastern Maine, and a magnitude 5.9 earthquake on November 25, 1988 centered north of Quebec City caused very minor damage in northernmost Maine. Both of these earthquakes were felt throughout the state.

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Appendix C

New England Scenario Earthquakes To Be Used in HAZUS