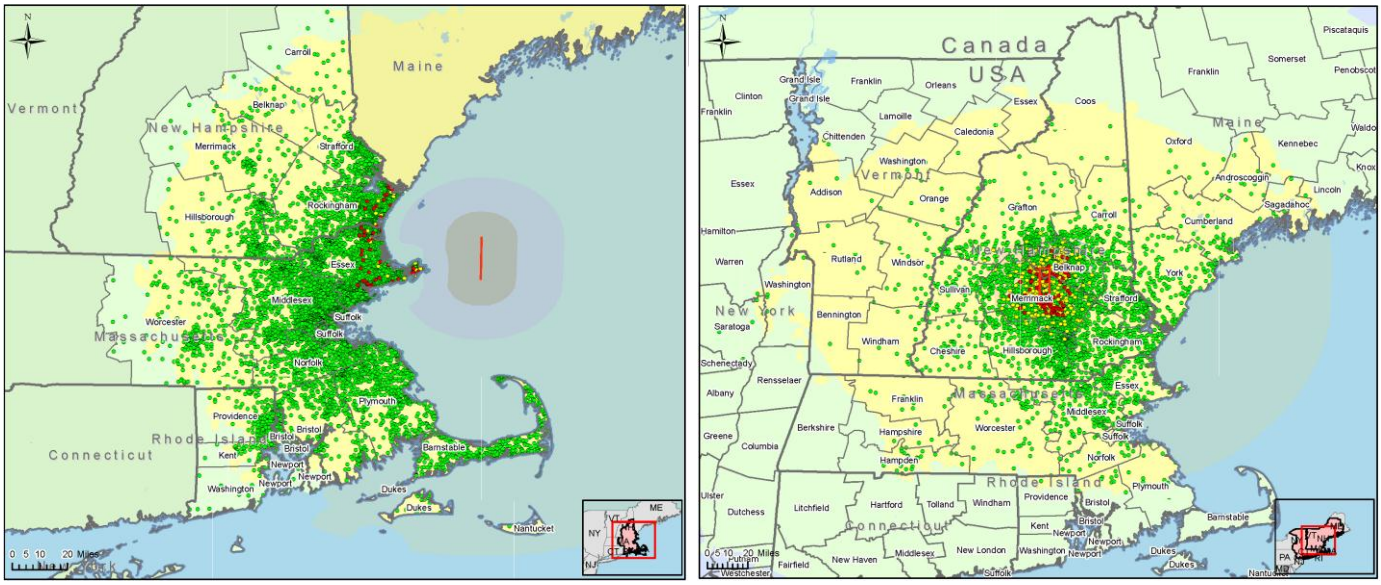
HAZUS ANALYSES OF ELEVEN SCENARIO EARTHQUAKES IN NEW ENGLAND



Prepared for

Federal Emergency Management Agency
99 High Street, 6th Floor
Boston, MA 02110

Prepared by

Ivan Wong and Fabia Terra
Seismic Hazards Group
URS Corporation
1333 Broadway, Suite 300
Oakland, CA 94612

Douglas Bausch and Jesse Rozelle
FEMA, Mitigation Division, Region VIII
Denver, CO 80225

Paul Morey
Risk Analysis Branch
FEMA Region I
Boston, MA 021110

Kenneth Rukstales
U.S. Geological Survey
Golden, CO 80401

John Ebel
Weston Observatory
Boston College
Weston, MA 02493

Laurence Becker
Vermont Geological Survey
Waterbury, VT 05671

Edward Fratto
Northeast States Emergency Consortium
Wakefield, MA 01880

September 2012

INTRODUCTION

The northeastern U.S. has been characterized by a moderate level of seismicity throughout its recorded history (Ebel and Kafka, 1991). Although the cause of this earthquake activity is unclear, seismicity tends to occur in some places more than others probably indicating there are some faults that are being activated or re-activated in the present-day stress field (Ebel and Kafka, 1991). Most of the damaging earthquakes in the northeastern U.S. have been in the range of moment magnitude (**M**) 5 to 6 but larger events are possible such as the 1638 Central New Hampshire earthquake, which may have been somewhere between **M** 6.5 to 7.0. The northeastern U.S. has also be impacted by large earthquakes in neighboring Canada particularly in the Charlevoix seismic zone, which has the potential for generating earthquakes of **M** 7 and larger. Hence the potential exists for large damaging earthquakes to strike again in the northeastern U.S. but with much more disastrous results because of the significant increase in population and the built environment since the beginning of the 20th century. In this study, losses have been estimated for 11 selected New England scenario earthquakes using FEMA's loss estimation software HAZUS.

Since 2004, under FEMA's Technical Assistance Research Contract (TARC), the Seismic Hazards Group of URS Corporation has been working with the HAZUS staff of FEMA Region VIII led by Doug Bausch in a project called the NEHRP Demonstration Project. The purpose of this project is to demonstrate the benefits of earthquake mitigation and to encourage the earthquake community to implement the National Earthquake Hazards Reduction Program (NEHRP) Strategic Plan.

The specific goals of the NEHRP Demonstration Project are to:

- Foster mitigation projects that are transferable to a wide range of geographic areas and applications.
- Conduct demonstration projects of two or more NEHRP agencies, in this case, FEMA and the U.S. Geological Survey (USGS) collaborating and partnering in common projects facilitated by NEHRP at the Federal level, but also encompassing state and local partners.
- Provide the necessary support to produce a project that ultimately benefits communities and the public at large and increases the awareness of the NEHRP.

To meet these goals, URS and FEMA identified a joint project between FEMA and the USGS, which would combine the benefits of ShakeMap and HAZUS. Estimates of potential losses including injuries, search and rescue, shelter, building inspection needs, and essential facility and lifeline functionality after a large earthquake are information critical for emergency management. However, ShakeMap coupled with HAZUS-MH can also provide planners and responders with valuable tools necessary to develop scientifically-grounded mitigation and response strategies as well as exercise earthquake response plans. Catalogs of ShakeMaps of potential scenario earthquakes and the HAZUS estimated losses for each scenario can be prepared for pre-disaster hazard mitigation and planning. Such information will enable state and local emergency management authorities to have "pre-scripted" estimates of earthquake impact and losses that will decrease response times and improve the speed at which recovery can begin. A key objective of this project was to use ShakeMaps to provide much more accurate ground motion hazard input into HAZUS-MH.

NEW ENGLAND SHAKEMAP/HAZUS WORKING GROUP

In March 2011, the New England ShakeMap/HAZUS Working Group was formed with the assistance of Paul Morey, FEMA Region I Earthquake Coordinator. Members of the Working Group included:

Ivan Wong, URS (Chair)
Douglas Bausch, FEMA Region VIII
Laurence Becker, Vermont Geological Survey
Brian Collins, FEMA Region I
John Ebel, Weston Observatory
Edward Fratto, Northeast States Emergency Consortium (NESEC)
Lauren McLane, FEMA Region I
Paul Morey, FEMA Region I
Paul Regan, FEMA Region I
Ken Rukstales, USGS
Fabia Terra, URS
Mike Tong, FEMA HQ
Erin Walsh, FEMA HQ

Members of the Working Group represented the key organizations involved in earthquake hazard mitigation in New England including NESEC, USGS, Northeast States Geological Surveys, FEMA Region I, and Weston Observatory. Two meetings of the Working Group were held at the Region I office in Boston in 2011: the kickoff meeting on 25 March and a meeting on 9 September to review the preliminary ShakeMaps. Other communications were through conference calls and emails. Joining the Working Group as an observer in the latest meeting held on 9 September was Miroslav Nastev of the Geological Survey of Canada (GSC). The GSC has expressed strong interest in collaborating with the Working Group in producing HAZUS estimates for eastern Canada.

SCENARIO EARTHQUAKES

As part of the Working Group's efforts, earthquake losses were estimated for 11 New England scenario earthquakes. A ShakeMap was produced for each scenario by Ken Rukstales of the USGS. The scenario earthquakes were selected prior to the formation of the Working Group by John Ebel, Paul Morey, Ed Fratto, Lauren McLane, and Brian Collins. The selected scenario events were presented to each of the state emergency management agencies for review. The states agreed with the selections.

The scenario earthquakes are listed below with their moment magnitudes (**M**) and their locations are shown on Figure 1. The scenarios are distributed throughout New England (Figure 1) and were generally selected based upon a historical precedence, i.e., a historical earthquake, which is referred to in Table 1.

- 1727 Newburyport, MA **M** 5.8
- Moodus, CT **M** 5.3
- Littleton, MA **M** 5.0
- Rumford, ME **M** 5.5
- 1755 Cape Ann Offshore, MA **M** 6.5
- 1663 Charlevoix, Canada **M** 7.5

- 1638 Central New Hampshire **M** 6.5
- 1904 Passamaquoddy Bay, ME **M** 6.2
- 1732 Montreal, Canada **M** 6.2
- 1983 Goodnow, NY **M** 5.8
- 2002 Plattsburgh, NY **M** 5.8

In all cases except one, the scenario events are known historical earthquakes with somewhat larger magnitudes than the estimated historical values. For the Newburyport, Moodus, Cape Ann, Passamaquoddy Bay, and Montreal earthquakes, all of which are near moderate to heavily populated areas, about 0.2 to 0.3 magnitude units were added to the best estimate magnitude for that event. For the Rumford, Goodnow, and Plattsburgh earthquakes in remote areas, about 0.8 to 1.0 magnitude unit were added to the largest earthquake magnitude (all instrumental magnitudes for events within that past 30 or so years) that are known.

The largest known earthquake in the Littleton area is about **M** 3.5 (instrumental since 1975). At that locality, which is quite active with small earthquakes, a **M** 5.0 was assumed to have a scenario earthquake within the Boston metropolitan area that would be capable of minor damage.

The 1663 Charlevoix and 1638 Central New Hampshire earthquakes were adopted as is for the scenario events. Note only in the case of the 1663 Charlevoix zone does the scenario earthquake that was selected represent a reasonable maximum magnitude for that location. In all other cases, the magnitudes are probably not the largest earthquakes that can occur at those sites. They are instead the "most likely" damaging scenario earthquakes.

Most of the earthquakes occur on blind or unknown faults and so there is no known causative fault for the majority of events. Fault parameters are listed in Table 1.

SHAKEMAP

ShakeMap is a geographic representation of the ground shaking produced by an earthquake (Wald *et al*., 1999). It can provide emergency management personnel information on the distribution of strong ground shaking to facilitate an informed and effective emergency response in the event of a catastrophic earthquake. Instrumental intensity (based on the Modified Mercalli [MM] scale) is one of the ways that ground shaking is expressed on ShakeMap, and it is easily correlated to expected damage. Other more quantitative measures of ground motion of interest to engineers include peak ground velocity (PGV), peak ground acceleration (PGA) (used in FEMA's Earthquake Structural Benefit-Cost Analysis module), and response spectral acceleration.

The strength of ShakeMap is that it provides a local or regional map of ground motion intensity produced by an earthquake based on both modeled shaking distribution and actual recordings at selected sites in real-time. The map portrays expected ground shaking at other locations where instruments are absent by use of ground motion prediction models. In a real earthquake, ShakeMap uses the ground motions recorded at all available strong motion stations to "correct" the model where it under- or overestimates shaking intensity. Because of the limited strong motion data in the central and eastern U.S., the ground motion prediction models rely on numerical ground motion modeling. The models used in the New England ShakeMaps are the same models used in the USGS National Seismic Hazard Maps (Petersen *et al*., 2008).

ShakeMap permits incorporation of the effect of local geology on ground shaking once the influence of geology is known theoretically or empirically. This effect is often referred to as site

amplification, which depends on the frequency content of the ground motion. ShakeMap currently uses NEHRP ground motion amplification factors based on studies of how California soils have responded to ground motion caused by various magnitude earthquakes.

ShakeMap can be generated at various spatial resolutions by the development of different scale map bases and grids. The base map is layered with a grid used in the modeling of ground motion, and each point of the grid is assigned an amplification factor based on a NEHRP classification.

NEHRP SITE CLASS MAP

For the New England ShakeMaps, a NEHRP site class map for the northeastern U.S. was developed by John Ebel (Figure 1). The NEHRP site class map was derived by starting with the surficial geology map of the central and eastern U.S. by Fullerton *et al*. (2003). In some places the surficial layer may be as thin as 1 m or less. For the purposes of this project, the surficial units on the Fullerton *et al*. (2003) are assumed to be at least 30 m thick. This is an uncertainty in the calculation of ShakeMap ground motions.

For each surficial unit shown on the map, a V_S30 (average shear-wave velocity in the top 30 m) was assigned. This was done by comparing the description of each surficial unit on the Fullerton *et al*. (2003) map with published relationships of lithology and V_S. The V_S30 values are shown on Figure 1. From the V_S30, the NEHRP site class is defined and with each site class there is an associated frequency- and amplitude-dependent amplification factor. It is known that the use of NEHRP amplification factors in the eastern U.S. may not be appropriate because the factors are based on observations of site response in California. The site response in some geologic situations in the eastern U.S. can be quite different (e.g., thin soil sites). Hence another uncertainty in ShakeMap.

There are soft soil sites (NEHRP E) in the northeastern U.S. However, these areas are small enough that they are below the resolution of the Fullerton *et al*. (2003) map. The Boston Harbor is one such area where the fill areas are likely NEHRP E. Hence the lack of addressing this site class is a significant uncertainty in our ShakeMaps.

HAZUS ANALYSIS

The default HAZUS analysis is a Level 1 analysis that uses a "canned" earthquake source within HAZUS along with the inventory available with the HAZUS software download. A Level 2 analysis incorporates additions to the HAZUS inventory as well as imported hazard potential maps that are used to assess ground shaking (i.e., ShakeMap) and sometimes liquefaction potential. Incorporation of new/modified inventory of essential facilities, updating the demographic information to using the Homeland Security Inflrastucture Program (HSIP) data from 2010, and the addition of the imported ShakeMaps bring the New England runs to a Level 2 HAZUS analysis.

HAZUS runs were made using version 2.0. Several changes were made to the default HAZUS databases. Schools, emergency operations centers (EOC), hospitals, and fire and police stations were added to the default HAZUS essential facilities database using data from the 2007 Homeland Security Infrastructure Program (HSIP). In the cases of missing information from HSIP, default HAZUS values were substituted.

A comprehensive summary packet that includes a set of up to 11 multi-risk maps was developed for each scenario earthquake. These maps include:

- Estimated Building Inspection Needs and Ground Shaking Intensity
- Estimated Building Economic Loss by Census Track and Ground Shaking Intensity
- Displaced Households and Ground Shaking Intensity
- Electrical, Natural Gas and Oil Facility Damage and Ground Shaking Intensity
- Estimated Debris and Highway Damage and Ground Shaking Intensity
- Estimated Highway Infrastructure Damage and Ground Shaking Intensity
- Impaired Hospitals (Day 1) and Ground Shaking Intensity
- Injuries Requiring Hospital Treatment 2 p.m. and Impaired Hospitals and Ground Shaking
- Potential Search and Rescue Needs 2 p.m. and Impaired Hospitals and Ground Intensity
- Short-Term Public Shelter Needs and Ground Shaking Intensity
- Estimated Potable Water Needs by County and Ground Shaking Intensity

In a few cases, a map may not have been produced or two maps may have been combined if the losses were very low. Included with the HAZUS maps are two versions of ShakeMap: a PGA map and a MM intensity map. The fault source that was modeled for each scenario earthquake is also shown on each map.

The maps, detailed loss summaries and losses for each state are contained in this report. No Canadian losses were calculated for any of the scenarios. In the case of three earthquakes, the areas analyzed had to be split into two regions due to a software limitation in HAZUS. The events were the Cape Ann, Central New Hampshire, and Goodnow scenario earthquakes.

The HAZUS results need to be viewed in the context of the limitations of regional loss estimation including the assumptions and simplifications that have to be made and the uncertainties associated with the seismic hazards input and inventory databases. **The uncertainties in the loss estimates were not explicitly quantified in this study and so the results should not be treated as if they were precise. A factor of two uncertainty in the cited losses would not be unusual.**

Table 2 summarizes the most significant U.S. losses in the 11 scenario earthquakes. The greatest losses are those associated with a repeat of the 1638 **M** 6.5 Central New Hampshire earthquake with total fatalities of nearly 100 people and more than 2,000 injuries (2 p.m.) and $8.3 billion in total economic losses including building and lifeline-related losses. This event is the largest onshore earthquake other than the repeat of the 1663 **M** 7.5 Charlevoix earthquake and so the high losses are expected.

The next most significant losses are sustained in a future **M** 5.8 Newburyport earthquake. Despite its moderate size, its occurrence in a highly populated area explains the high losses. A future offshore **M** 6.5 Cape Ann earthquake would result in one death, 245 injuries, and 246 extensively damaged buildings. Total economic losses are estimated to be about $3.4 billion.

The above estimates are probably low particularly for the Cape Ann earthquake because the extensive inventory of URM (unreinforced masonry) buildings has been underestimated, particularly for the Boston area. As previously stated, fill and alluvial areas along the waterfronts in Boston have also not been accounted for in the NEHRP site class map.

The losses should be considered **preliminary first-order** estimates that can be improved with future improvements in ShakeMap, HAZUS, and its inputs. Such improvements would include

incorporating (1) detailed NEHRP site class and liquefaction potential maps for the greater Boston area based on a surficial geological map from Professor Laurie Baise, Tufts University; (2) region-specific amplification factors; (3) improved building inventories including URM buildings from Ed Fratto for the city of Boston; and (4) 2010 census information.

ACKNOWLEDGMENTS

This project was supported by the TARC contract HSFEHQ-04-D-0733 to URS Corporation. Our sincere thanks to Jessie Rozelle, FEMA Region VIII for his assistance. Melinda Lee assisted in the preparation of this report.

REFERENCES

Brown, E.J. and Ebel, J.E., 1985, An investigation of the January 1982 Gaza, New Hampshire aftershock sequence: Earthquake Notes, v. 56, p. 125-133.

Ebel, J.E., 1989, A comparison of the 1981, 1982, 1986, and 1987-1988 microearthquake swarms at Moodus, Connecticut: Seismological Research Letters, v. 60, p. 177-183.

Ebel, J.E., 2000, A reanalysis of the 1727 earthquake at Newbury, Massachusetts: Seismological Research Letters, v. 71, p. 364-374.

Ebel, J.E., 2006, The Cape Ann, Massachusetts earthquake of 1755: a 250th anniversary perspective: Seismological Research Letters, v. 77, p. 74-86.

Ebel, J.E., 2011, A new analysis of the magnitude of the February 1663 earthquake at Charlevoix, Quebec: Bulletin of the Seismological Society of America, v. 101, p. 1024-1038.

Ebel, J.E. and Bouck, B.R., 1988, New focal mechanisms for the New England region: constraints on the regional stress regime: Seismological Research Letters, v. 59, 183-187.

Ebel, J.E. and Kafka, A.L., 1991, Earthquake activity in the northeastern United States, *in* D.B. Slemmons, E.R. Engdahl, M.D. Zoback, and D. Blackwell (eds.), Neotectonics of North America: Geological Society of America, Decade Map, v. 1, p. 277-290.

Ebel, J.E. and McCaffrey, J.P., 1984, Hypocentral parameters and focal mechanisms of the 1983 earthquake near Dixfield, Maine: Earthquake Notes, v. 55, p. 21-24.

Fullerton, D.S., Bush, C.A., and Pennell, J.N., 2003, Map of surficial deposits and materials in the Eastern and Central United States (east of 102° west longitude): U.S. Geological Survey Geologic Investigations Series Issue I-2789.

Nabelek, J. and Suarez, G., 1989, The 1983 Goodnow earthquake in the central Adirondacks, New York: rupture of a simple, circular crack: Bulletin of the Seismological Society of America, v. 79, p. 1762-1777.

Petersen, M.D., Frankel, A.D., Harmsen, S.C., Mueller, C.S., Haller, K.M., Wheeler, R.L., Wesson, R.L., Zeng, Y., Boyd, O.S., Perkins, D.M., Luco, N., Field, E.H., Wills, C.J., and Rukstales, K.S., 2008, Documentation for the 2008 update of the United States National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 2008-1128, 61 p.

Seeber, L., Kim, W-Y., Armbruster, J.G., Du, W-X., and Lerner-Lam, A., 2002, The 20 April 2002 Mw 5.0 earthquake near Au Sable Forks, Adirondacks, New York: a first glance at a new sequence: Seismological Research Letters, v. 73, p. 480-489.

Wald, D.J., Vincent Quitoriano, T.H. Heaton, H. Kanamori, C.W. Scrivner, and C. Bruce Worden, 1999, TriNet "ShakeMaps": Rapid generation of instrumental ground motion and intensity maps for earthquakes in Southern California: Earthquake Spectra, v. 15, p. 537-556.

Wells, D.L. and Coppersmith, K.J., 1994, New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement: Bulletin of the Seismological Society of America, v. 84, p. 974-1002.

Table 1

New England Scenario Earthquakes Parameters

No.	Earthquake Scenario[1]	Epicenter		Focal Depth (km)	Magnitude (M)	Fault Strike	Fault Dip	Fault Style	Depth to Top of Fault (km)	Depth to Bottom of Fault (km)	Subsurface Rupture Length[2] (km)	Subsurface Rupture Width[3] (km)	Point Source (PS)/ Finite Fault (FF)	Notes - URL
		Latitude (N)	Longitude (W)											
1	1727 Newburyport, MA (**M** 5.6)	42.84°	-70.98°	5	5.8	NW-SE	45°W	Reverse	1	5.2	10	6	FF	Larger repeat of 1727 Ebel (2000) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Newburyport5.8_se/
2	Moodus, CT	41.5°	-72.5°	5	5.3	NNE-SSW	45°	Reverse	1	3.8	5	4	PS	Larger repeat of 1791 Ebel (1989) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Moodus5.3_se/
3	Littleton, MA	42.55°	-71.48°	5	5.0	NW-SE	45°	Reverse	5	7.1	4	3	PS	Ebel (Estimated) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Littleton5.0_se/
4	Rumford, ME	44.49°	-70.40°	5	5.5	N-S	45°	Reverse	1	4.5	7	5	PS	Ebel and McCaffrey (EQ Notes, 1984) - http://earthquake.usgs.gov/earthquakes/shakemap/global/ shake/Rumford5.5_se/
5	1755 Cape Ann Offshore, MA (**M** 5.9)	42.7°	-70.3°	5	6.5	N-S	45°	Reverse	1	8.8	25	11	FF	Slightly larger than 1755 Ebel (2006) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/CapeAnn6.5_se/
6	1663 Charlevoix, Canada (**M** 7.5 ± 0.5)	47.6°	-70.1°	10	7.5	NE-SW	45°SE	Reverse	1	18.7	73	25	FF	Ebel (2011) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Charlevoix7.5_se/
7	1638 Central New Hampshire (**M** 6.5-7.0)	43.39°	-71.61°	5	6.5	N-S	45°W	Reverse	1	8.8	25	11	FF	Brown and Ebel (EQ Notes, 1985); Ebel and Bouck (SRL, 1988); Ebel (unpublished) – http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/CentralNewHampshire1638M6.5_se/
8	1904 Passamaquoddy Bay, ME (**M** 5.9)	45.0°	-67.2°	5	6.2	NW-SE	45°	Reverse	2	7.7	17	8	FF	Ebel (Estimated) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/PassamaquoddyBay6.2_se/
9	1732 Montreal, Canada (**M** 5.8)	45.5°	-73.6°	10	6.2	NW-SE	45°	Reverse	7	12.7	17	8	FF	Natural Resources Canada - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Montreal6.2_se/
10	1983 Goodnow, NY (**M** 5.3)	43.94°	-74.25°	10	5.8	N-S	60°W	Reverse	8	13.2	10	6	FF	Nabêlek and Suarez (1989) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/NY1983M5.8_se/
11	2002 Plattsburgh, NY (**M** 5.0)	44.51°	-73.68°	10	5.8	N-S	60°W	Reverse	8	13.2	10	6	FF	USGS; Seeber et al. (SRL, 2002) - http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Plattsburgh5.8_se/

Note: The 1983 Goodnow earthquake was used as a calibration event. Its fault source was located between depths of 6.5 to 8.5 km and had a rupture length of 2 km (Nabêlek and Suarez, 1989).

[1] Magnitudes in parentheses are the estimated values for the historical event. Modeled magnitudes are shown in "Magnitude" column.

[2] Subsurface rupture length (RLD) calculated using log (RLD) = -2.44 + 0.59 **M** (Wells and Coppersmith, 1994).

[3] Rupture width calculated using log RA = -3.49 + 0.91 **M** (Wells and Coppersmith, 1994) and then RA/RLD = RW.

Table 2

Summary of Significant U.S. Losses in New England Scenario Earthquakes*

Scenario	Magnitude (M)	Number of States Analyzed**	Total Fatalities (2AM)	Total Fatalities (2PM)	Total Fatalities (5PM)	Total Injuries (Severity 1, 2 3) at 2PM	Injuries Requiring Hospital Treatment (Severity 2 & 3) 2PM	Total Number of Buildings Extensively Damaged	Total Number of Buildings Completely Damaged	Total Economic Losses (millions of U.S. dollars)+	Total Building-Related Losses (millions of U.S. dollars) +	Total Transpor-tation System Losses (millions of U.S. dollars) +	Displaced Households	People Requiring Public Shelter (Individuals)	Debris Total in Millions of Tons	Truckloads of Debris (25 Tons Per Truckload)	People Without Power (Day 1)	People Without Potable Water (Day 1)
1727 Newburyport, MA	5.8	7	5	9	11	483	61	2,942	207	4,830	3,720	220	1,423	806	0.64	25,600	84,071	0
Moodus, CT	5.3	4	0	0	0	10	0	7	0	770	510	40	3	2	0.02	800	11,763	0
Littleton, MA	5.0	6	0	0	0	8	0	2	0	850	560	50	1	1	0.02	800	19,988	0
Rumford, ME	5.5	2	0	0	0	3	0	9	0	190	80	20	2	1	0.01	400	2,452	0
1755 Cape Ann Offshore, MA	6.5	4	0	0	1	245	14	246	2	3,392	2,606	195	149	88	0.35	14,200	29,038	0
1983 Goodnow, NY	5.8	4	0	0	0	3	0	20	0	160	60	10	1	0	0.01	400	495	0
No Losses Estimated for Canada																		
1663 Charlevoix, Canada	7.5	4	0	0	0	18	1	131	1	220	100	30	10	7	0.03	1,200	0	7
1638 Central New Hampshire	6.5	7	47	96	80	2,010	412	9,093	2,483	8,300	5,810	470	4,495	2,714	1.69	67,600	72,099	8,380
1904 Passamaquoddy Bay, ME	6.2	1	0	1	1	33	4	434	55	370	150	20	64	46	0.04	1,600	4,893	4
1732 Montreal, Canada	6.2	4	0	0	0	2	0	1	0	60	20	10	0	0	> 1	120	0	0
2002 Plattsburgh, NY	5.8	3	0	0	0	22	1	168	4	470	230	20	19	13	0.04	1,600	7,205	0

* **Disclaimer: The estimate of social and economic impacts illustrated on this table and the map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and the actual losses following a specific earthquake.**

** Ground motions with peak horizontal ground acceleration (PGA) exceeding 0.05 g

+ Values rounded to the nearest 10 million

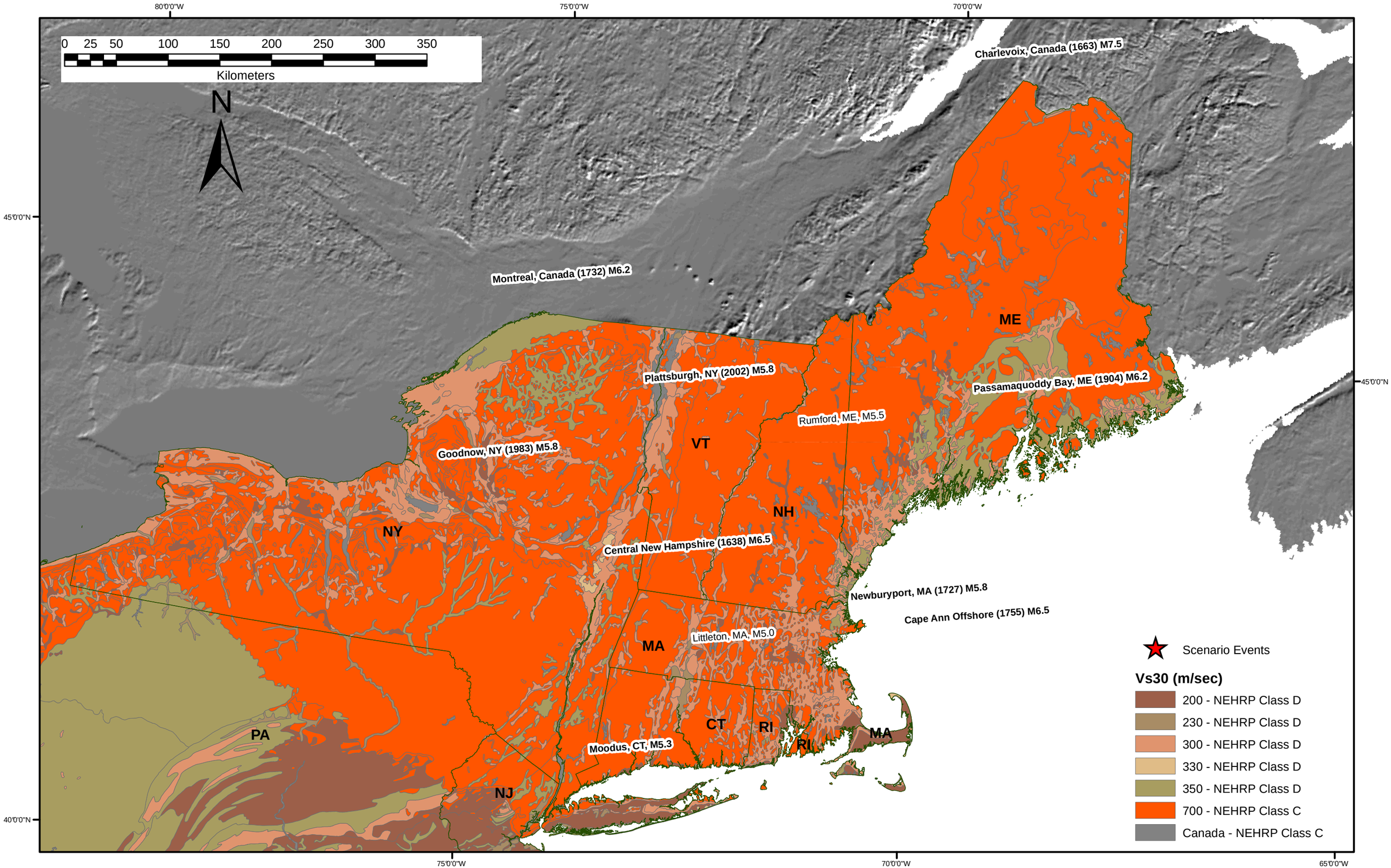


Figure 1 Scenario Earthquakes and Vs30 Map for New England

Central New Hampshire
M 6.5

Hazus-MH: Earthquake Event Report

Region Name: Central_NH_1638_M65_NY_CT_NJ

Earthquake Scenario: Central NH M65

Print Date: October 24, 2011

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

Table of Contents

Section	Page #
General Description of the Region	3
Building and Lifeline Inventory	4
Building Inventory	
Critical Facility Inventory	
Transportation and Utility Lifeline Inventory	
Earthquake Scenario Parameters	6
Direct Earthquake Damage	7
Buildings Damage	
Critical Facilities Damage	
Transportation and Utility Lifeline Damage	
Induced Earthquake Damage	11
Fire Following Earthquake	
Debris Generation	
Social Impact	12
Shelter Requirements	
Casualties	
Economic Loss	13
Building Losses	
Transportation and Utility Lifeline Losses	
Long-term Indirect Economic Impacts	
Appendix A: County Listing for the Region	
Appendix B: Regional Population and Building Value Data	

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 40 county(ies) from the following state(s):

Connecticut

New Jersey

New York

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

The geographical size of the region is 30,918.64 square miles and contains 3,381 census tracts. There are over 5,099 thousand households in the region which has a total population of 14,118,801 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 4,771 thousand buildings in the region with a total building replacement value (excluding contents) of 1,314,371 (millions of dollars). Approximately 90.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 312,820 and 48,253 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 4,771 thousand buildings in the region which have an aggregate total replacement value of 1,314,371 (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 76% 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 facilities (HPL). 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 192 hospitals in the region with a total bed capacity of 50,585 beds. There are 5,443 schools, 1,436 fire stations, 764 police stations and 96 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 2,263 dams identified within the region. Of these, 550 of the dams are classified as 'high hazard'. The inventory also includes 2,177 hazardous material sites, 0 military installations and 4 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 1 and 2.

The total value of the lifeline inventory is over 361,073.00 (millions of dollars). This inventory includes over 20,572 kilometers of highways, 12,425 bridges, 346,192 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	12,425	180,899.70
	Segments	8,353	120,351.20
	Tunnels	2	2.70
		Subtotal	**301,253.60**
Railways	Bridges	516	160.50
	Facilities	53	141.10
	Segments	2,098	4,780.40
	Tunnels	0	0.00
		Subtotal	**5,082.00**
Light Rail	Bridges	13	149.30
	Facilities	81	215.70
	Segments	103	524.00
	Tunnels	0	0.00
		Subtotal	**889.00**
Bus	Facilities	199	254.20
		Subtotal	**254.20**
Ferry	Facilities	47	62.60
		Subtotal	**62.60**
Port	Facilities	336	671.00
		Subtotal	**671.00**
Airport	Facilities	62	660.40
	Runways	104	3,948.30
		Subtotal	**4,608.60**
		Total	**312,820.90**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	3,461.90
	Facilities	53	2,075.60
	Pipelines	0	0.00
		Subtotal	**5,537.50**
Waste Water	Distribution Lines	NA	2,077.20
	Facilities	464	36,329.00
	Pipelines	0	0.00
		Subtotal	**38,406.10**
Natural Gas	Distribution Lines	NA	1,384.80
	Facilities	17	21.80
	Pipelines	0	0.00
		Subtotal	**1,406.60**
Oil Systems	Facilities	26	3.10
	Pipelines	0	0.00
		Subtotal	**3.10**
Electrical Power	Facilities	76	9,777.90
		Subtotal	**9,777.90**
Communication	Facilities	393	46.10
		Subtotal	**46.10**
		Total	**55,177.30**

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	Central NH M65
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	6.50
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Hazus estimates that about 119 buildings will be at least moderately damaged. This is over 0.00 % of the 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 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	19,671	0.41	16	0.74	1	0.96	0	0.72	0	0.00
Commercial	303,660	6.37	246	11.09	16	13.80	0	13.13	0	0.00
Education	10,643	0.22	8	0.34	0	0.36	0	0.30	0	0.00
Government	8,687	0.18	9	0.40	1	0.46	0	0.39	0	0.00
Industrial	92,115	1.93	67	3.04	4	3.77	0	2.82	0	0.00
Other Residential	903,347	18.94	1,007	45.34	51	42.79	0	28.89	0	0.00
Religion	20,761	0.44	20	0.89	1	1.03	0	1.15	0	0.00
Single Family	3,410,056	71.51	847	38.16	44	36.83	0	52.61	0	0.00
Total	**4,768,940**		**2,220**		**119**		**0**		**0**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3,606,855	75.63	167	7.52	0	0.00	0	0.00	0	0.00
Steel	228,850	4.80	121	5.47	9	7.34	0	4.21	0	0.00
Concrete	81,944	1.72	26	1.17	0	0.17	0	0.00	0	0.00
Precast	14,609	0.31	17	0.78	2	1.80	0	2.02	0	0.00
RM	107,978	2.26	30	1.37	3	2.11	0	0.00	0	0.00
URM	631,780	13.25	1354	60.99	84	70.21	0	93.77	0	0.00
MH	96,924	2.03	504	22.71	22	18.37	0	0.00	0	0.00
Total	**4,768,940**		**2,220**		**119**		**0**		**0**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 50,585 hospital beds available for use. On the day of the earthquake, the model estimates that only 50,270 hospital beds (99.00%) 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 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	192	0	0	192
Schools	5,443	0	0	5,443
EOCs	96	0	0	96
PoliceStations	764	0	0	764
FireStations	1,436	0	0	1,436

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: 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	8,353	0	0	8,353	8,353
	Bridges	12,425	0	0	12,425	12,425
	Tunnels	2	0	0	2	2
Railways	Segments	2,098	0	0	2,098	2,098
	Bridges	516	0	0	516	516
	Tunnels	0	0	0	0	0
	Facilities	53	0	0	53	53
Light Rail	Segments	103	0	0	103	103
	Bridges	13	0	0	13	13
	Tunnels	0	0	0	0	0
	Facilities	81	0	0	81	81
Bus	Facilities	199	0	0	199	199
Ferry	Facilities	47	0	0	47	47
Port	Facilities	336	0	0	336	336
Airport	Facilities	62	0	0	62	62
	Runways	104	0	0	104	104

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 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 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 9 provides a summary of the system performance information.

Table 7 : 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	53	0	0	53	53
Waste Water	464	0	0	464	464
Natural Gas	17	0	0	17	17
Oil Systems	26	0	0	26	26
Electrical Power	76	0	0	76	76
Communication	393	0	0	393	393

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	173,096	468	117
Waste Water	103,858	235	59
Natural Gas	69,239	81	20
Oil	0	0	0

Table 9: 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	5,099,454	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 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (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 0.01 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 93.00% 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 360 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 14,118,801) 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 10 provides a summary of the casualties estimated for this earthquake

Table 10: 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	2	0	0	0
	Single Family	1	0	0	0
	Total	**3**	**0**	**0**	**0**
2 PM	Commercial	2	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	**4**	**0**	**0**	**0**
5 PM	Commercial	2	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	0	0	0	0
	Total	**3**	**0**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 95.15 (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 56.28 (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 42 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	0.02	0.54	0.02	0.16	0.74
	Capital-Related	0.00	0.01	0.46	0.01	0.02	0.51
	Rental	0.07	0.28	0.59	0.01	0.02	0.98
	Relocation	0.16	0.13	0.32	0.04	0.08	0.72
	Subtotal	**0.23**	**0.44**	**1.91**	**0.08**	**0.28**	**2.95**
Capital Stock Losses							
	Structural	0.83	0.64	0.90	0.21	0.21	2.79
	Non_Structural	7.74	6.49	9.54	4.11	2.23	30.11
	Content	4.91	2.60	7.19	2.97	1.96	19.63
	Inventory	0.00	0.00	0.19	0.59	0.03	0.80
	Subtotal	**13.48**	**9.72**	**17.81**	**7.89**	**4.44**	**53.33**
	Total	**13.71**	**10.16**	**19.73**	**7.97**	**4.72**	**56.28**

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 12 & 13 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 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	120,351.21	$0.00	0.00
	Bridges	180,899.70	$3.25	0.00
	Tunnels	2.71	$0.00	0.00
	Subtotal	**301253.60**	**3.30**	
Railways	Segments	4,780.39	$0.00	0.00
	Bridges	160.51	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	141.14	$1.24	0.88
	Subtotal	**5082.00**	**1.20**	
Light Rail	Segments	523.98	$0.00	0.00
	Bridges	149.27	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	215.70	$0.44	0.20
	Subtotal	**889.00**	**0.40**	
Bus	Facilities	254.16	$1.24	0.49
	Subtotal	**254.20**	**1.20**	
Ferry	Facilities	62.56	$0.43	0.69
	Subtotal	**62.60**	**0.40**	
Port	Facilities	670.99	$3.88	0.58
	Subtotal	**671.00**	**3.90**	
Airport	Facilities	660.36	$4.48	0.68
	Runways	3,948.26	$0.00	0.00
	Subtotal	**4608.60**	**4.50**	
	Total	**312820.90**	**15.00**	

Table 13: 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	2,075.60	$0.68	0.03
	Distribution Lines	3,461.90	$2.11	0.06
	Subtotal	**5,537.51**	**$2.78**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	36,329.00	$15.94	0.04
	Distribution Lines	2,077.20	$1.06	0.05
	Subtotal	**38,406.12**	**$16.99**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	21.80	$0.01	0.03
	Distribution Lines	1,384.80	$0.36	0.03
	Subtotal	**1,406.57**	**$0.37**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	3.10	$0.00	0.04
	Subtotal	**3.08**	**$0.00**	
Electrical Power	Facilities	9,777.90	$3.74	0.04
	Subtotal	**9,777.90**	**$3.74**	
Communication	Facilities	46.10	$0.02	0.05
	Subtotal	**46.07**	**$0.02**	
	Total	**55,177.25**	**$23.91**	

Table 14. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS		Total	%
First Year			
	Employment Impact	104,535	2.36
	Income Impact	510	0.17
Second Year			
	Employment Impact	35,200	0.80
	Income Impact	253	0.08
Third Year			
	Employment Impact	792	0.02
	Income Impact	66	0.02
Fourth Year			
	Employment Impact	47	0.00
	Income Impact	2	0.00
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(1)	0.00
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(2)	0.00

Appendix A: County Listing for the Region

Fairfield,CT

Hartford,CT

Litchfield,CT

Middlesex,CT

New Haven,CT

New London,CT

Tolland,CT

Windham,CT

Bergen,NJ

Morris,NJ

Passaic,NJ

Sussex,NJ

Albany,NY

Clinton,NY

Columbia,NY

Delaware,NY

Dutchess,NY

Essex,NY

Franklin,NY

Fulton,NY

Greene,NY

Hamilton,NY

Montgomery,NY

Nassau,NY

Orange,NY

Otsego,NY

Putnam,NY

Queens,NY

Rensselaer,NY

Rockland,NY

Saint Lawrence,NY

Saratoga,NY

Schenectady,NY

Schoharie,NY

Suffolk,NY

Sullivan,NY

Ulster,NY

Warren,NY

Washington,NY

Westchester,NY

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Connecticut					
	Fairfield	882,567	62,553	26,168	88,722
	Hartford	857,183	55,530	24,195	79,725
	Litchfield	182,193	13,303	4,968	18,271
	Middlesex	155,071	11,586	4,428	16,015
	New Haven	824,008	52,527	24,205	76,732
	New London	259,088	17,484	5,796	23,281
	Tolland	136,364	9,103	2,277	11,381
	Windham	109,091	6,350	2,398	8,748
Total State		**3,405,565**	**228,436**	**94,435**	**322,875**
New Jersey					
	Bergen	884,118	63,288	27,750	91,039
	Morris	470,212	36,382	15,078	51,460
	Passaic	489,049	26,889	12,267	39,156
	Sussex	144,166	9,749	3,032	12,782
Total State		**1,987,545**	**136,308**	**58,127**	**194,437**
New York					
	Albany	294,565	18,615	9,473	28,088
	Clinton	79,894	3,862	1,555	5,417
	Columbia	63,094	4,269	1,254	5,523
	Delaware	48,055	3,069	859	3,929
	Dutchess	280,150	18,637	5,327	23,964
	Essex	38,851	2,512	659	3,171
	Franklin	51,134	2,511	784	3,295
	Fulton	55,073	3,136	961	4,098
	Greene	48,195	3,242	776	4,019
	Hamilton	5,379	777	120	897
	Montgomery	49,708	2,470	1,004	3,475
	Nassau	1,334,544	111,337	36,901	148,238
	Orange	341,367	22,097	7,794	29,892
	Otsego	61,676	3,392	1,057	4,450
	Putnam	95,745	7,746	1,499	9,246
	Queens	2,229,379	130,195	28,411	158,606
	Rensselaer	152,538	8,846	2,825	11,671
	Rockland	286,753	20,466	6,625	27,091
	Saint Lawrence	111,931	5,390	1,606	6,996
	Saratoga	200,635	11,741	3,408	15,149
	Schenectady	146,555	9,138	5,606	14,745
	Schoharie	31,582	1,814	455	2,270
	Suffolk	1,419,369	118,835	39,844	158,680
	Sullivan	73,966	6,175	1,498	7,674
	Ulster	177,749	11,496	3,922	15,418
	Warren	63,303	4,410	1,550	5,961
	Washington	61,042	3,048	821	3,869
	Westchester	923,459	67,540	23,665	91,206

Total State		**8,725,691**	**606,766**	**190,259**	**797,038**
Total Region		**14,118,801**	**971,510**	**342,821**	**1,314,350**

Hazus-MH: Earthquake Event Report

Region Name: Central_NH_1638_M65_VT_MA_ME_NH_RI

Earthquake Scenario: Central NH M65

Print Date: October 25, 2011

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

Table of Contents

Section	Page #
General Description of the Region	3
Building and Lifeline Inventory	4
Building Inventory	
Critical Facility Inventory	
Transportation and Utility Lifeline Inventory	
Earthquake Scenario Parameters	6
Direct Earthquake Damage	7
Buildings Damage	
Critical Facilities Damage	
Transportation and Utility Lifeline Damage	
Induced Earthquake Damage	11
Fire Following Earthquake	
Debris Generation	
Social Impact	12
Shelter Requirements	
Casualties	
Economic Loss	13
Building Losses	
Transportation and Utility Lifeline Losses	
Long-term Indirect Economic Impacts	
Appendix A: County Listing for the Region	
Appendix B: Regional Population and Building Value Data	

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 57 county(ies) from the following state(s):

Maine

Massachusetts

New Hampshire

Rhode Island

Vermont

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

The geographical size of the region is 50,729.17 square miles and contains 2,352 census tracts. There are over 4,040 thousand households in the region which has a total population of 10,409,073 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 4,033 thousand buildings in the region with a total building replacement value (excluding contents) of 918,799 (millions of dollars). Approximately 91.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 243,909 and 56,992 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 4,033 thousand buildings in the region which have an aggregate total replacement value of 918,799 (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 79% 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 facilities (HPL). 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 218 hospitals in the region with a total bed capacity of 35,555 beds. There are 5,276 schools, 1,156 fire stations, 893 police stations and 175 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 3,116 dams identified within the region. Of these, 493 of the dams are classified as 'high hazard'. The inventory also includes 2,456 hazardous material sites, 0 military installations and 5 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 1 and 2.

The total value of the lifeline inventory is over 300,901.00 (millions of dollars). This inventory includes over 20,170 kilometers of highways, 11,462 bridges, 427,068 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	11,462	119,925.50
	Segments	7,619	109,038.80
	Tunnels	0	0.00
		Subtotal	**228,964.20**
Railways	Bridges	157	11.70
	Facilities	101	269.00
	Segments	3,011	5,483.00
	Tunnels	2	0.70
		Subtotal	**5,764.40**
Light Rail	Bridges	0	0.00
	Facilities	268	713.70
	Segments	347	699.60
	Tunnels	0	0.00
		Subtotal	**1,413.30**
Bus	Facilities	155	185.90
		Subtotal	**185.90**
Ferry	Facilities	85	113.10
		Subtotal	**113.10**
Port	Facilities	230	459.30
		Subtotal	**459.30**
Airport	Facilities	102	1,086.40
	Runways	156	5,922.40
		Subtotal	**7,008.80**
		Total	**243,909.00**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	4,270.70
	Facilities	47	1,786.20
	Pipelines	0	0.00
		Subtotal	**6,056.90**
Waste Water	Distribution Lines	NA	2,562.40
	Facilities	408	29,105.50
	Pipelines	0	0.00
		Subtotal	**31,667.90**
Natural Gas	Distribution Lines	NA	1,708.30
	Facilities	8	10.00
	Pipelines	0	0.00
		Subtotal	**1,718.30**
Oil Systems	Facilities	5	0.50
	Pipelines	0	0.00
		Subtotal	**0.50**
Electrical Power	Facilities	216	26,031.50
		Subtotal	**26,031.50**
Communication	Facilities	543	58.70
		Subtotal	**58.70**
		Total	**65,533.90**

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	Central NH M65
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	6.50
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Hazus estimates that about 47,367 buildings will be at least moderately damaged. This is over 1.00 % of the buildings in the region. There are an estimated 2,482 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 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	14,833	0.38	599	0.63	315	0.88	113	1.25	33	1.33
Commercial	223,452	5.74	8,288	8.73	3,976	11.11	1,594	17.54	478	19.25
Education	9,348	0.24	314	0.33	156	0.44	74	0.82	22	0.89
Government	7,999	0.21	257	0.27	201	0.56	166	1.82	54	2.17
Industrial	69,536	1.79	2,647	2.79	1,426	3.98	612	6.74	187	7.53
Other Residential	900,639	23.14	31,078	32.75	13,859	38.72	4,801	52.81	1,487	59.91
Religion	15,518	0.40	522	0.55	220	0.62	90	0.98	27	1.08
Single Family	2,650,173	68.10	51,202	53.95	15,639	43.69	1,642	18.05	195	7.84
Total	**3,891,497**		**94,906**		**35,792**		**9,093**		**2,483**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3,123,471	80.26	56125	59.14	17,543	49.01	1,433	15.77	37	1.48
Steel	177,261	4.56	5469	5.76	3,336	9.32	1,590	17.48	520	20.96
Concrete	59,698	1.53	2258	2.38	1,395	3.90	612	6.73	172	6.93
Precast	11,169	0.29	447	0.47	294	0.82	137	1.51	42	1.68
RM	98,489	2.53	1755	1.85	1,426	3.98	716	7.88	124	5.01
URM	303,533	7.80	17492	18.43	5,553	15.52	2,047	22.51	699	28.16
MH	117,877	3.03	11360	11.97	6,245	17.45	2,557	28.12	888	35.79
Total	**3,891,497**		**94,906**		**35,792**		**9,093**		**2,483**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 35,555 hospital beds available for use. On the day of the earthquake, the model estimates that only 32,569 hospital beds (92.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 96.00% of the beds will be back in service. By 30 days, 98.00% will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	218	6	0	210
Schools	5,276	115	0	5,050
EOCs	175	5	0	166
PoliceStations	893	39	0	830
FireStations	1,156	34	0	1,096

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: 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	7,619	0	0	7,619	7,619
	Bridges	11,462	32	0	11,430	11,442
	Tunnels	0	0	0	0	0
Railways	Segments	3,011	0	0	3,011	3,011
	Bridges	157	0	0	157	157
	Tunnels	2	0	0	2	2
	Facilities	101	0	0	101	101
Light Rail	Segments	347	0	0	347	347
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	268	0	0	268	268
Bus	Facilities	155	4	0	151	152
Ferry	Facilities	85	0	0	85	85
Port	Facilities	230	0	0	230	230
Airport	Facilities	102	2	0	100	102
	Runways	156	0	0	156	156

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 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 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 9 provides a summary of the system performance information.

Table 7 : 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	47	0	0	47	47
Waste Water	408	13	0	384	400
Natural Gas	8	0	0	8	8
Oil Systems	5	0	0	5	5
Electrical Power	216	19	0	189	211
Communication	543	20	0	528	540

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	213,534	2655	664
Waste Water	128,121	1334	333
Natural Gas	85,414	457	114
Oil	0	0	0

Table 9: 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	4,040,970	8,380	2,966	0	0	0
Electric Power		72,099	50,819	26,107	6,726	85

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 11 ignitions that will burn about 0.10 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 1,246 people and burn about 89 (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 1.68 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 67,200 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 4,495 households to be displaced due to the earthquake. Of these, 2,714 people (out of a total population of 10,409,073) 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 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	16	4	1	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	9	2	0	1
	Industrial	21	5	1	1
	Other-Residential	732	161	20	39
	Single Family	246	32	3	5
	Total	**1,024**	**204**	**25**	**47**
2 PM	Commercial	969	222	30	59
	Commuting	1	1	2	0
	Educational	284	67	10	19
	Hotels	2	0	0	0
	Industrial	154	35	5	9
	Other-Residential	140	32	4	8
	Single Family	43	6	1	1
	Total	**1,592**	**363**	**51**	**96**
5 PM	Commercial	750	173	24	45
	Commuting	21	27	47	9
	Educational	31	7	1	2
	Hotels	3	1	0	0
	Industrial	96	22	3	6
	Other-Residential	281	63	8	15
	Single Family	95	13	1	2
	Total	**1,277**	**305**	**84**	**80**

Economic Loss

The total economic loss estimated for the earthquake is 8,198.08 (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 5,751.03 (millions of dollars); 19 % 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 48 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	34.49	195.83	9.41	31.14	270.86
	Capital-Related	0.00	14.49	167.42	5.96	4.24	192.11
	Rental	20.00	83.98	111.55	3.90	15.90	235.33
	Relocation	74.56	64.22	159.52	18.71	76.95	393.96
	Subtotal	**94.56**	**197.18**	**634.32**	**37.98**	**128.23**	**1,092.27**
Capital Stock Losses							
	Structural	109.10	120.22	198.12	50.62	65.01	543.06
	Non_Structural	871.14	682.75	679.08	229.31	219.80	2,682.08
	Content	461.25	218.19	412.00	161.93	133.23	1,386.60
	Inventory	0.00	0.00	12.02	33.42	1.58	47.01
	Subtotal	**1,441.48**	**1,021.17**	**1,301.21**	**475.28**	**419.61**	**4,658.76**
	Total	**1,536.05**	**1,218.35**	**1,935.53**	**513.26**	**547.84**	**5,751.03**

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 12 & 13 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 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	109,038.76	$0.00	0.00
	Bridges	119,925.47	$341.41	0.28
	Tunnels	0.00	$0.00	0.00
	Subtotal	**228964.20**	**341.40**	
Railways	Segments	5,483.05	$0.00	0.00
	Bridges	11.69	$0.01	0.12
	Tunnels	0.66	$0.00	0.00
	Facilities	268.96	$11.10	4.13
	Subtotal	**5764.40**	**11.10**	
Light Rail	Segments	699.57	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	713.68	$29.03	4.07
	Subtotal	**1413.30**	**29.00**	
Bus	Facilities	185.90	$9.98	5.37
	Subtotal	**185.90**	**10.00**	
Ferry	Facilities	113.14	$2.54	2.24
	Subtotal	**113.10**	**2.50**	
Port	Facilities	459.31	$15.94	3.47
	Subtotal	**459.30**	**15.90**	
Airport	Facilities	1,086.40	$43.16	3.97
	Runways	5,922.38	$0.00	0.00
	Subtotal	**7008.80**	**43.20**	
	Total	**243909.00**	**453.20**	

Table 13: 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	1,786.20	$16.64	0.93
	Distribution Lines	4,270.70	$11.95	0.28
	Subtotal	**6,056.90**	**$28.59**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	29,105.50	$736.29	2.53
	Distribution Lines	2,562.40	$6.00	0.23
	Subtotal	**31,667.94**	**$742.29**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	10.00	$0.03	0.28
	Distribution Lines	1,708.30	$2.06	0.12
	Subtotal	**1,718.32**	**$2.08**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.50	$0.00	0.73
	Subtotal	**0.54**	**$0.00**	
Electrical Power	Facilities	26,031.50	$1,219.23	4.68
	Subtotal	**26,031.50**	**$1,219.23**	
Communication	Facilities	58.70	$1.67	2.85
	Subtotal	**58.67**	**$1.67**	
	Total	**65,533.86**	**$1,993.87**	

Table 14. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS		Total	%
First Year			
	Employment Impact	4,356,877	122.29
	Income Impact	17,946	8.44
Second Year			
	Employment Impact	1,546,857	43.42
	Income Impact	9,340	4.39
Third Year			
	Employment Impact	35,392	0.99
	Income Impact	2,440	1.15
Fourth Year			
	Employment Impact	1,995	0.06
	Income Impact	(6)	0.00
Fifth Year			
	Employment Impact	114	0.00
	Income Impact	(144)	-0.07
Years 6 to 15			
	Employment Impact	5	0.00
	Income Impact	(151)	-0.07

Appendix A: County Listing for the Region

Androscoggin,ME

Cumberland,ME

Franklin,ME

Hancock,ME

Kennebec,ME

Knox,ME

Lincoln,ME

Oxford,ME

Penobscot,ME

Piscataquis,ME

Sagadahoc,ME

Somerset,ME

Waldo,ME

York,ME

Barnstable,MA

Berkshire,MA

Bristol,MA

Dukes,MA

Essex,MA

Franklin,MA

Hampden,MA

Hampshire,MA

Middlesex,MA

Nantucket,MA

Norfolk,MA

Plymouth,MA

Suffolk,MA

Worcester,MA

Belknap,NH

Carroll,NH

Cheshire,NH

Coos,NH

Grafton,NH

Hillsborough,NH

Merrimack,NH

Rockingham,NH

Strafford,NH

Sullivan,NH

Bristol,RI

Kent,RI

Newport,RI

Providence,RI

Washington,RI

Addison,VT

Bennington,VT

Caledonia,VT

Chittenden,VT

Essex,VT

Franklin,VT

Grand Isle,VT

Lamoille,VT

Orange,VT

Orleans,VT

Rutland,VT

Washington,VT

Windham,VT

Windsor,VT

Appendix B: Regional Population and Building Value Data

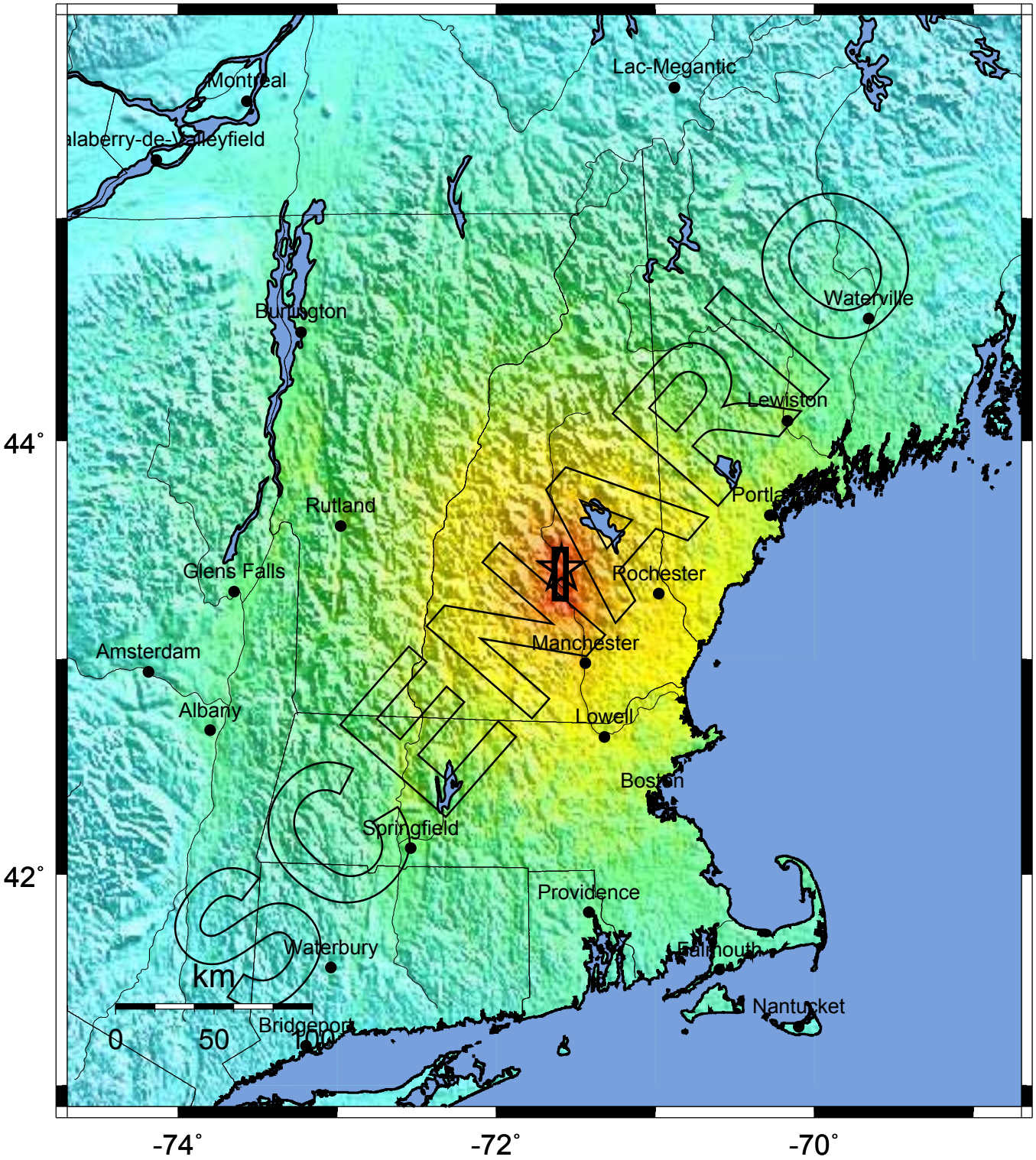
State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Maine					
	Androscoggin	103,793	5,208	2,016	7,224
	Cumberland	265,612	16,601	6,538	23,139
	Franklin	29,467	1,688	478	2,167
	Hancock	51,791	3,753	1,085	4,838
	Kennebec	117,114	6,291	2,188	8,479
	Knox	39,618	2,388	813	3,202
	Lincoln	33,616	2,358	622	2,980
	Oxford	54,755	3,392	899	4,291
	Penobscot	144,919	6,999	2,676	9,675
	Piscataquis	17,235	1,147	267	1,415
	Sagadahoc	35,214	1,942	468	2,410
	Somerset	50,888	2,498	765	3,264
	Waldo	36,280	1,791	559	2,351
	York	186,742	11,579	2,901	14,480
Total State		**1,167,044**	**67,635**	**22,275**	**89,915**
Massachusetts					
	Barnstable	222,230	23,858	5,614	29,472
	Berkshire	134,953	9,021	3,299	12,320
	Bristol	534,678	32,571	12,169	44,741
	Dukes	14,987	2,458	578	3,037
	Essex	723,419	44,561	15,650	60,212
	Franklin	71,535	4,371	1,677	6,049
	Hampden	456,228	26,881	12,455	39,337
	Hampshire	152,251	9,444	3,164	12,609
	Middlesex	1,465,396	102,752	42,073	144,825
	Nantucket	9,520	1,731	494	2,225
	Norfolk	650,308	48,205	18,485	66,691
	Plymouth	472,822	32,612	10,284	42,897
	Suffolk	689,807	40,215	25,601	65,816
	Worcester	750,963	47,390	19,448	66,838
Total State		**6,349,097**	**426,070**	**170,991**	**597,069**
New Hampshire					
	Belknap	56,325	3,656	1,164	4,821
	Carroll	43,666	3,776	920	4,697
	Cheshire	73,825	3,542	1,488	5,030
	Coos	33,111	1,760	653	2,413
	Grafton	81,743	4,393	1,698	6,092
	Hillsborough	380,841	20,779	8,609	29,389
	Merrimack	136,225	6,704	2,996	9,700
	Rockingham	277,359	16,201	6,625	22,826
	Strafford	112,233	4,988	1,904	6,892
	Sullivan	40,458	1,879	652	2,531
Total State		**1,235,786**	**67,678**	**26,709**	**94,391**
Rhode Island					

	Bristol	50,648	3,519	938	4,457
	Kent	167,090	11,322	3,860	15,183
	Newport	85,433	6,620	1,881	8,501
	Providence	621,602	35,932	15,327	51,260
	Washington	123,546	9,960	3,331	13,292
Total State		**1,048,319**	**67,353**	**25,337**	**92,693**
Vermont					
	Addison	35,974	1,871	657	2,528
	Bennington	36,994	2,458	962	3,420
	Caledonia	29,702	1,402	509	1,912
	Chittenden	146,571	7,279	3,361	10,641
	Essex	6,459	370	76	446
	Franklin	45,417	2,016	703	2,719
	Grand Isle	6,901	483	87	571
	Lamoille	23,233	1,230	461	1,691
	Orange	28,226	1,370	395	1,765
	Orleans	26,277	1,232	457	1,689
	Rutland	63,400	3,358	1,241	4,599
	Washington	58,039	3,015	1,374	4,390
	Windham	44,216	2,844	1,187	4,031
	Windsor	57,418	3,206	1,094	4,300
Total State		**608,827**	**32,134**	**12,564**	**44,702**
Total Region		**10,409,073**	**660,870**	**257,876**	**918,770**

-- Earthquake Planning Scenario --

ShakeMap for Central New Hampshire 1638 M6.5 Scenario

Scenario Date: Wed Sep 7, 2011 12:00:00 GMT M 6.5 N43.41 W71.59



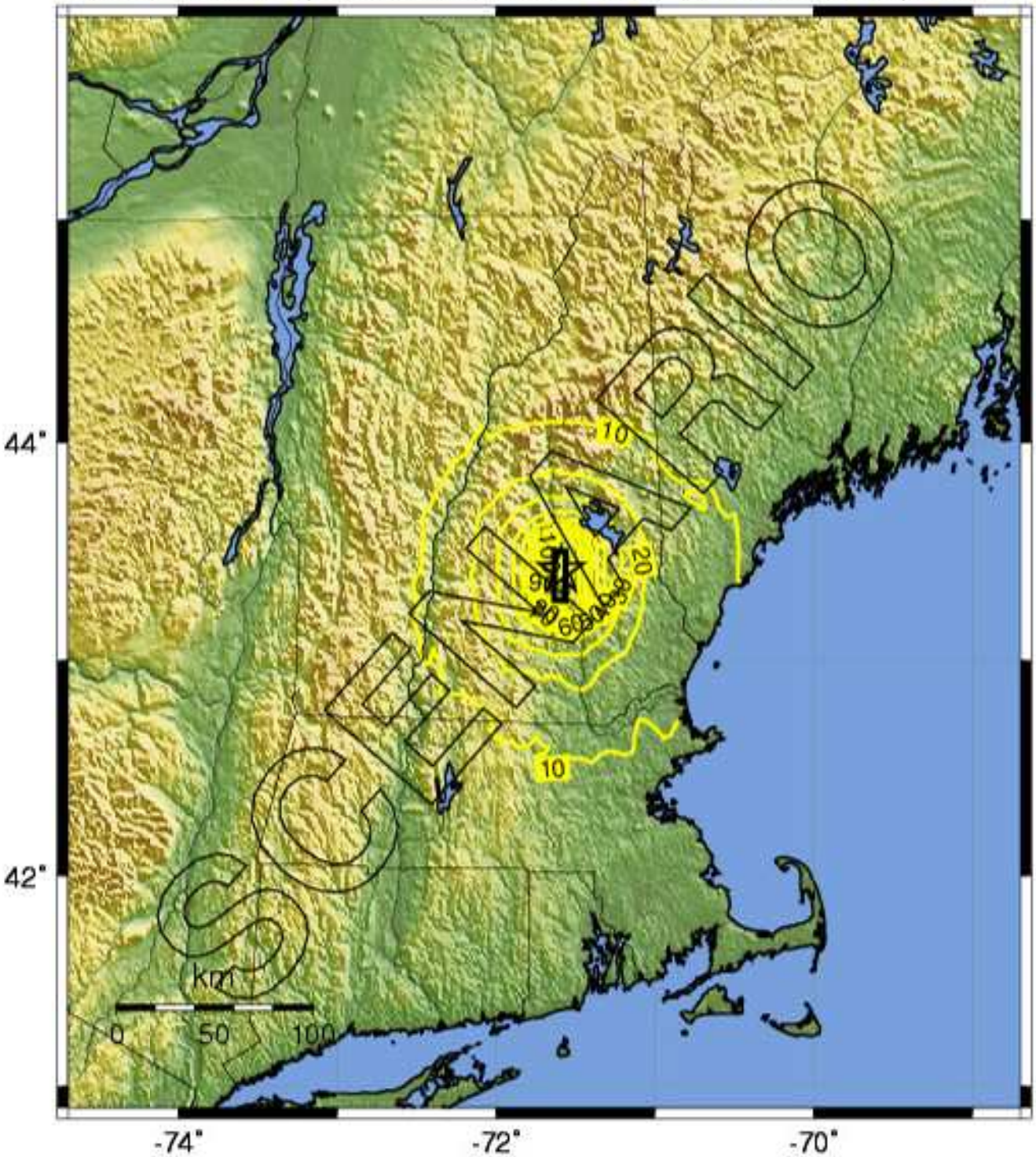
PLANNING SCENARIO ONLY -- Map Version 5 Processed Thu Sep 8, 2011 05:51:47 PM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

-- Earthquake Planning Scenario --

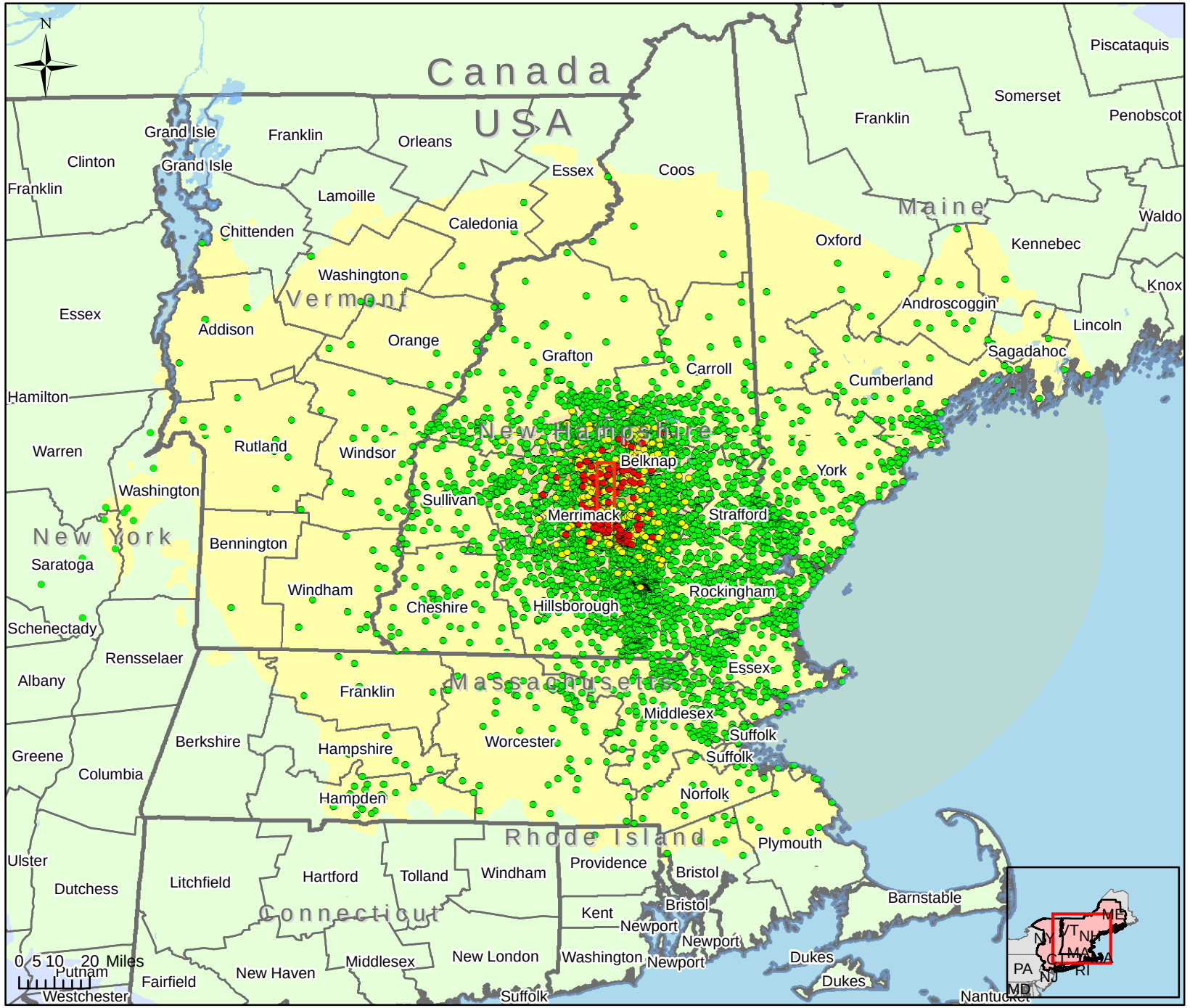
Peak Accel. Map (in %g) for CentralNewHampshire1638M6.5 Scenario

Scenario Date: Fri Sep 2, 2011 12:00:00 GMT M 6.5 N43.41 W71.59



PLANNING SCENARIO ONLY -- Map Version 1 Processed Mon Sep 5, 2011 12:10:04 PM MDT

Estimated Building Inspection Needs and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

- **Red Tag (Complete Damage)**
- **YellowTag (Extensive Damage)**
- **GreenTag (Slight/Moderate Damage)**

1 Dot = 25 Buildings (by census tract)

* Estimated number of inspectors needed to complete inspections in 30 days

	Estimated # of Structures	Estimated # of Inspectors
Red (Complete)	2,483	17
Yellow (Extensive)	9,093	121
Green (Slight/ Moderate)	133,037	887

Fault Source

Instrumental Intensity

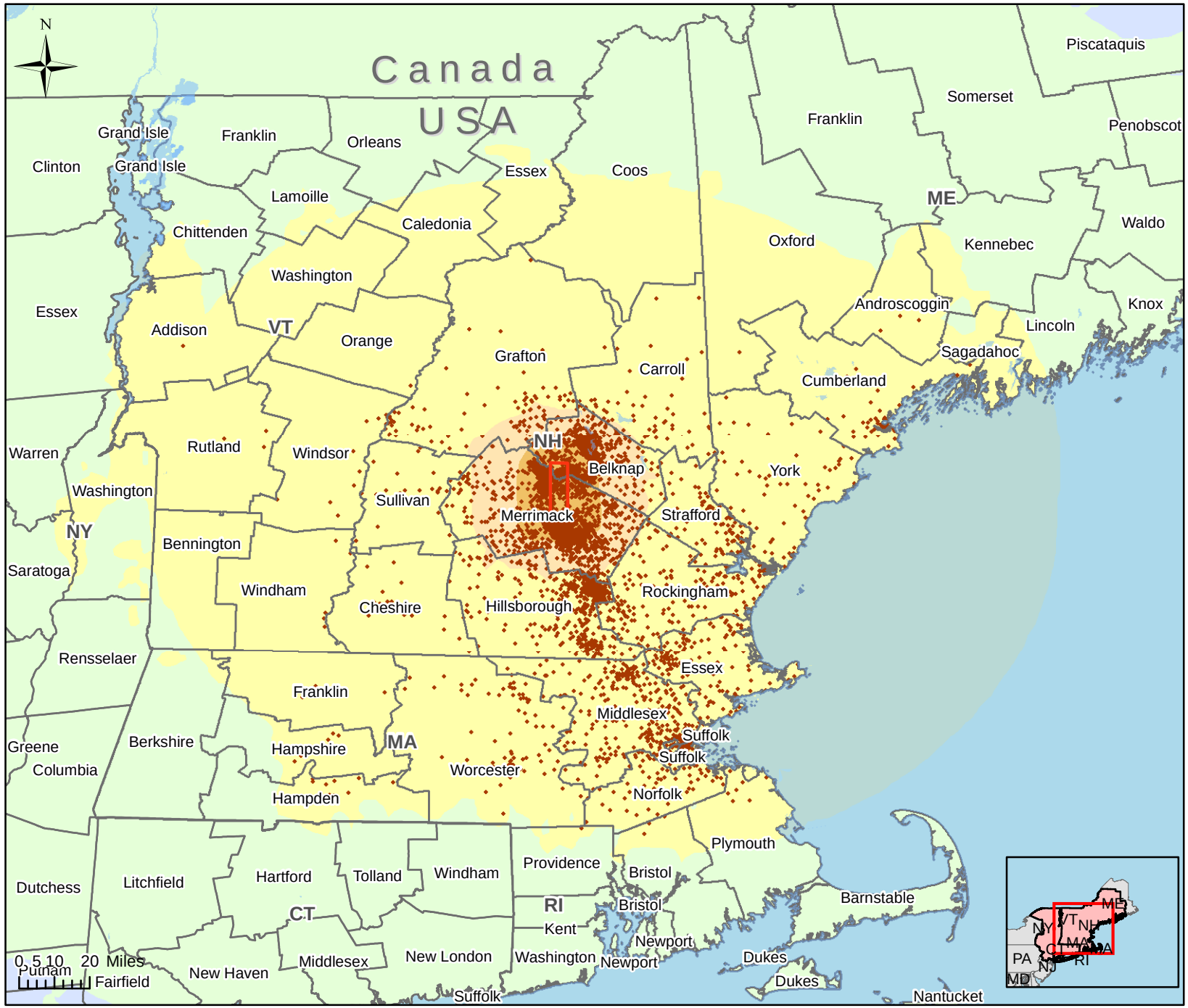
Not felt | Weak | Light | Moderate | Strong | Very strong | Severe | Violent | Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Estimated Building Economic Loss by County and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

Direct Economic Losses

(Losses include all building-related losses)

1 Dot = $10 Million

Fault Source

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

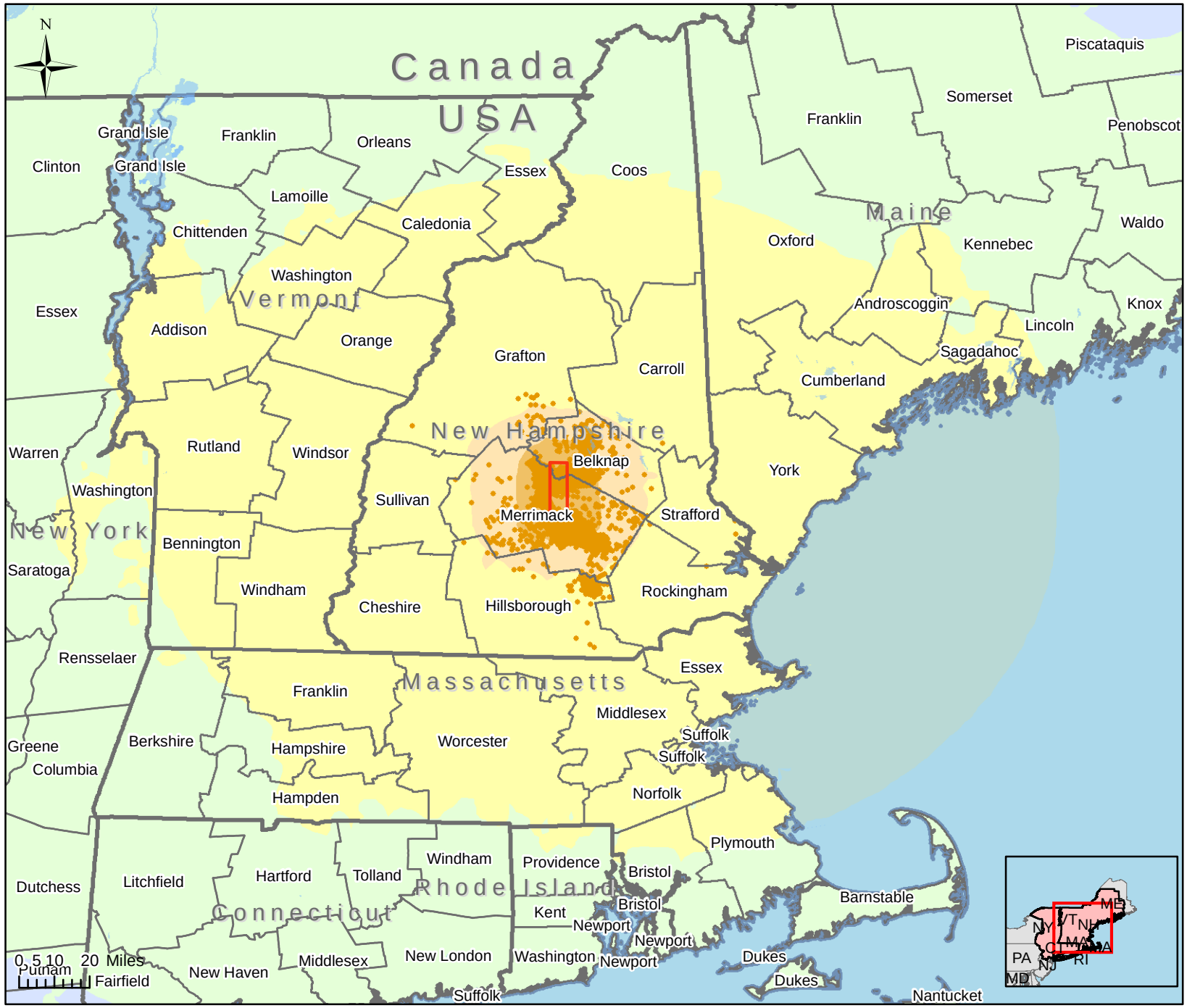
Cost Structural Damage	Cost Non-Structural Damage	Total Loss (Including Contents)
$546	$2,712	$4,712
all values in Millions		
Total Loss $4.7 Billion		

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Displaced Households and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

● 1 Dot = 1 Household

Shelter Requirements	Total #
Displaced Households	4,495

Earthquakes can cause loss of function or habitability of buildings that contain housing units, resulting in approximately predictable numbers of displaced households. Loss of habitability is calculated directly from damage to the residential occupancy inventory, and from loss of water and power.

Fault Source

Instrumental Intensity

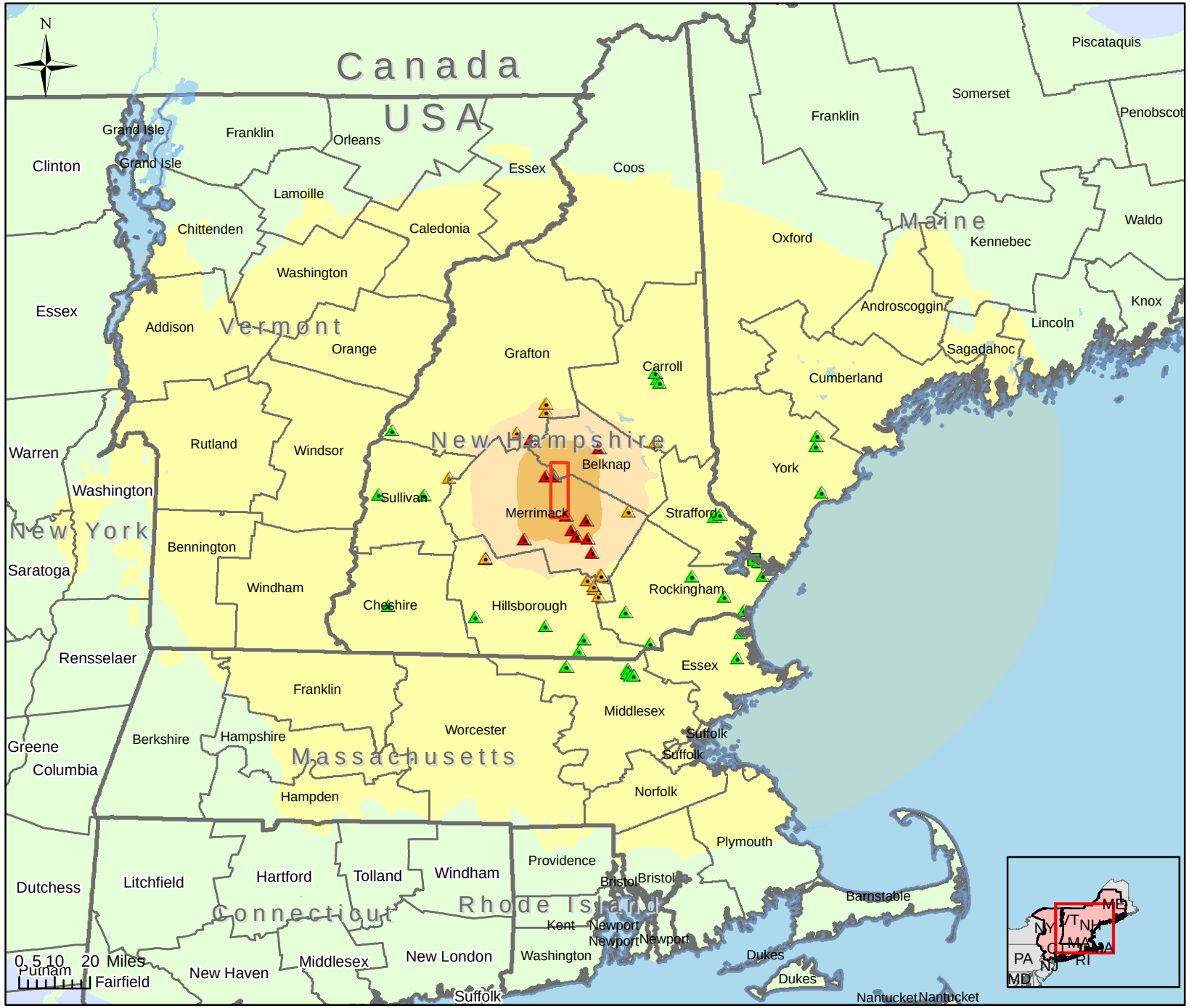
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Electrical, Natural Gas & Oil Facility Damage and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

Utility Facility Damage (at least moderate)

Damage is expressed as the probability that a given hospitalwill realize at least moderate damage.

Electric Power

- Low
- Moderate
- High

Fault Source

Instrumental Intensity

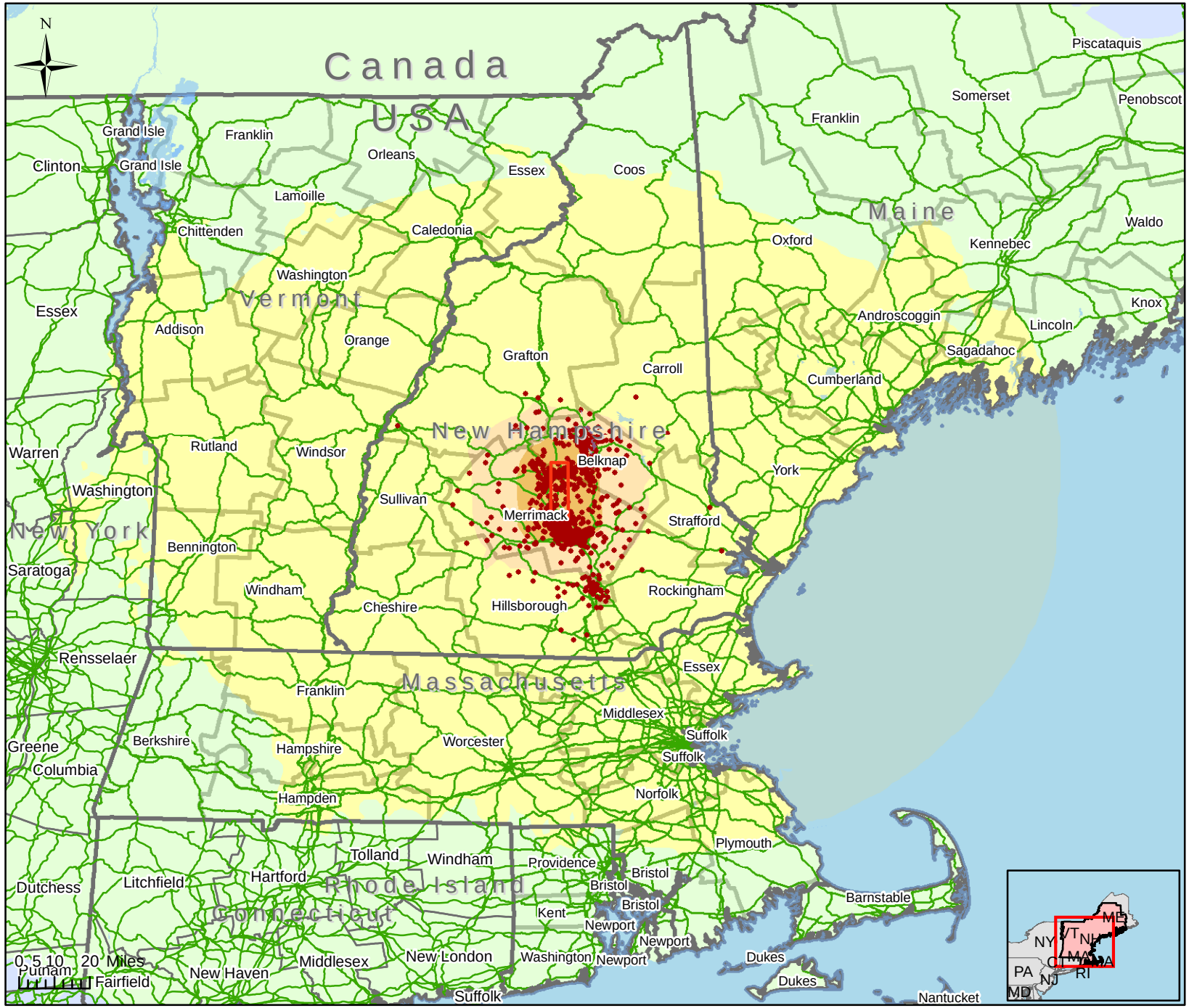
Not felt	Strong
Weak	Very strong
Light	Severe
Moderate	Violent
	Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Estimated Debris and Highway Damage and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

1 dot = 10 thousand tons of Concrete and Steel Debris (by Census Tract)

Debris Totals	Total (in tons)	Estimated Truck Loads*
Brick and Wood	**769,000**	30,760
Concrete and Steel	**921,000**	36,840

* Truck loads estimated to be 25 tons per truck.

Fault Source

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Highway Center Impact

- Low
- Moderate
- High

Instrumental Intensity

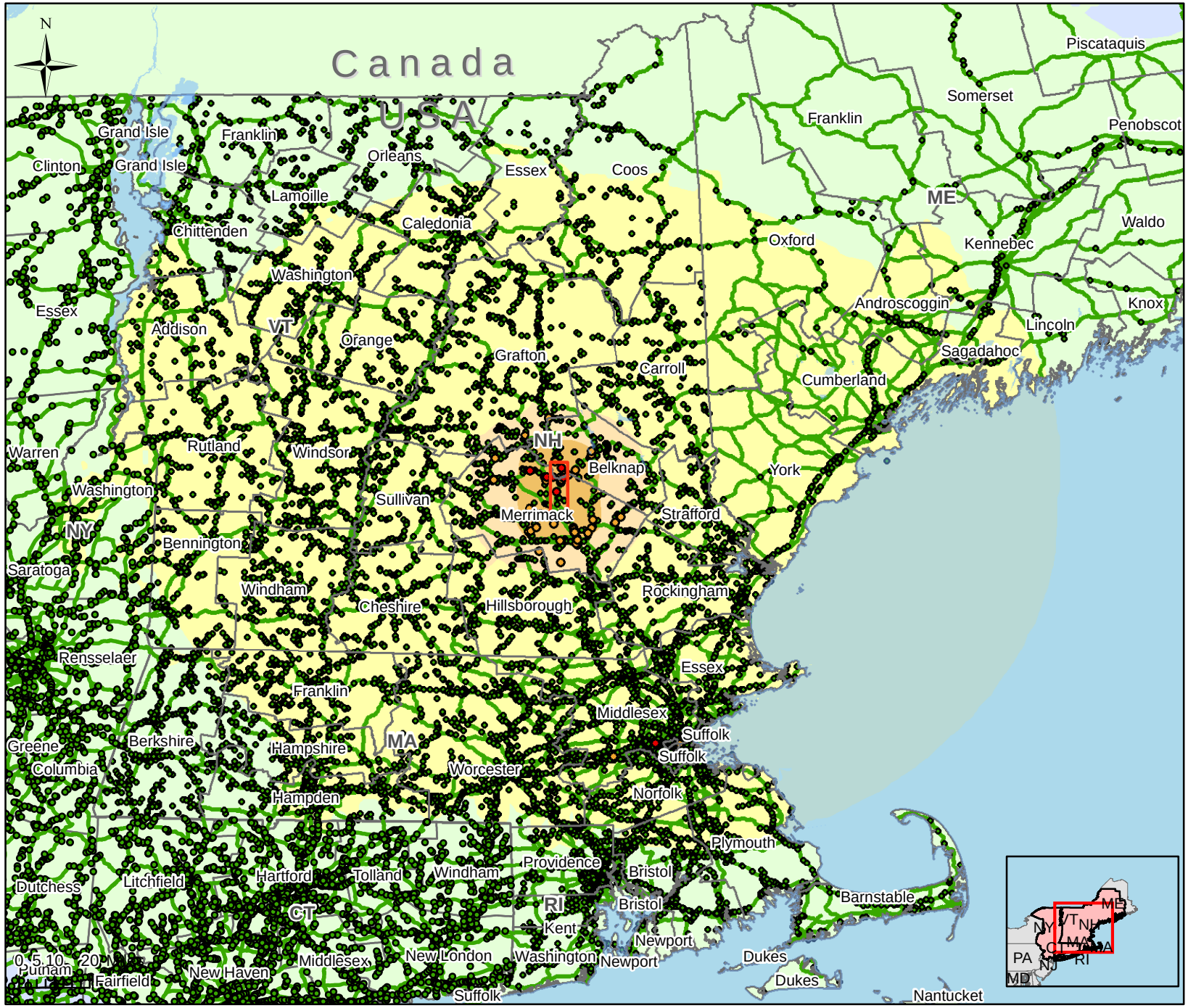
Not felt	Strong
Weak	Very strong
Light	Severe
Moderate	Violent
	Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Estimated Highway Infrastructure Damage and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Major Roadway Bridge Impact

- Low
- Moderate
- High

Highway Segment Impact

- Low
- Moderate
- High

- Fault Source

Instrumental Intensity

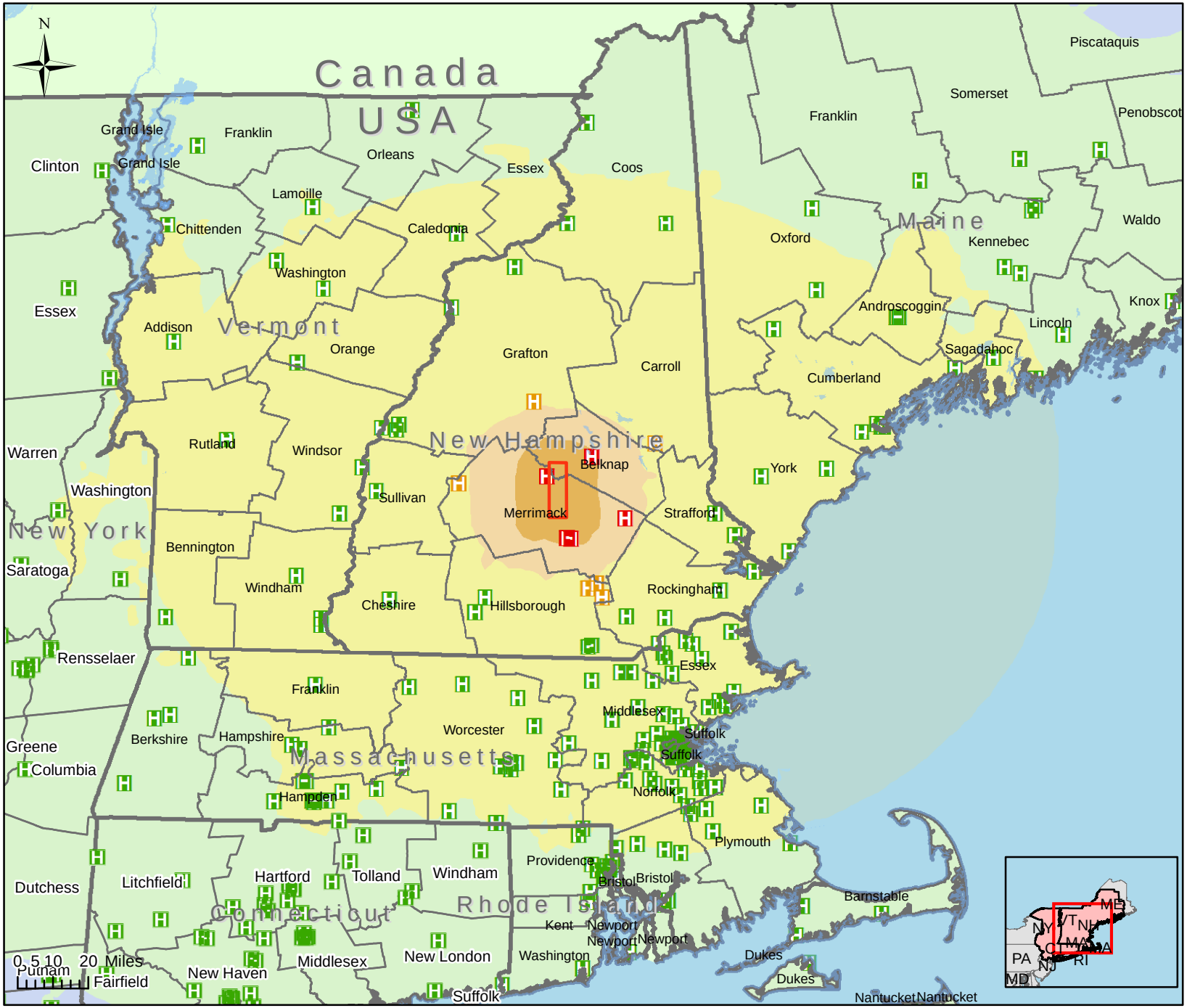
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Impaired Hospitals (Day 1) and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

Impaired Hospitals (Day 1)

- High (<25%)
- Moderate (25% to 75%)
- Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

Fault Source

Instrumental Intensity

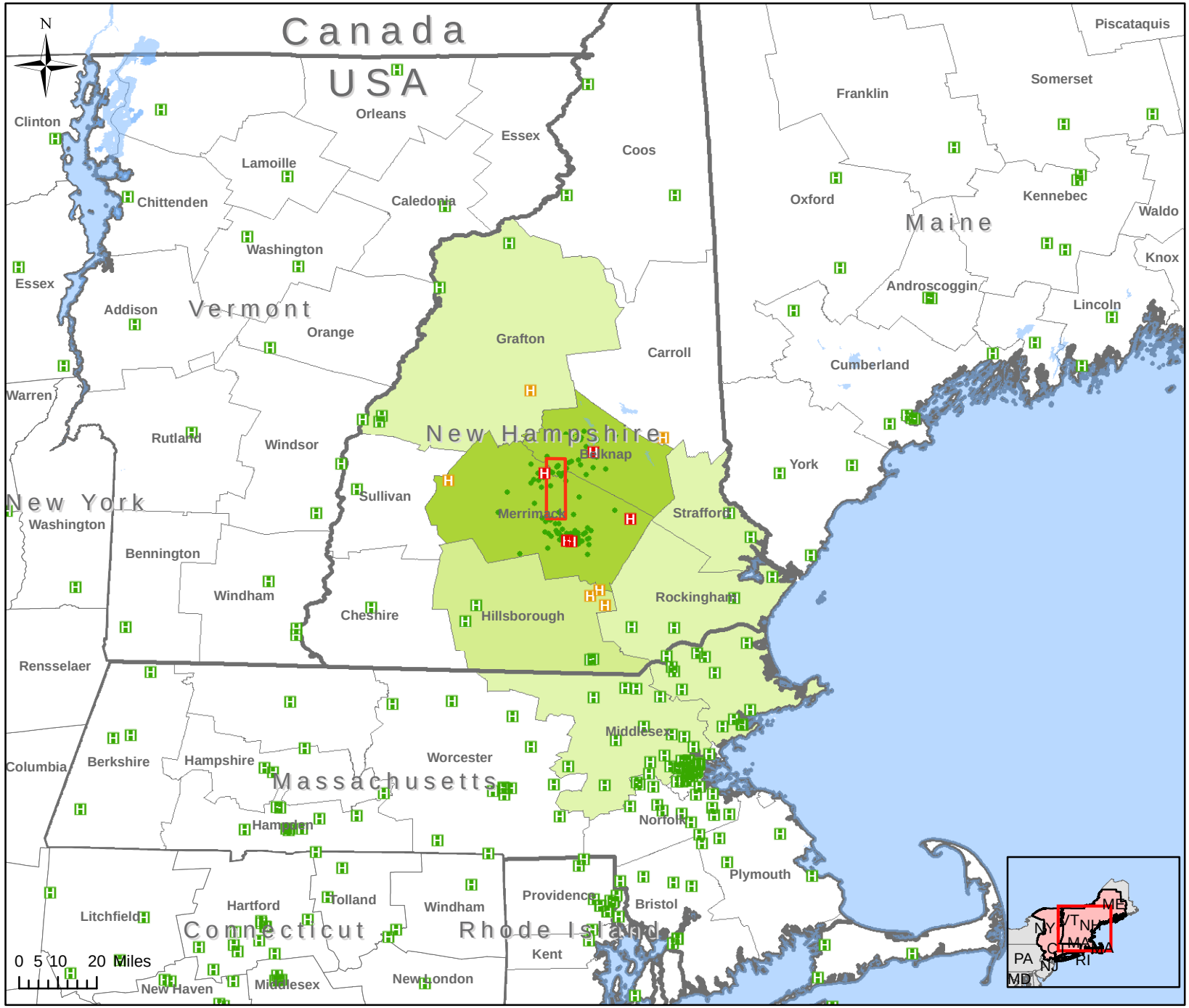
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Injuries Requiring Hospital Treatment 2 p.m. and Impaired Hospitals



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

Estimated Number of Persons Requiring Hospital Treatment (2 p.m.)

1 Dot = 5 Persons

Fault Source

Impaired Hospitals (Day 1)

Level 2 and 3 Injuries	
0	
1 - 5	
5 - 10	
10 - 50	
50 - 100	
100 - 500	
500 or more	

High	(<25%)
Moderate	(25% to 75%)
Low	(>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event

The estimate od the number of persons requiring hospital treatment includes Severity 2 and Severity 3 levels from Hazus-MH results.

Severity 2 are injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life-threatening status.

Severity 3 are injuries that pose an immediate life-threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

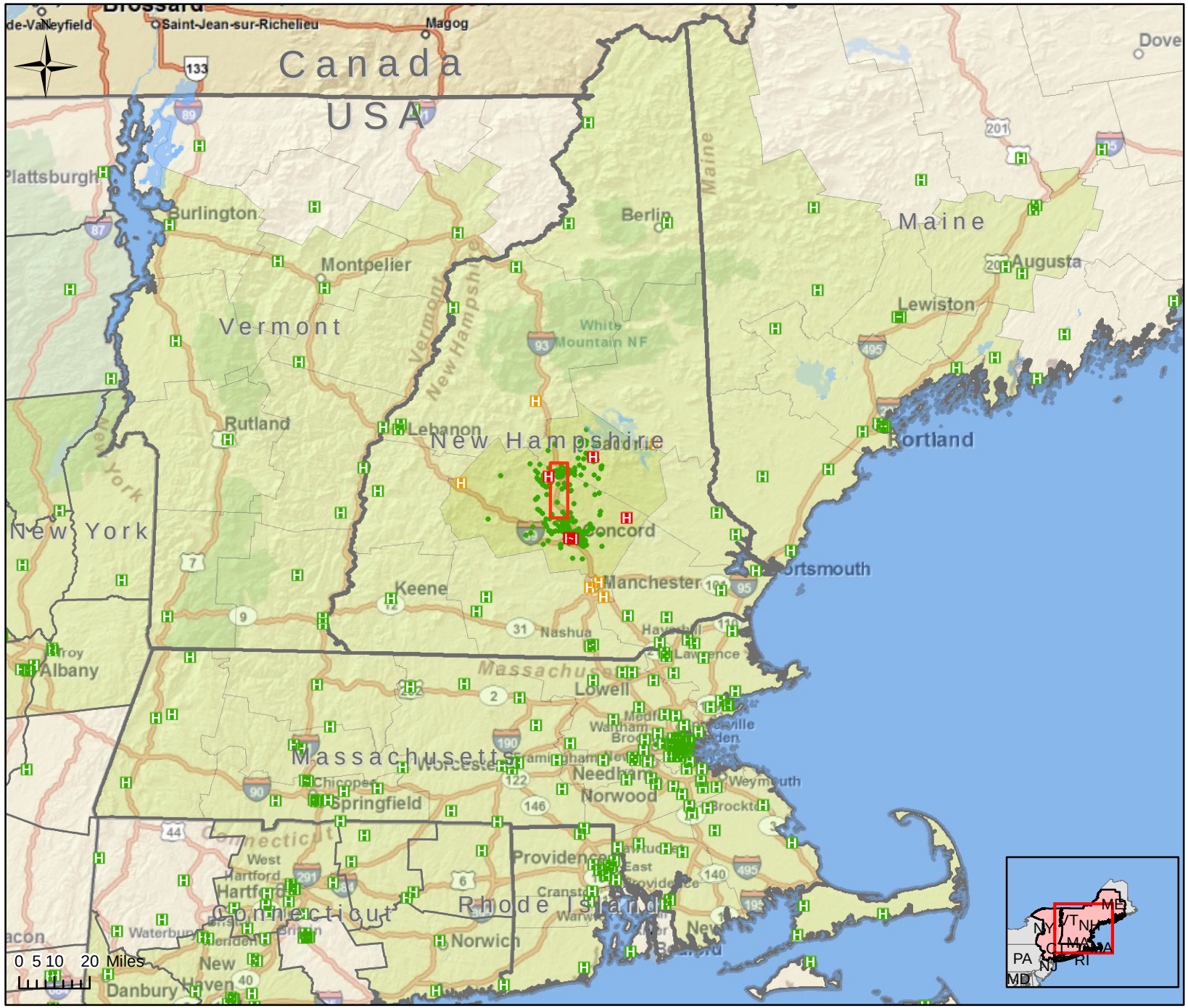
Requiring Hospital Treatment	Immediate Life Threatening Injuries
412	51

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Potential Search and Rescue Needs 2 p.m. and Impaired Hospitals



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

Threatening Injury (Severity Level 3)
1 Dot = 1 Person

Severity 3 are injuries that pose an immediate life-threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

Impaired Hospitals
(Day 1)

- H High (<25%)
- H Moderate (25% to 75%)
- H Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

Fault Source

Level 3 Injury

0 | 1 - 5 | 5 - 10 | 10 - 50 | 50 - 100 | 100 - 500 | 500 or more

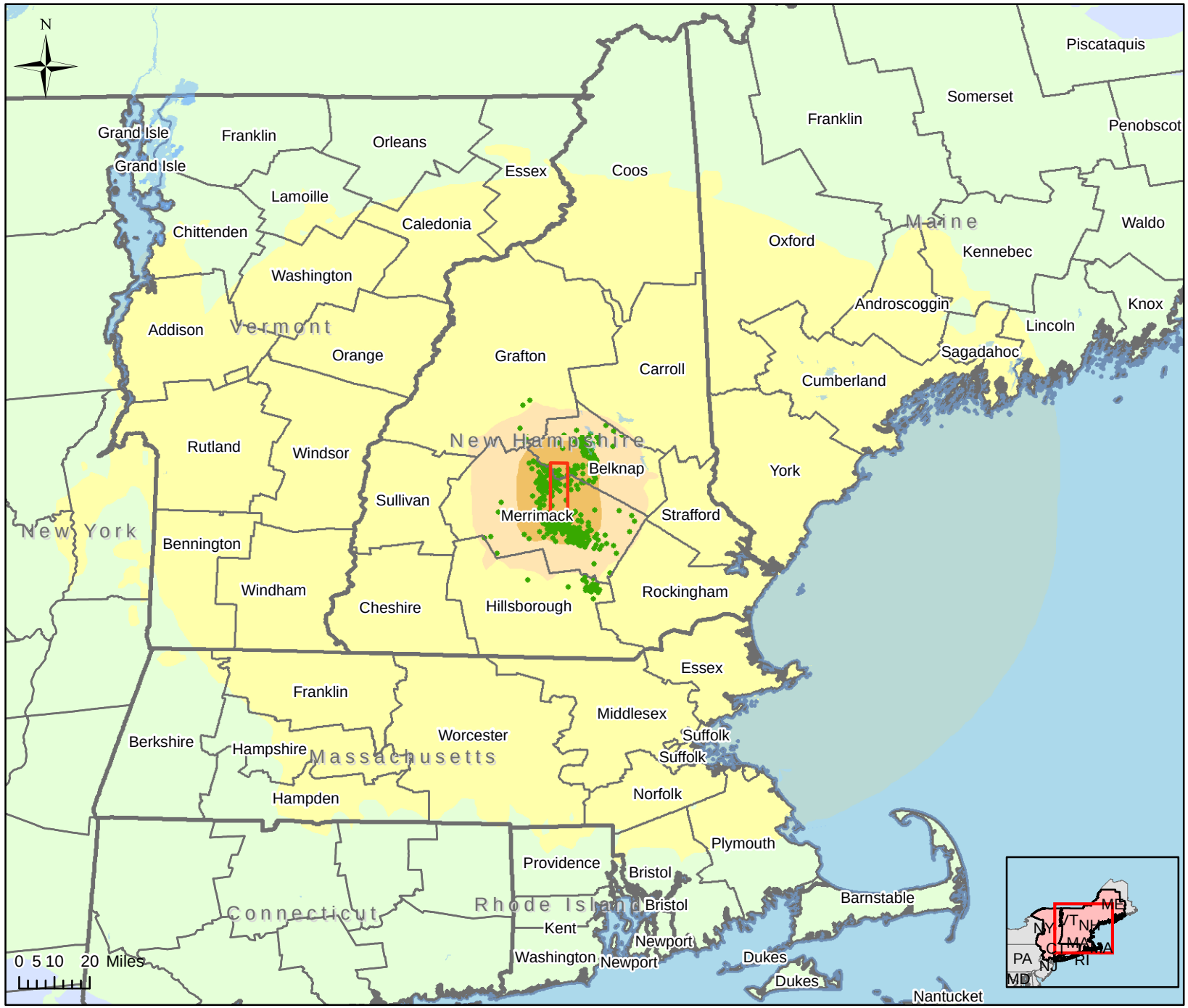
Structure Type	Red (Complete)	Total Collapse
Concrete	172	17
Manufactured Housing	888	27
Precast	42	5
Reinforced Masonry	124	12
Steel	520	31
Unreinforced Masonry	699	105
Wood	37	1
Total	2,482	199

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Short Term Public Shelter Needs and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

● 1 Dot = 5 Individuals

Hazus-MH methodology only estimates the number of displaced persons seeking short-term public shelter.

Shelter Requirements	Total #
Public Shelter Needs (Individuals)	2,714

Fault Source

Instrumental Intensity

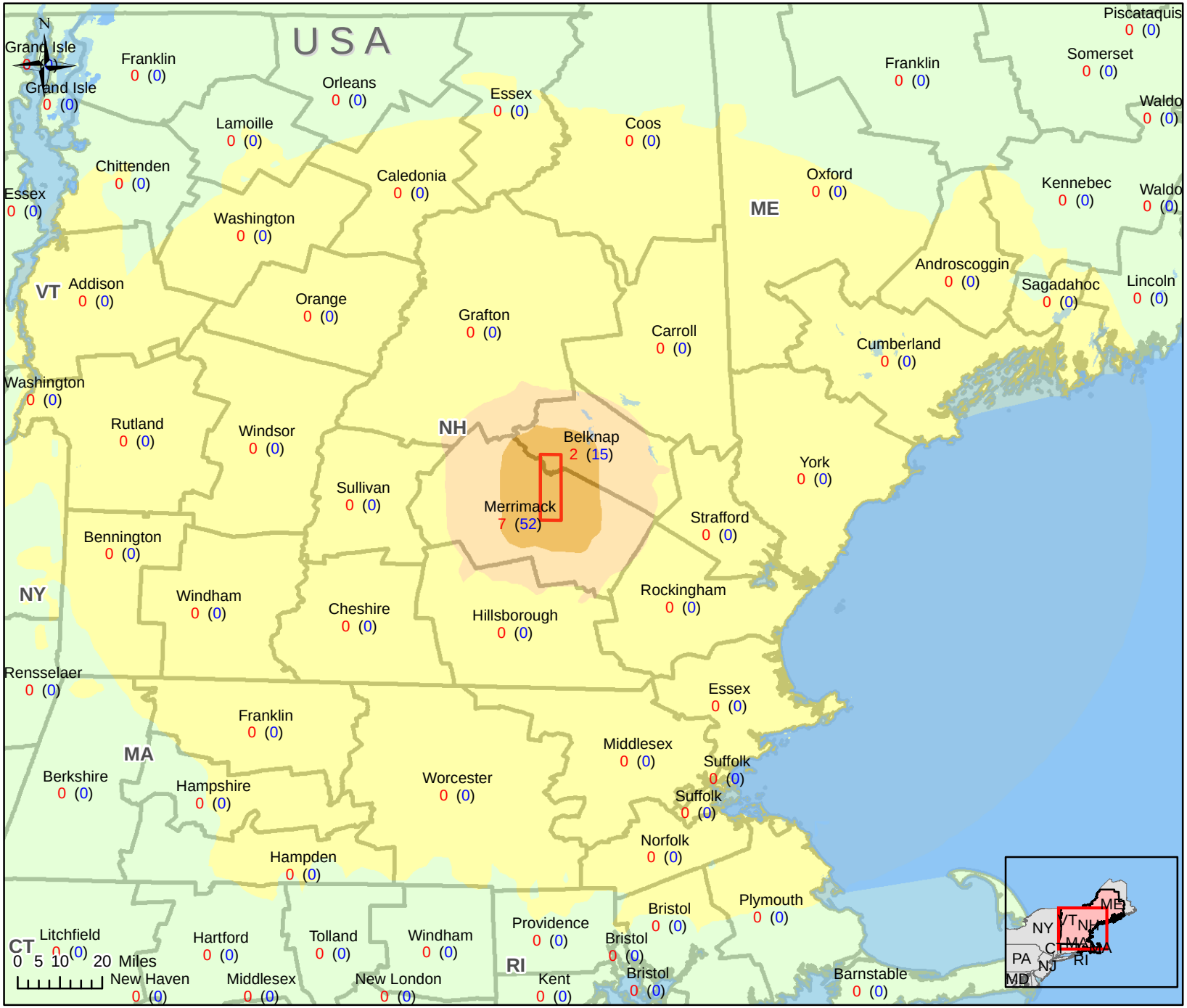
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Estimated Potable Water Needs by County and Ground Shaking Intensity



Earthquake Scenario:
Central New Hampshire
Magnitude 6.5
Date: May 2012 (URS and FEMA)

Estimated Liters of Potable Water Needed *

Red # = Households without Potable Water (Thousands)

(Blue #) = Daily Potable Water Needs (Thousand liters /day)

* Based on U.S. Army Corp Mission Guidebook (Daily water is based on an estimated 3 people per household).

Fault Source

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 6 - Maps of ground shaking and intensity for event CentralNewHampshire1638M6.5_se, Central New Hampshire 1638 M6.5 Scenario

Montreal, Canada
M 6.2

Hazus-MH: Earthquake Event Report

Region Name: NE Scenarios - Montreal

Earthquake Scenario: Mw 6.2 Montreal Scenario

Print Date: October 20, 2011

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

Table of Contents

Section	Page #
General Description of the Region	3
Building and Lifeline Inventory	4
Building Inventory	
Critical Facility Inventory	
Transportation and Utility Lifeline Inventory	
Earthquake Scenario Parameters	6
Direct Earthquake Damage	7
Buildings Damage	
Critical Facilities Damage	
Transportation and Utility Lifeline Damage	
Induced Earthquake Damage	11
Fire Following Earthquake	
Debris Generation	
Social Impact	12
Shelter Requirements	
Casualties	
Economic Loss	13
Building Losses	
Transportation and Utility Lifeline Losses	
Long-term Indirect Economic Impacts	
Appendix A: County Listing for the Region	
Appendix B: Regional Population and Building Value Data	

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 26 county(ies) from the following state(s):

Maine

New Hampshire

New York

Vermont

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

The geographical size of the region is 30,371.45 square miles and contains 362 census tracts. There are over 516 thousand households in the region which has a total population of 1,341,336 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 725 thousand buildings in the region with a total building replacement value (excluding contents) of 96,515 (millions of dollars). Approximately 93.00 % of the buildings (and 74.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 82,482 and 17,881 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 725 thousand buildings in the region which have an aggregate total replacement value of 96,515 (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 72% 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 facilities (HPL). 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 42 hospitals in the region with a total bed capacity of 4,398 beds. There are 913 schools, 461 fire stations, 184 police stations and 16 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 926 dams identified within the region. Of these, 117 of the dams are classified as 'high hazard'. The inventory also includes 319 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 1 and 2.

The total value of the lifeline inventory is over 100,363.00 (millions of dollars). This inventory includes over 10,144 kilometers of highways, 4,696 bridges, 169,860 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	4,696	28,278.20
	Segments	1,955	50,162.00
	Tunnels	0	0.00
		Subtotal	**78,440.20**
Railways	Bridges	106	8.80
	Facilities	21	55.90
	Segments	1,090	2,108.50
	Tunnels	0	0.00
		Subtotal	**2,173.20**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	33	38.40
		Subtotal	**38.40**
Ferry	Facilities	9	12.00
		Subtotal	**12.00**
Port	Facilities	1	2.00
		Subtotal	**2.00**
Airport	Facilities	28	298.20
	Runways	40	1,518.60
		Subtotal	**1,816.80**
		Total	**82,482.60**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	1,698.60
	Facilities	1	32.30
	Pipelines	0	0.00
		Subtotal	**1,730.90**
Waste Water	Distribution Lines	NA	1,019.20
	Facilities	192	13,922.70
	Pipelines	0	0.00
		Subtotal	**14,941.90**
Natural Gas	Distribution Lines	NA	679.40
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**679.40**
Oil Systems	Facilities	1	0.10
	Pipelines	0	0.00
		Subtotal	**0.10**
Electrical Power	Facilities	34	3,906.10
		Subtotal	**3,906.10**
Communication	Facilities	188	20.30
		Subtotal	**20.30**
		Total	**21,278.80**

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	Mw 6.2 Montreal Scenario
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	6.20
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Hazus estimates that about 89 buildings will be at least moderately damaged. This is over 0.00 % of the 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 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	3,566	0.49	9	0.69	1	0.96	0	1.44	0	0.00
Commercial	31,952	4.41	101	7.81	9	10.53	0	17.45	0	0.00
Education	1,434	0.20	3	0.26	0	0.30	0	0.48	0	0.00
Government	2,220	0.31	5	0.39	0	0.48	0	0.69	0	0.00
Industrial	10,076	1.39	25	1.97	2	2.73	0	4.03	0	0.00
Other Residential	215,375	29.72	801	62.01	56	62.30	0	32.73	0	0.00
Religion	2,436	0.34	8	0.60	1	0.74	0	1.39	0	0.00
Single Family	457,540	63.14	339	26.26	20	21.96	0	41.79	0	0.00
Total	**724,599**		**1,291**		**89**		**1**		**0**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	520,690	71.86	123	9.55	0	0.45	0	0.00	0	0.00
Steel	27,999	3.86	50	3.84	5	6.00	0	7.10	0	0.00
Concrete	15,392	2.12	22	1.67	1	1.18	0	0.00	0	0.00
Precast	1,760	0.24	8	0.59	1	1.45	0	2.68	0	0.00
RM	17,417	2.40	16	1.23	2	2.22	0	0.54	0	0.00
URM	76,358	10.54	500	38.69	41	45.48	1	89.68	0	0.00
MH	64,983	8.97	574	44.43	39	43.22	0	0.00	0	0.00
Total	**724,599**		**1,291**		**89**		**1**		**0**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 4,398 hospital beds available for use. On the day of the earthquake, the model estimates that only 4,377 hospital beds (100.00%) 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 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	42	0	0	42
Schools	913	0	0	913
EOCs	16	0	0	16
PoliceStations	184	0	0	184
FireStations	461	0	0	461

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: 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	1,955	0	0	1,955	1,955
	Bridges	4,696	0	0	4,696	4,696
	Tunnels	0	0	0	0	0
Railways	Segments	1,090	0	0	1,090	1,090
	Bridges	106	0	0	106	106
	Tunnels	0	0	0	0	0
	Facilities	21	0	0	21	21
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	33	0	0	33	33
Ferry	Facilities	9	0	0	9	9
Port	Facilities	1	0	0	1	1
Airport	Facilities	28	0	0	28	28
	Runways	40	0	0	40	40

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 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 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 9 provides a summary of the system performance information.

Table 7 : 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	1	0	0	1	1
Waste Water	192	0	0	192	192
Natural Gas	0	0	0	0	0
Oil Systems	1	0	0	1	1
Electrical Power	34	0	0	34	34
Communication	188	0	0	188	188

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	84,930	235	59
Waste Water	50,958	118	30
Natural Gas	33,972	40	10
Oil	0	0	0

Table 9: 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	516,368	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 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (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 90.00% 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 120 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 1,341,336) 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 10 provides a summary of the casualties estimated for this earthquake

Table 10: 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	1	0	0	0
	Total	**2**	**0**	**0**	**0**
2 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	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	0	0	0	0
	Total	**2**	**0**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 63.34 (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 23.43 (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 48 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	0.02	0.27	0.01	0.08	0.37
	Capital-Related	0.00	0.01	0.22	0.01	0.01	0.24
	Rental	0.03	0.14	0.24	0.01	0.01	0.43
	Relocation	0.07	0.10	0.17	0.02	0.05	0.40
	Subtotal	**0.10**	**0.26**	**0.90**	**0.04**	**0.14**	**1.44**
Capital Stock Losses							
	Structural	0.26	0.32	0.31	0.07	0.09	1.05
	Non_Structural	3.45	3.26	3.48	1.39	0.95	12.53
	Content	2.20	1.30	2.71	1.03	0.84	8.07
	Inventory	0.00	0.00	0.09	0.22	0.02	0.33
	Subtotal	**5.91**	**4.88**	**6.58**	**2.72**	**1.90**	**21.99**
	Total	**6.01**	**5.14**	**7.48**	**2.76**	**2.04**	**23.43**

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 12 & 13 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 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	50,162.04	$0.00	0.00
	Bridges	28,278.19	$0.99	0.00
	Tunnels	0.00	$0.00	0.00
	Subtotal	**78440.20**	**1.00**	
Railways	Segments	2,108.53	$0.00	0.00
	Bridges	8.78	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	55.92	$0.88	1.57
	Subtotal	**2173.20**	**0.90**	
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	38.40	$0.42	1.10
	Subtotal	**38.40**	**0.40**	
Ferry	Facilities	11.98	$0.27	2.27
	Subtotal	**12.00**	**0.30**	
Port	Facilities	2.00	$0.02	0.97
	Subtotal	**2.00**	**0.00**	
Airport	Facilities	298.23	$3.31	1.11
	Runways	1,518.56	$0.00	0.00
	Subtotal	**1816.80**	**3.30**	
	Total	**82482.60**	**5.90**	

Table 13: 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	32.30	$0.02	0.07
	Distribution Lines	1,698.60	$1.06	0.06
	Subtotal	**1,730.91**	**$1.08**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	13,922.70	$26.44	0.19
	Distribution Lines	1,019.20	$0.53	0.05
	Subtotal	**14,941.89**	**$26.97**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	679.40	$0.18	0.03
	Subtotal	**679.44**	**$0.18**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.10	$0.00	0.10
	Subtotal	**0.10**	**$0.00**	
Electrical Power	Facilities	3,906.10	$5.75	0.15
	Subtotal	**3,906.10**	**$5.75**	
Communication	Facilities	20.30	$0.03	0.14
	Subtotal	**20.32**	**$0.03**	
	Total	**21,278.76**	**$34.01**	

Table 14. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS		Total	%
First Year			
	Employment Impact	182	0.06
	Income Impact	0	0.00
Second Year			
	Employment Impact	34	0.01
	Income Impact	0	0.00
Third Year			
	Employment Impact	0	0.00
	Income Impact	(1)	0.00
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(1)	0.00
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(1)	0.00
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(1)	0.00

Appendix A: County Listing for the Region

Franklin,ME

Oxford,ME

Coos,NH

Grafton,NH

Clinton,NY

Essex,NY

Franklin,NY

Hamilton,NY

Herkimer,NY

Jefferson,NY

Lewis,NY

Saint Lawrence,NY

Warren,NY

Washington,NY

Addison,VT

Caledonia,VT

Chittenden,VT

Essex,VT

Franklin,VT

Grand Isle,VT

Lamoille,VT

Orange,VT

Orleans,VT

Rutland,VT

Washington,VT

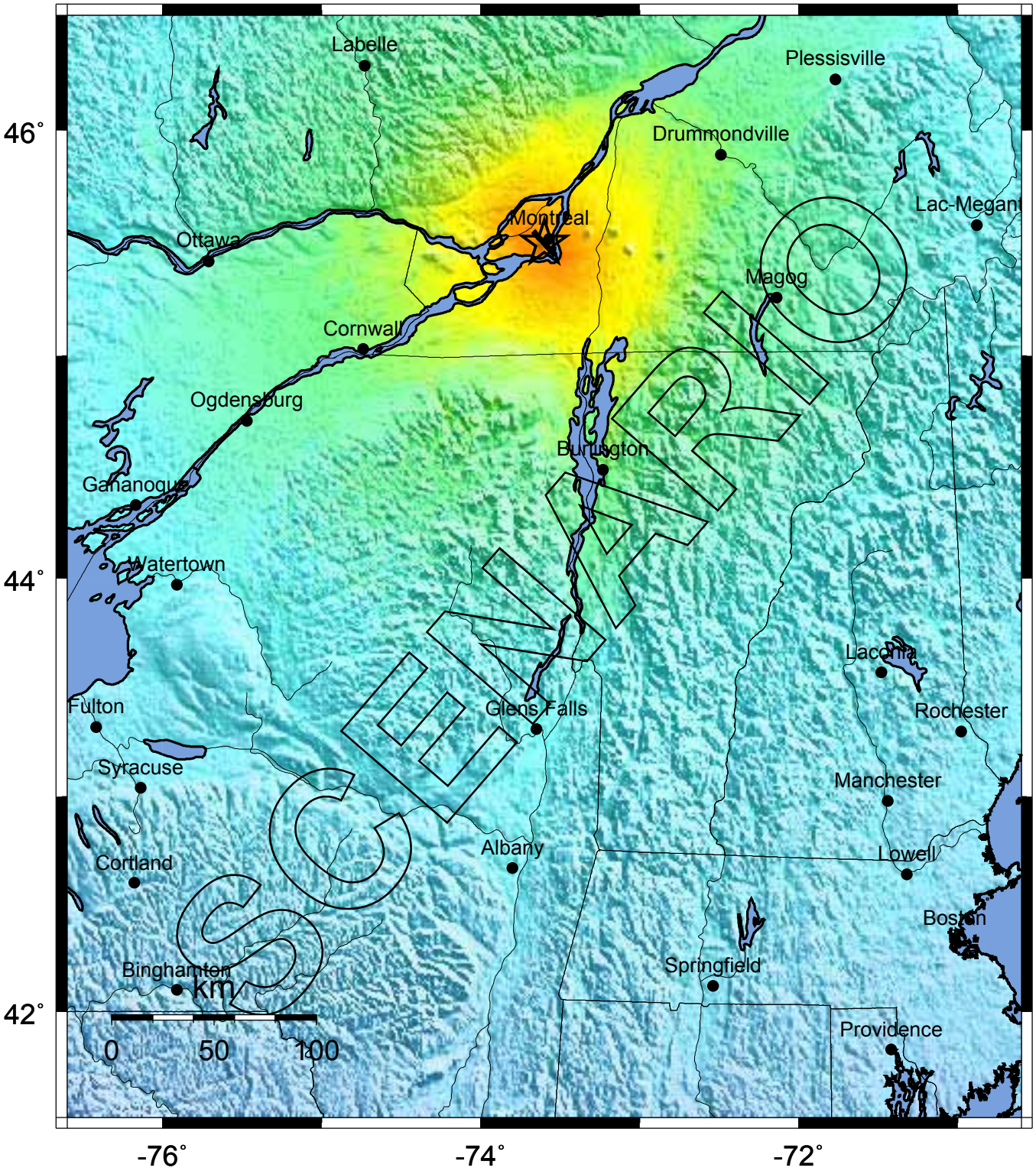
Windsor,VT

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Maine					
	Franklin	29,467	1,688	478	2,167
	Oxford	54,755	3,392	899	4,291
Total State		**84,222**	**5,080**	**1,377**	**6,458**
New Hampshire					
	Coos	33,111	1,760	653	2,413
	Grafton	81,743	4,393	1,698	6,092
Total State		**114,854**	**6,153**	**2,351**	**8,505**
New York					
	Clinton	79,894	3,862	1,555	5,417
	Essex	38,851	2,512	659	3,171
	Franklin	51,134	2,511	784	3,295
	Hamilton	5,379	777	120	897
	Herkimer	64,427	3,411	1,085	4,496
	Jefferson	111,738	6,251	1,976	8,228
	Lewis	26,944	1,576	381	1,958
	Saint Lawrence	111,931	5,390	1,606	6,996
	Warren	63,303	4,410	1,550	5,961
	Washington	61,042	3,048	821	3,869
Total State		**614,643**	**33,748**	**10,537**	**44,288**
Vermont					
	Addison	35,974	1,871	657	2,528
	Caledonia	29,702	1,402	509	1,912
	Chittenden	146,571	7,279	3,361	10,641
	Essex	6,459	370	76	446
	Franklin	45,417	2,016	703	2,719
	Grand Isle	6,901	483	87	571
	Lamoille	23,233	1,230	461	1,691
	Orange	28,226	1,370	395	1,765
	Orleans	26,277	1,232	457	1,689
	Rutland	63,400	3,358	1,241	4,599
	Washington	58,039	3,015	1,374	4,390
	Windsor	57,418	3,206	1,094	4,300
Total State		**527,617**	**26,832**	**10,415**	**37,251**
Total Region		**1,341,336**	**71,813**	**24,680**	**96,502**

-- Earthquake Planning Scenario --
ShakeMap for Montreal6.2 Scenario

Scenario Date: Wed Sep 7, 2011 12:00:00 GMT M 6.2 N45.50 W73.60



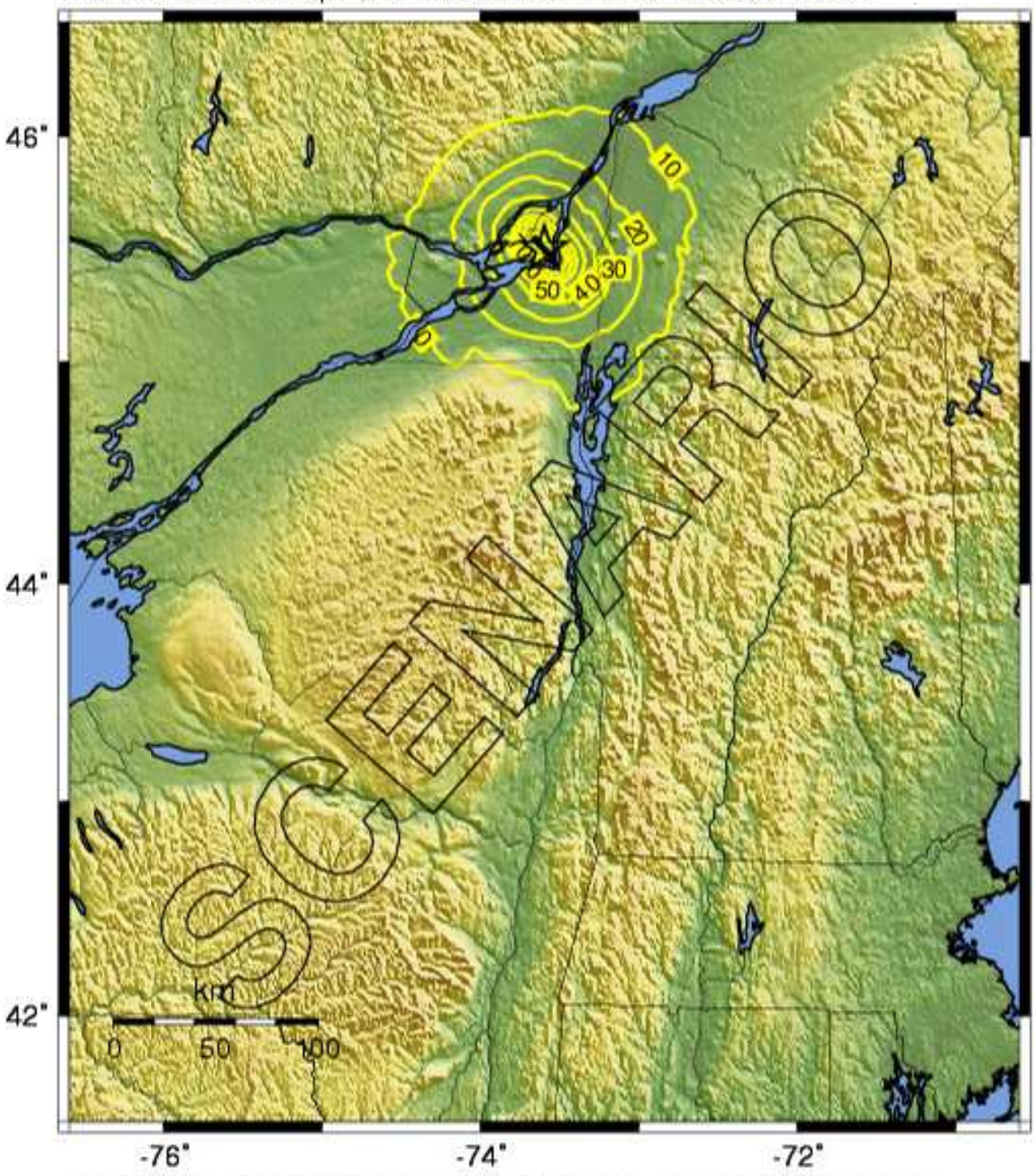
PLANNING SCENARIO ONLY -- Map Version 1 Processed Fri Sep 9, 2011 09:30:33 AM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

-- Earthquake Planning Scenario --

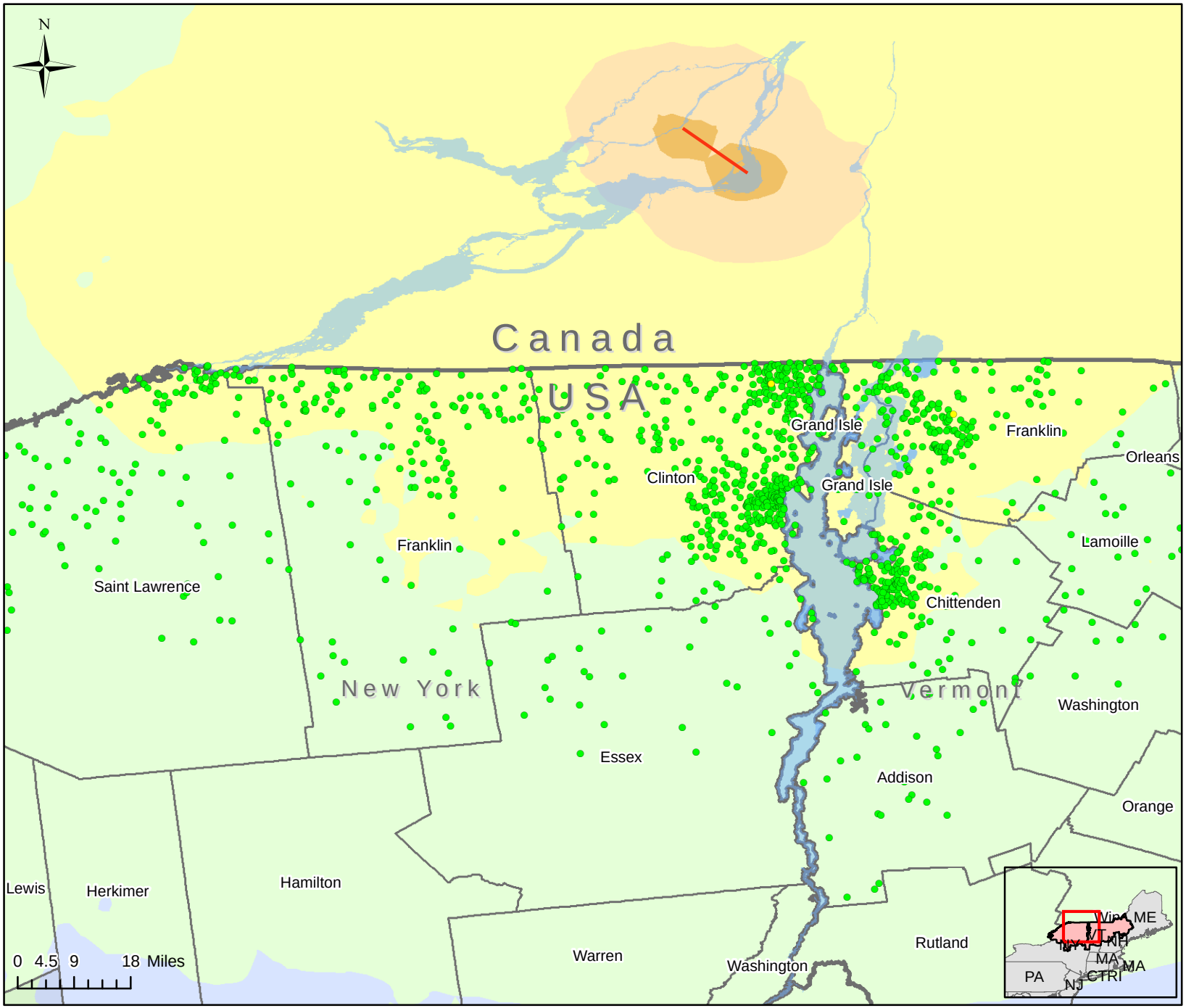
Peak Accel. Map (in %g) for Montreal6.2 Scenario

Scenario Date: Wed Sep 7, 2011 12:00:00 GMT M 6.2 N45.50 W73.60



PLANNING SCENARIO ONLY -- Map Version 1 Processed Fri Sep 9, 2011 09:30:33 AM MDT

Estimated Building Inspection Needs and Ground Shaking Intensity



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

- **Red Tag (Complete Damage)**
- **YellowTag (Extensive Damage)**
- **GreenTag (Slight/Moderate Damage)**

1 Dot = 1 Building (by census tract)

	Estimated # of Structures	Estimated # of Inspectors
Red (Complete)	0	0
Yellow (Extensive)	1	1
Green (Slight/ Moderate)	1,380	9

* Estimated number of inspectors needed to complete inspections in 30 days

Fault Source

Instrumental Intensity

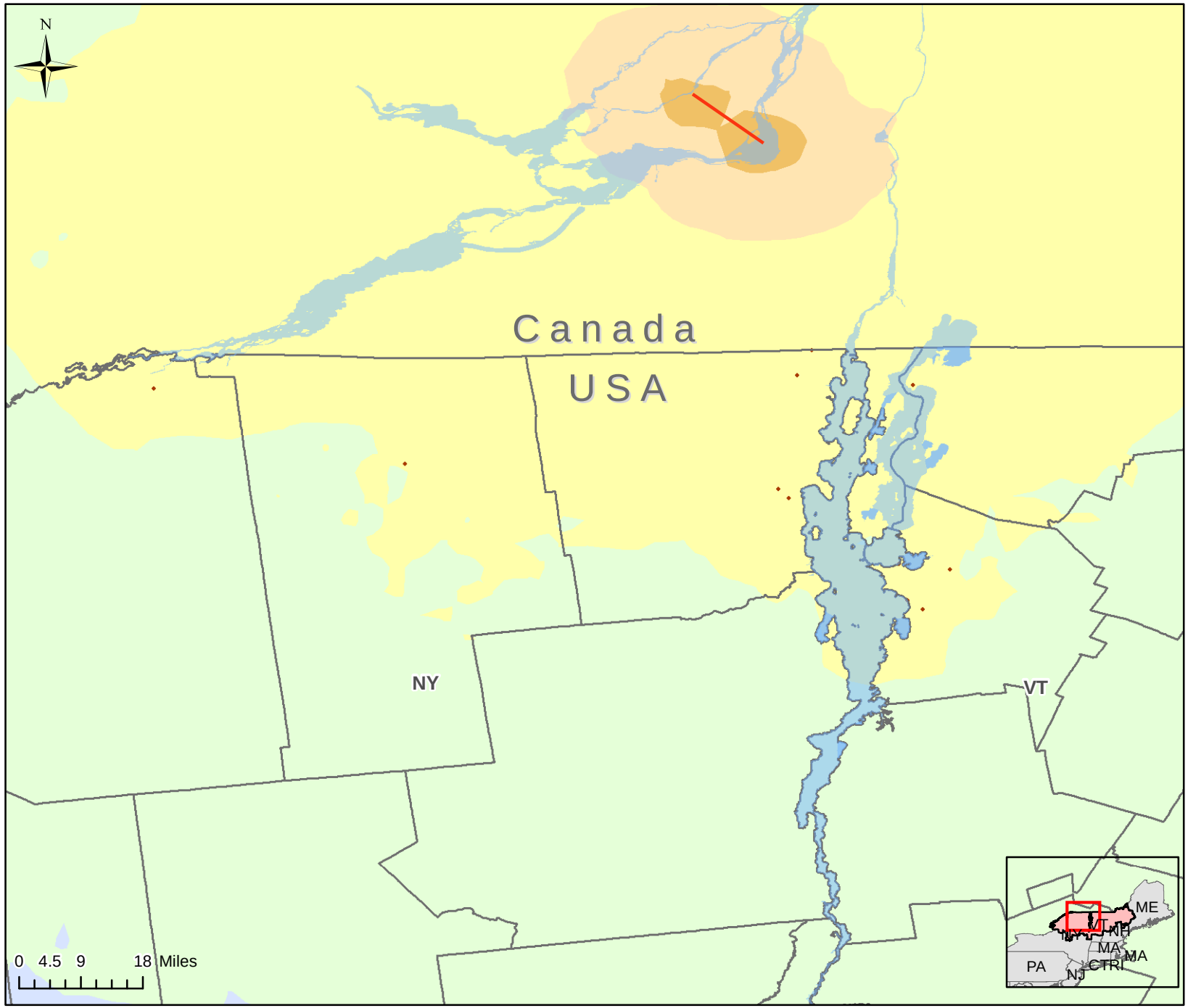
Not felt | Weak | Light | Moderate | Strong | Very strong | Severe | Violent | Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Estimated Building Economic Loss by Census Tract and Ground Shaking Intensity



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

Direct Economic Losses

(Losses include all building-related losses)

1 Dot = $1 Million

Fault Source

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

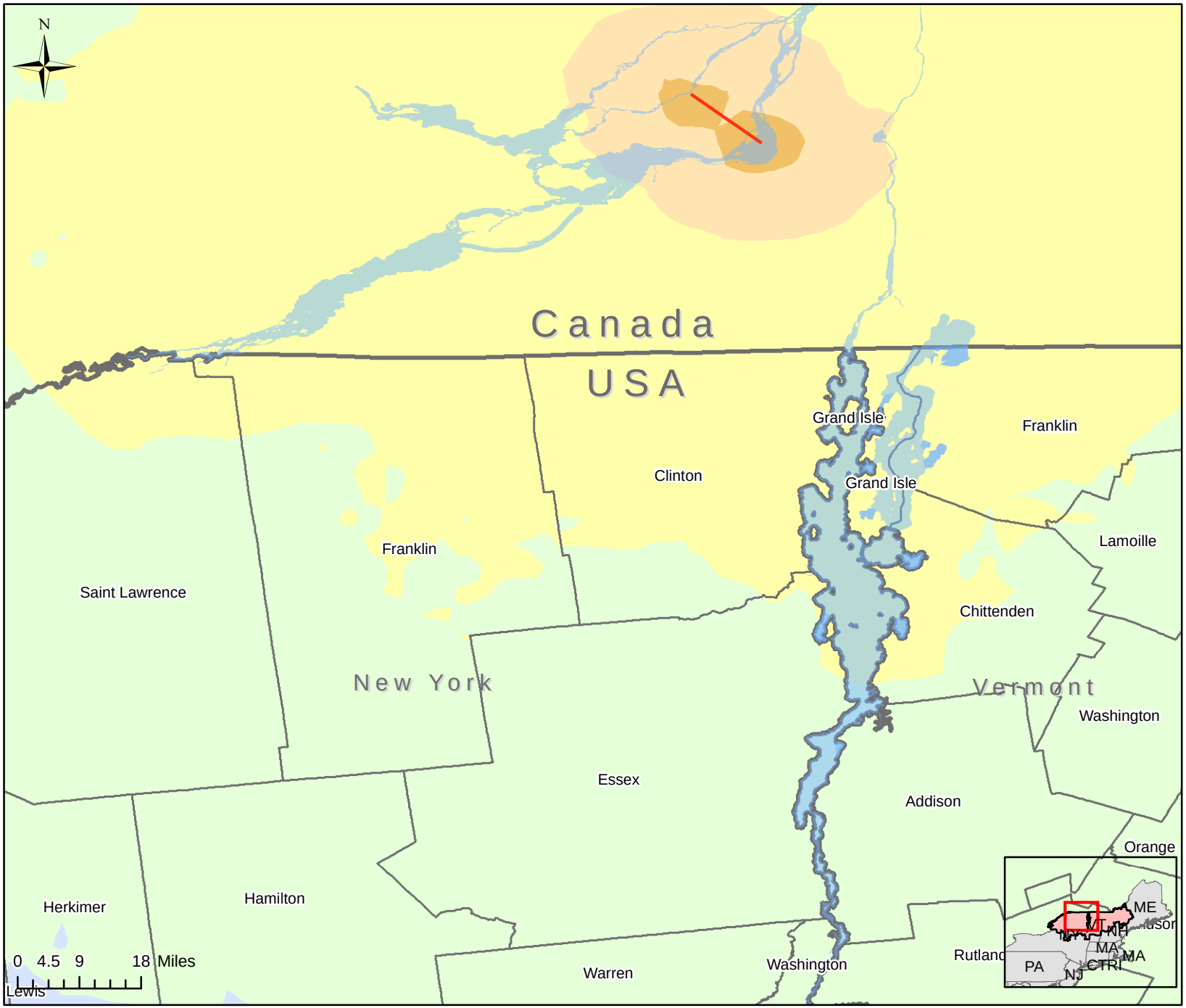
Cost Structural Damage	Cost Non-Structural Damage	Total Loss (Including Contents)
$1	$13	$22
all values in Millions		
Total Loss $22 Million		

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Displaced Households and Ground Shaking Intensity



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

1 Dot = 1 Household

1 Dot = 1 Individual

Shelter Requirements	Total #
Public Shelter Needs (Individuals)	0
Displaced Households	0

Earthquakes can cause loss of function or habitability of buildings that contain housing units, resulting in approximately predictable numbers of displaced households. Loss of habitability is calculated directly from damage to the residential occupancy inventory, and from loss of water and power.

Fault Source

Instrumental Intensity

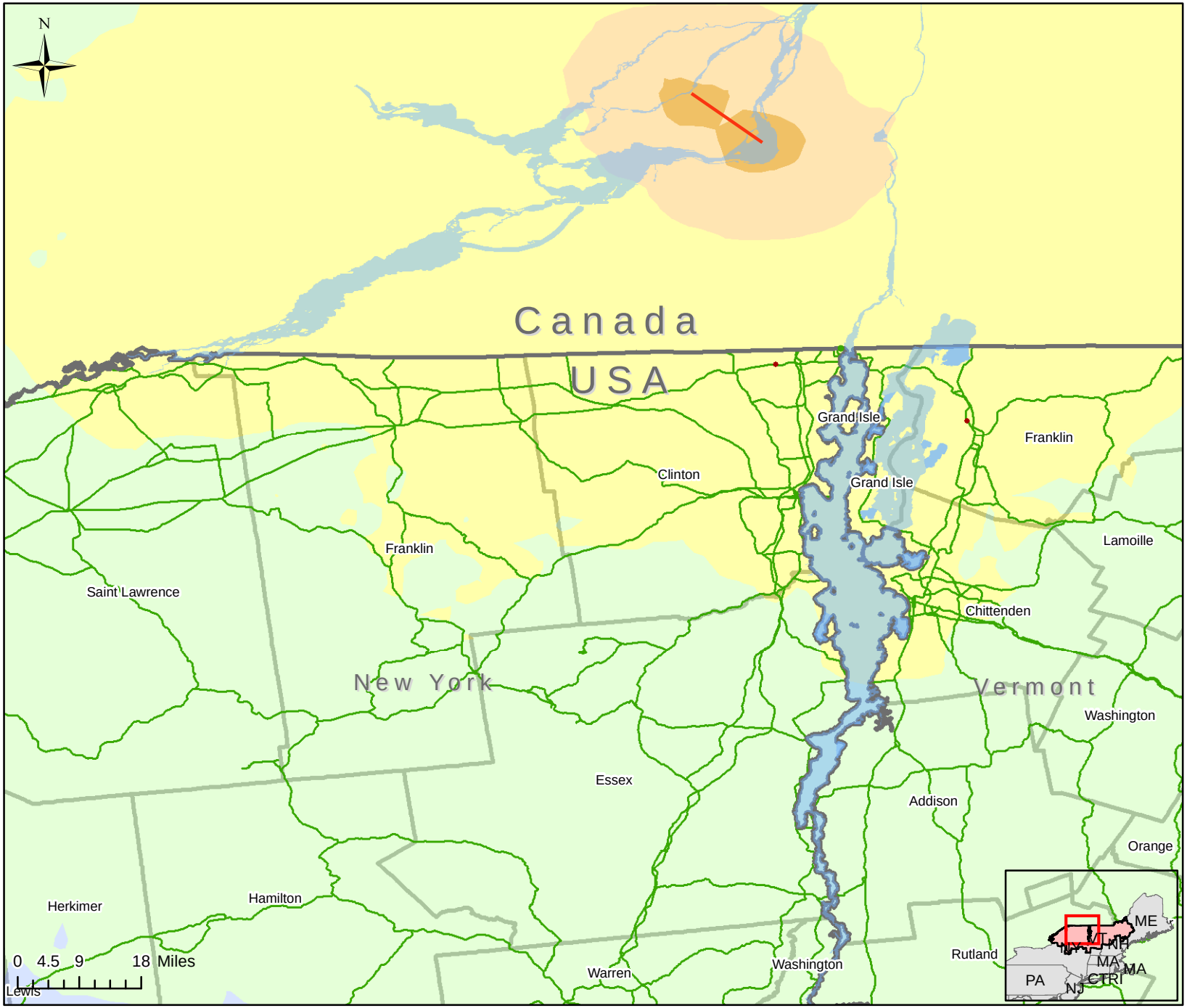
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Estimated Debris and Highway Damage and Ground Shaking Intensity



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

1 dot = 1 thousand tons of Concrete and Steel Debris (by Census Tract)

1 dot = 1 thousand tons of Brick and Wood Debris (by Census Tract)

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

Fault Source

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Highway Center Impact

- Low
- Moderate
- High

Debris Totals	Total (in tons)	Estimated Truck Loads*
Brick and Wood	4,000	160
Concrete and Steel	1,000	40

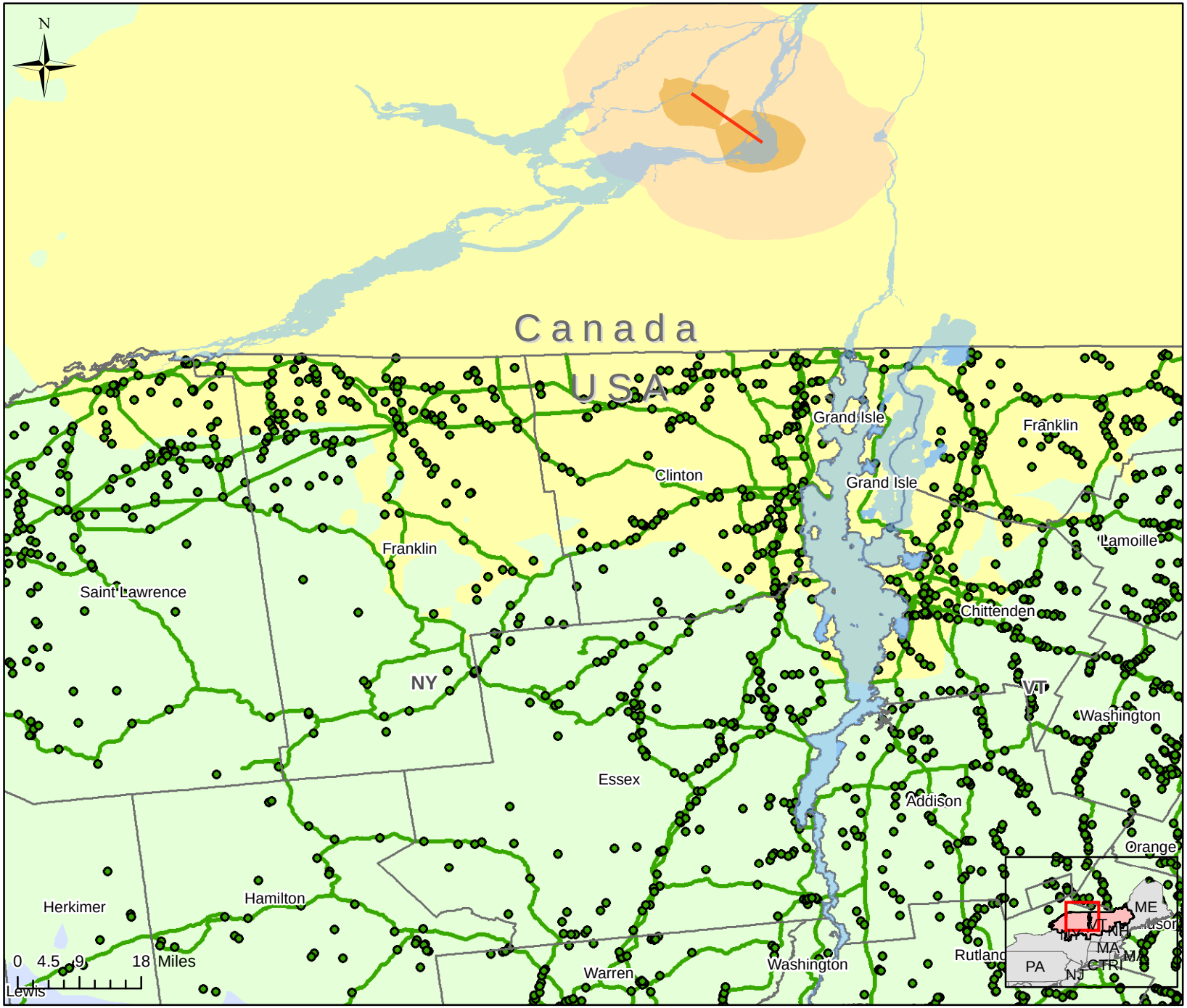
* Truck loads estimated to be 25 tons per truck.

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Estimated Highway Infrastructure Damage and Ground Shaking Intensity



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Major Roadway Bridge Impact

- Low
- Moderate
- High

Highway Segment Impact

- Low
- Moderate
- High

- Fault Source

Instrumental Intensity

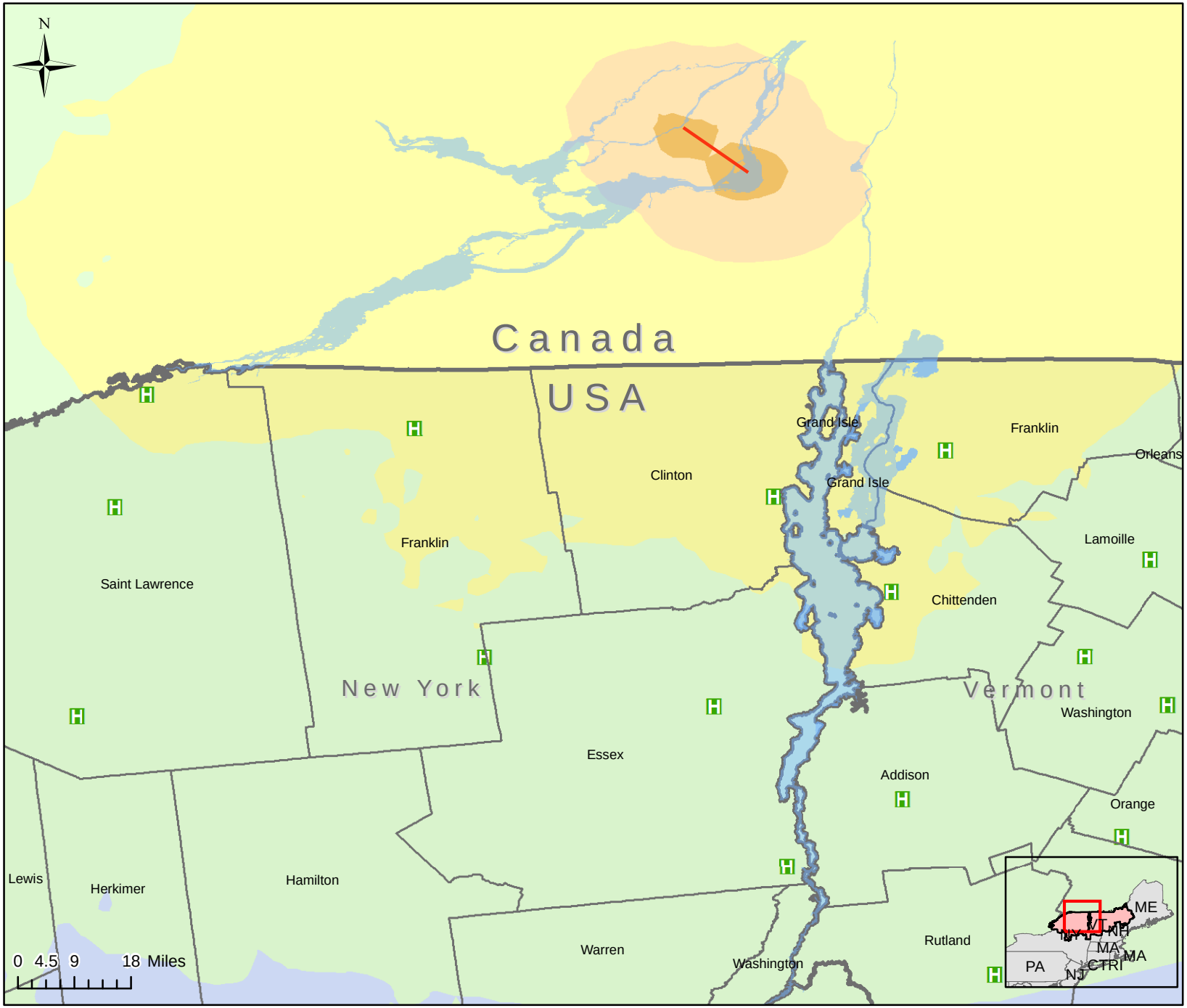
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Impaired Hospitals (Day 1) and Ground Shaking Intensity



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

Impaired Hospitals (Day 1)

H	High	(<25%)
H	Moderate	(25% to 75%)
H	Low	(>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

Fault Source

Instrumental Intensity

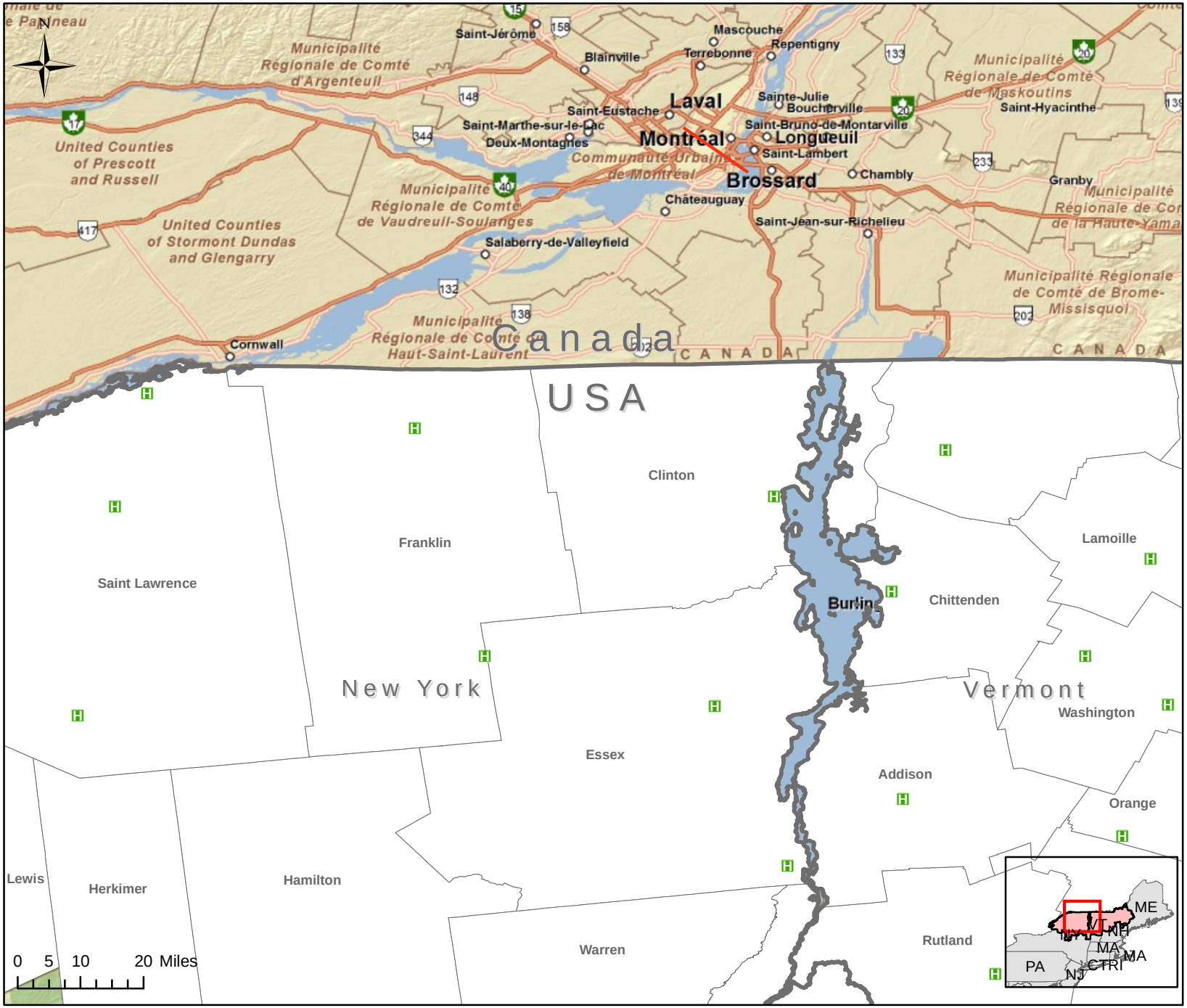
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Injuries Requiring Hospital Treatment 2 p.m. and Impaired Hospitals



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

Estimated Number of Persons Requiring Hospital Treatment (2 p.m.)

Level 2 and 3 Injuries

- 0
- 1 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 500
- 500 or more
- Fault Source

Impaired Hospitals (Day 1)

- H High (<25%)
- H Moderate (25% to 75%)
- H Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

The estimate od the number of persons requiring hospital treatment includes Severity 2 and Severity 3 levels from Hazus-MH results.

Severity 2 are injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life-threatening status.

Severity 3 are injuries that pose an immediate life-threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

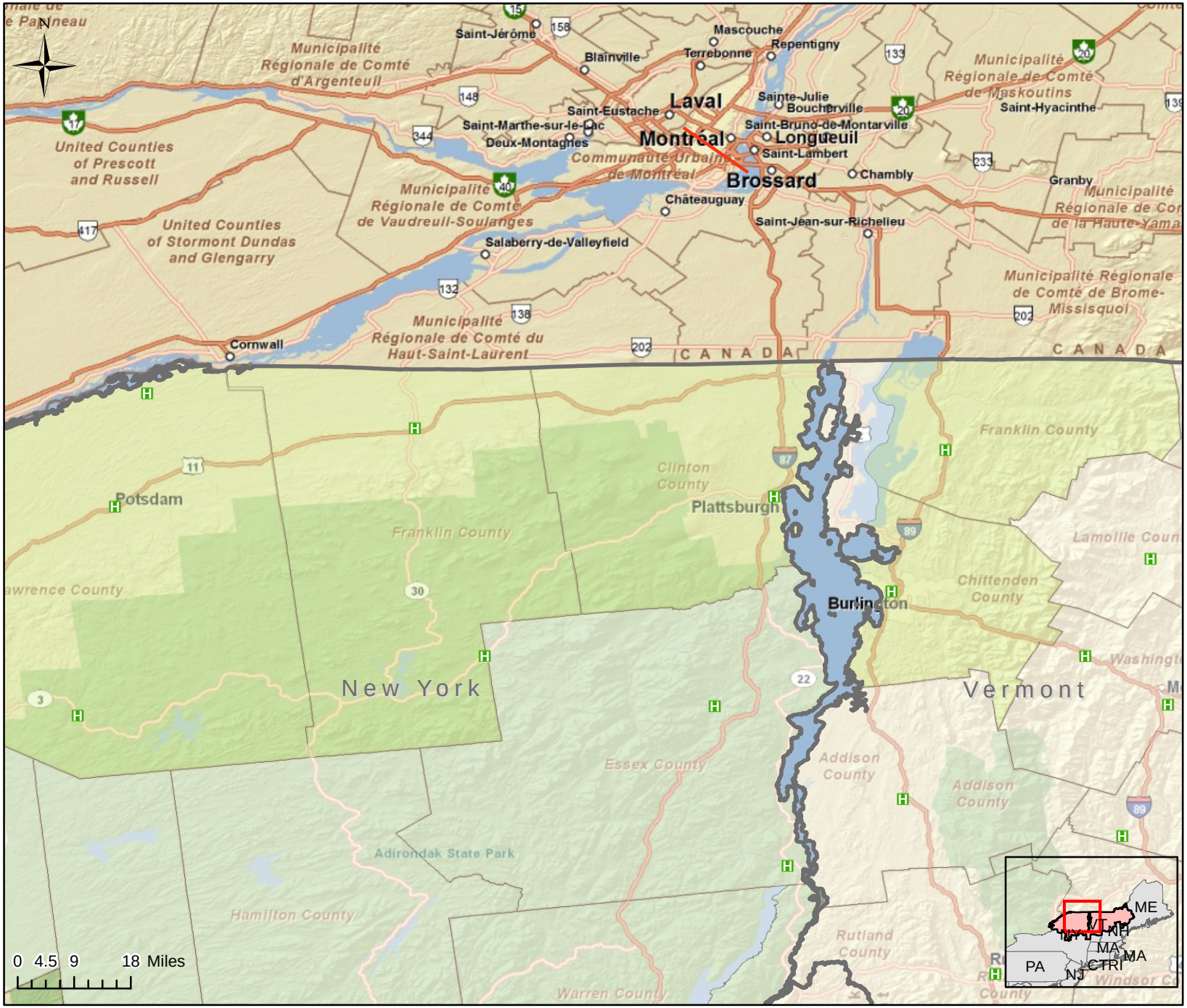
Requiring Hospital Treatment	Immediate Life Threatening Injuries
0	0

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Potential Search and Rescue Needs 2 p.m. and Impaired Hospitals



Shakemap Description: Not Available

Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

Severity 3 are injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

Impaired Hospitals
(Day 1)

- H High (<25%)
- H Moderate (25% to 75%)
- H Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

Fault Source

Level 3 Injury

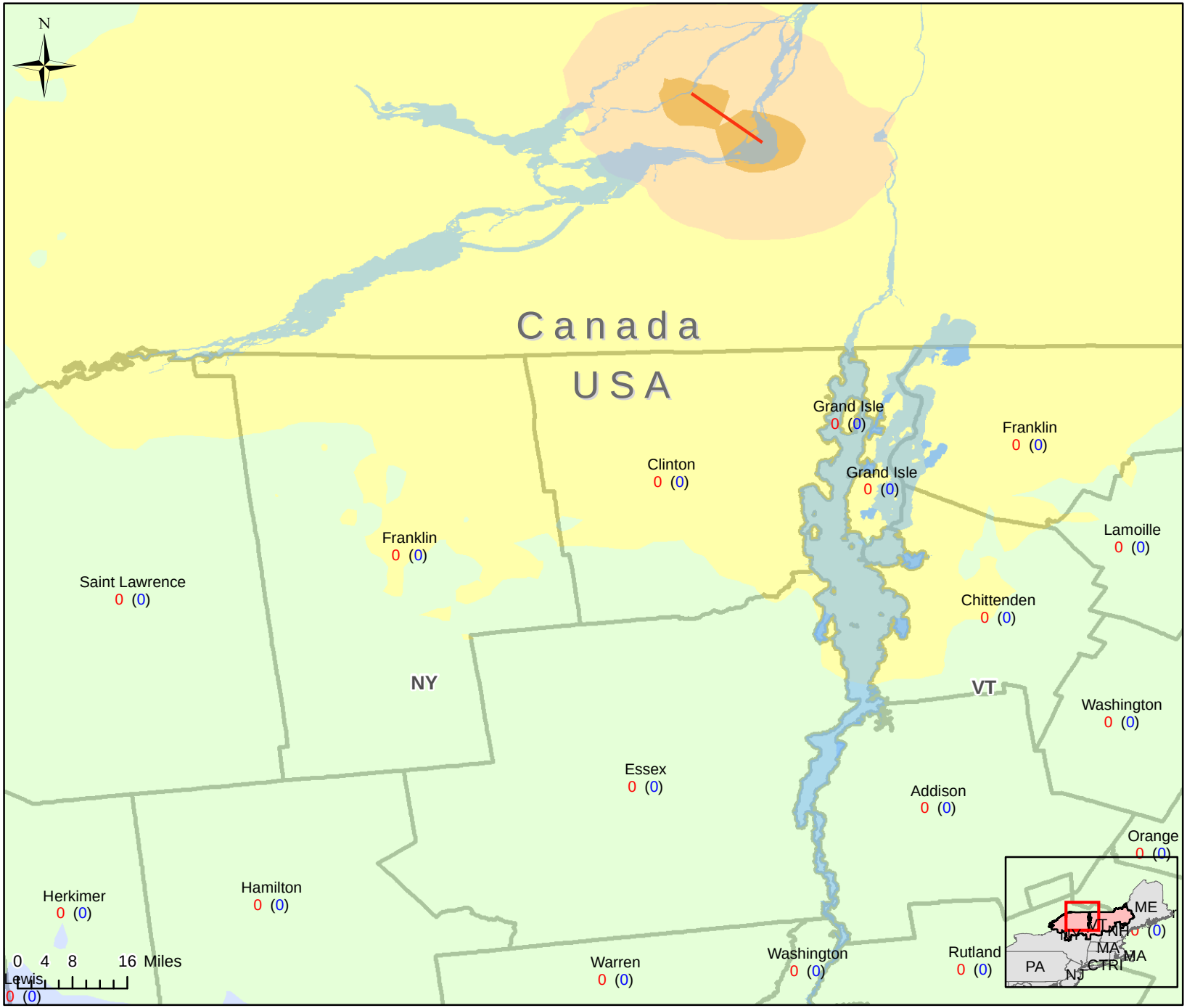
0 | 1 - 5 | 5 - 10 | 10 - 50 | 50 - 100 | 100 - 500 | 500 or more

Structure Type	Red (Complete)	Total Collapse
Concrete	0	0
Manufactured Housing	0	0
Precast	0	0
Reinforced Masonry	0	0
Steel	0	0
Unreinforced Masonry	0	0
Wood	0	0
Total	0	0

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Estimated Potable Water Needs by County and Ground Shaking Intensity



Earthquake Scenario:
Montreal
Magnitude 6.2
Date: May 2012 (URS and FEMA)

Estimated Liters of Potable Water Needed *

Red # = Households without Potable Water (Thousands)

(Blue #) = Daily Potable Water Needs (Thousand liters /day)

* Based on U.S. Army Corp Mission Guidebook (Daily water is based on an estimated 3 people per household).

Fault Source

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Not Available

Goodnow, NY
M 5.8

Hazus-MH: Earthquake Event Report

Region Name: NY_1983_M58_NYState

Earthquake Scenario: NY_1983_M58_NY State

Print Date: October 24, 2011

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

Section	Page #
General Description of the Region	3
Building and Lifeline Inventory	4
Building Inventory	
Critical Facility Inventory	
Transportation and Utility Lifeline Inventory	
Earthquake Scenario Parameters	6
Direct Earthquake Damage	7
Buildings Damage	
Critical Facilities Damage	
Transportation and Utility Lifeline Damage	
Induced Earthquake Damage	11
Fire Following Earthquake	
Debris Generation	
Social Impact	12
Shelter Requirements	
Casualties	
Economic Loss	13
Building Losses	
Transportation and Utility Lifeline Losses	
Long-term Indirect Economic Impacts	
Appendix A: County Listing for the Region	
Appendix B: Regional Population and Building Value Data	

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 30 county(ies) from the following state(s):

New York

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

The geographical size of the region is 30,152.79 square miles and contains 839 census tracts. There are over 1,200 thousand households in the region which has a total population of 3,105,419 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 1,425 thousand buildings in the region with a total building replacement value (excluding contents) of 247,383 (millions of dollars). Approximately 92.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 144,618 and 26,402 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 1,425 thousand buildings in the region which have an aggregate total replacement value of 247,383 (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 68% 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 facilities (HPL). 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 64 hospitals in the region with a total bed capacity of 11,510 beds. There are 1,316 schools, 751 fire stations, 290 police stations and 10 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 1,067 dams identified within the region. Of these, 174 of the dams are classified as 'high hazard'. The inventory also includes 802 hazardous material sites, 0 military installations and 3 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 1 and 2.

The total value of the lifeline inventory is over 171,020.00 (millions of dollars). This inventory includes over 14,477 kilometers of highways, 6,437 bridges, 212,841 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	6,437	64,049.80
	Segments	4,115	75,101.80
	Tunnels	0	0.00
		Subtotal	**139,151.70**
Railways	Bridges	137	23.90
	Facilities	25	66.60
	Segments	1,654	2,943.00
	Tunnels	0	0.00
		Subtotal	**3,033.40**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	53	68.20
		Subtotal	**68.20**
Ferry	Facilities	5	6.70
		Subtotal	**6.70**
Port	Facilities	68	135.80
		Subtotal	**135.80**
Airport	Facilities	34	362.10
	Runways	49	1,860.20
		Subtotal	**2,222.40**
		Total	**144,618.00**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	2,128.40
	Facilities	11	432.20
	Pipelines	0	0.00
		Subtotal	**2,560.60**
Waste Water	Distribution Lines	NA	1,277.00
	Facilities	292	22,947.70
	Pipelines	0	0.00
		Subtotal	**24,224.70**
Natural Gas	Distribution Lines	NA	851.40
	Facilities	3	3.90
	Pipelines	0	0.00
		Subtotal	**855.20**
Oil Systems	Facilities	13	1.50
	Pipelines	0	0.00
		Subtotal	**1.50**
Electrical Power	Facilities	23	2,985.40
		Subtotal	**2,985.40**
Communication	Facilities	271	32.00
		Subtotal	**32.00**
		Total	**30,659.50**

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	NY_1983_M58_NY State
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	5.80
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Hazus estimates that about 488 buildings will be at least moderately damaged. This is over 0.00 % of the 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 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	6,766	0.48	8	0.23	1	0.17	0	0.06	0	0.00
Commercial	68,293	4.80	157	4.41	24	5.15	1	4.88	0	2.57
Education	2,633	0.19	6	0.17	1	0.20	0	0.17	0	0.11
Government	4,222	0.30	10	0.29	2	0.45	0	0.47	0	0.24
Industrial	19,650	1.38	38	1.06	6	1.29	0	1.18	0	0.54
Other Residential	404,201	28.44	1,489	41.81	217	46.31	7	37.40	0	29.80
Religion	5,693	0.40	15	0.41	2	0.47	0	0.50	0	0.44
Single Family	909,970	64.02	1,838	51.63	215	45.97	11	55.32	0	66.29
Total	**1,421,429**		**3,560**		**469**		**20**		**0**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	973,858	68.51	1153	32.38	58	12.29	0	1.57	0	0.00
Steel	56,912	4.00	93	2.62	19	4.04	1	3.34	0	1.02
Concrete	27,874	1.96	60	1.68	14	2.94	0	2.28	0	0.46
Precast	3,600	0.25	12	0.32	3	0.69	0	0.87	0	0.14
RM	34,267	2.41	47	1.32	16	3.47	1	4.24	0	0.00
URM	211,634	14.89	1388	38.99	248	52.90	16	78.14	0	96.41
MH	113,285	7.97	807	22.68	111	23.67	2	9.56	0	1.98
Total	**1,421,429**		**3,560**		**469**		**20**		**0**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 11,510 hospital beds available for use. On the day of the earthquake, the model estimates that only 11,402 hospital beds (99.00%) 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 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	64	0	0	64
Schools	1,316	1	0	1,313
EOCs	10	0	0	10
PoliceStations	290	0	0	290
FireStations	751	1	0	747

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: 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	4,115	0	0	4,115	4,115
	Bridges	6,437	0	0	6,437	6,437
	Tunnels	0	0	0	0	0
Railways	Segments	1,654	0	0	1,654	1,654
	Bridges	137	0	0	137	137
	Tunnels	0	0	0	0	0
	Facilities	25	0	0	25	25
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	53	0	0	53	53
Ferry	Facilities	5	0	0	5	5
Port	Facilities	68	0	0	68	68
Airport	Facilities	34	0	0	34	34
	Runways	49	0	0	49	49

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 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 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 9 provides a summary of the system performance information.

Table 7 : 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	11	0	0	11	11
Waste Water	292	2	0	290	292
Natural Gas	3	0	0	3	3
Oil Systems	13	0	0	13	13
Electrical Power	23	0	0	23	23
Communication	271	1	0	271	271

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	106,421	335	84
Waste Water	63,852	168	42
Natural Gas	42,568	58	14
Oil	0	0	0

Table 9: 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	1,200,697	0	0	0	0	0
Electric Power		495	284	93	13	1

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 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (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 0.01 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 86.00% 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 400 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 1 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 3,105,419) 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 10 provides a summary of the casualties estimated for this earthquake

Table 10: 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	2	0	0	0
	Single Family	2	0	0	0
	Total	**4**	**0**	**0**	**0**
2 PM	Commercial	2	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**
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	1	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 149.45 (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 58.43 (millions of dollars); 8 % 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 63 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	0.17	0.60	0.01	0.17	0.95
	Capital-Related	0.00	0.08	0.55	0.01	0.02	0.65
	Rental	0.24	0.49	0.45	0.01	0.03	1.23
	Relocation	0.79	0.28	0.38	0.03	0.15	1.63
	Subtotal	**1.03**	**1.02**	**1.98**	**0.06**	**0.37**	**4.46**
Capital Stock Losses							
	Structural	1.60	0.70	0.59	0.11	0.19	3.18
	Non_Structural	13.86	7.06	6.17	1.95	1.98	31.02
	Content	8.62	2.82	4.74	1.40	1.74	19.33
	Inventory	0.00	0.00	0.13	0.31	0.01	0.45
	Subtotal	**24.09**	**10.58**	**11.62**	**3.77**	**3.92**	**53.97**
	Total	**25.12**	**11.60**	**13.59**	**3.82**	**4.30**	**58.43**

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 12 & 13 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 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	75,101.81	$0.00	0.00
	Bridges	64,049.84	$1.26	0.00
	Tunnels	0.00	$0.00	0.00
	Subtotal	**139151.70**	**1.30**	
Railways	Segments	2,942.96	$0.00	0.00
	Bridges	23.86	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	66.58	$0.96	1.44
	Subtotal	**3033.40**	**1.00**	
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	68.17	$0.87	1.28
	Subtotal	**68.20**	**0.90**	
Ferry	Facilities	6.66	$0.15	2.23
	Subtotal	**6.70**	**0.10**	
Port	Facilities	135.80	$0.91	0.67
	Subtotal	**135.80**	**0.90**	
Airport	Facilities	362.13	$5.28	1.46
	Runways	1,860.24	$0.00	0.00
	Subtotal	**2222.40**	**5.30**	
	Total	**144618.00**	**9.40**	

Table 13: 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	432.20	$0.26	0.06
	Distribution Lines	2,128.40	$1.51	0.07
	Subtotal	**2,560.65**	**$1.77**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	22,947.70	$77.09	0.34
	Distribution Lines	1,277.00	$0.76	0.06
	Subtotal	**24,224.74**	**$77.85**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	3.90	$0.00	0.07
	Distribution Lines	851.40	$0.26	0.03
	Subtotal	**855.22**	**$0.26**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	1.50	$0.00	0.07
	Subtotal	**1.53**	**$0.00**	
Electrical Power	Facilities	2,985.40	$1.63	0.05
	Subtotal	**2,985.40**	**$1.63**	
Communication	Facilities	32.00	$0.09	0.30
	Subtotal	**31.98**	**$0.09**	
	Total	**30,659.53**	**$81.60**	

Table 14. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS		Total	%
First Year			
	Employment Impact	3,156	0.38
	Income Impact	11	0.03
Second Year			
	Employment Impact	916	0.11
	Income Impact	4	0.01
Third Year			
	Employment Impact	16	0.00
	Income Impact	0	0.00
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(2)	0.00
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(2)	0.00
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(2)	0.00

Appendix A: County Listing for the Region

Albany,NY

Cayuga,NY

Chenango,NY

Clinton,NY

Columbia,NY

Cortland,NY

Delaware,NY

Essex,NY

Franklin,NY

Fulton,NY

Greene,NY

Hamilton,NY

Herkimer,NY

Jefferson,NY

Lewis,NY

Madison,NY

Montgomery,NY

Oneida,NY

Onondaga,NY

Oswego,NY

Otsego,NY

Rensselaer,NY

Saint Lawrence,NY

Saratoga,NY

Schenectady,NY

Schoharie,NY

Ulster,NY

Warren,NY

Washington,NY

Wayne,NY

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
New York					
	Albany	294,565	18,615	9,473	28,088
	Cayuga	81,963	4,286	1,386	5,672
	Chenango	51,401	2,403	1,001	3,404
	Clinton	79,894	3,862	1,555	5,417
	Columbia	63,094	4,269	1,254	5,523
	Cortland	48,599	2,416	1,049	3,466
	Delaware	48,055	3,069	859	3,929
	Essex	38,851	2,512	659	3,171
	Franklin	51,134	2,511	784	3,295
	Fulton	55,073	3,136	961	4,098
	Greene	48,195	3,242	776	4,019
	Hamilton	5,379	777	120	897
	Herkimer	64,427	3,411	1,085	4,496
	Jefferson	111,738	6,251	1,976	8,228
	Lewis	26,944	1,576	381	1,958
	Madison	69,441	3,665	1,216	4,882
	Montgomery	49,708	2,470	1,004	3,475
	Oneida	235,469	12,862	4,368	17,230
	Onondaga	458,336	27,936	12,253	40,190
	Oswego	122,377	5,932	2,020	7,953
	Otsego	61,676	3,392	1,057	4,450
	Rensselaer	152,538	8,846	2,825	11,671
	Saint Lawrence	111,931	5,390	1,606	6,996
	Saratoga	200,635	11,741	3,408	15,149
	Schenectady	146,555	9,138	5,606	14,745
	Schoharie	31,582	1,814	455	2,270
	Ulster	177,749	11,496	3,922	15,418
	Warren	63,303	4,410	1,550	5,961
	Washington	61,042	3,048	821	3,869
	Wayne	93,765	5,272	2,177	7,449
Total State		**3,105,419**	**179,748**	**67,607**	**247,369**
Total Region		**3,105,419**	**179,748**	**67,607**	**247,369**

Hazus-MH: Earthquake Event Report

Region Name: NY_1983_M58_VT_NH_MA

Earthquake Scenario: NY_1983_M58_VT_NH_MA

Print Date: October 24, 2011

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

Table of Contents

Section	Page #
General Description of the Region	3
Building and Lifeline Inventory	4
Building Inventory	
Critical Facility Inventory	
Transportation and Utility Lifeline Inventory	
Earthquake Scenario Parameters	6
Direct Earthquake Damage	7
Buildings Damage	
Critical Facilities Damage	
Transportation and Utility Lifeline Damage	
Induced Earthquake Damage	11
Fire Following Earthquake	
Debris Generation	
Social Impact	12
Shelter Requirements	
Casualties	
Economic Loss	13
Building Losses	
Transportation and Utility Lifeline Losses	
Long-term Indirect Economic Impacts	
Appendix A: County Listing for the Region	
Appendix B: Regional Population and Building Value Data	

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 25 county(ies) from the following state(s):

Massachusetts

New Hampshire

Vermont

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

The geographical size of the region is 19,566.99 square miles and contains 978 census tracts. There are over 1,675 thousand households in the region which has a total population of 4,353,245 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 1,647 thousand buildings in the region with a total building replacement value (excluding contents) of 379,435 (millions of dollars). Approximately 91.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 111,969 and 27,984 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 1,647 thousand buildings in the region which have an aggregate total replacement value of 379,435 (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 79% 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 facilities (HPL). 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 88 hospitals in the region with a total bed capacity of 14,185 beds. There are 2,293 schools, 540 fire stations, 427 police stations and 87 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 1,704 dams identified within the region. Of these, 340 of the dams are classified as 'high hazard'. The inventory also includes 1,074 hazardous material sites, 0 military installations and 2 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 1 and 2.

The total value of the lifeline inventory is over 139,953.00 (millions of dollars). This inventory includes over 9,259 kilometers of highways, 7,282 bridges, 184,102 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	7,282	56,989.60
	Segments	3,202	49,433.00
	Tunnels	0	0.00
		Subtotal	**106,422.60**
Railways	Bridges	92	7.10
	Facilities	61	162.40
	Segments	1,335	2,514.20
	Tunnels	1	0.50
		Subtotal	**2,684.30**
Light Rail	Bridges	0	0.00
	Facilities	65	173.10
	Segments	84	219.70
	Tunnels	0	0.00
		Subtotal	**392.80**
Bus	Facilities	72	85.10
		Subtotal	**85.10**
Ferry	Facilities	4	5.30
		Subtotal	**5.30**
Port	Facilities	11	22.00
		Subtotal	**22.00**
Airport	Facilities	36	383.40
	Runways	52	1,974.10
		Subtotal	**2,357.60**
		Total	**111,969.60**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	1,841.00
	Facilities	19	723.60
	Pipelines	0	0.00
		Subtotal	**2,564.60**
Waste Water	Distribution Lines	NA	1,104.60
	Facilities	204	14,544.80
	Pipelines	0	0.00
		Subtotal	**15,649.40**
Natural Gas	Distribution Lines	NA	736.40
	Facilities	5	6.30
	Pipelines	0	0.00
		Subtotal	**742.70**
Oil Systems	Facilities	2	0.20
	Pipelines	0	0.00
		Subtotal	**0.20**
Electrical Power	Facilities	105	12,681.90
		Subtotal	**12,681.90**
Communication	Facilities	262	28.20
		Subtotal	**28.20**
		Total	**31,667.00**

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	NY_1983_M58_VT_NH_MA
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	5.80
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Hazus estimates that about 6 buildings will be at least moderately damaged. This is over 0.00 % of the 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 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	7,245	0.44	2	1.12	0	1.75	0	0.00	0	0.00
Commercial	100,584	6.10	19	12.28	1	17.64	0	0.00	0	0.00
Education	4,552	0.28	1	0.47	0	0.57	0	0.00	0	0.00
Government	3,936	0.24	1	0.46	0	0.61	0	0.00	0	0.00
Industrial	32,988	2.00	5	3.46	0	5.07	0	0.00	0	0.00
Other Residential	391,633	23.77	100	63.41	4	61.02	0	0.00	0	0.00
Religion	7,002	0.42	1	0.87	0	1.12	0	0.00	0	0.00
Single Family	1,099,865	66.75	28	17.94	1	12.23	0	0.00	0	0.00
Total	**1,647,805**		**157**		**7**		**0**		**0**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	1,298,270	78.79	14	8.82	0	0.00	0	0.00	0	0.00
Steel	80,816	4.90	10	6.33	1	10.37	0	0.00	0	0.00
Concrete	30,068	1.82	3	1.91	0	0.02	0	0.00	0	0.00
Precast	5,209	0.32	1	0.90	0	2.22	0	0.00	0	0.00
RM	43,395	2.63	2	1.31	0	2.82	0	0.00	0	0.00
URM	142,045	8.62	63	39.89	3	49.71	0	0.00	0	0.00
MH	48,001	2.91	64	40.84	2	34.87	0	0.00	0	0.00
Total	**1,647,805**		**157**		**7**		**0**		**0**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 14,185 hospital beds available for use. On the day of the earthquake, the model estimates that only 14,176 hospital beds (100.00%) 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 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	88	0	0	88
Schools	2,293	0	0	2,293
EOCs	87	0	0	87
PoliceStations	427	0	0	427
FireStations	540	0	0	540

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: 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	3,202	0	0	3,202	3,202
	Bridges	7,282	0	0	7,282	7,282
	Tunnels	0	0	0	0	0
Railways	Segments	1,335	0	0	1,335	1,335
	Bridges	92	0	0	92	92
	Tunnels	1	0	0	1	1
	Facilities	61	0	0	61	61
Light Rail	Segments	84	0	0	84	84
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	65	0	0	65	65
Bus	Facilities	72	0	0	72	72
Ferry	Facilities	4	0	0	4	4
Port	Facilities	11	0	0	11	11
Airport	Facilities	36	0	0	36	36
	Runways	52	0	0	52	52

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 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 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 9 provides a summary of the system performance information.

Table 7 : 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	19	0	0	19	19
Waste Water	204	0	0	204	204
Natural Gas	5	0	0	5	5
Oil Systems	2	0	0	2	2
Electrical Power	105	0	0	105	105
Communication	262	0	0	262	262

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	92,051	245	61
Waste Water	55,231	123	31
Natural Gas	36,821	42	11
Oil	0	0	0

Table 9: 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	1,675,257	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 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (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 91.00% 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 4,353,245) 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 10 provides a summary of the casualties estimated for this earthquake

Table 10: 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	0	0	0	0
	Total	**0**	**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	**0**	**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	**0**	**0**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 14.46 (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 3.95 (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 40 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	0.00	0.04	0.00	0.01	0.05
	Capital-Related	0.00	0.00	0.03	0.00	0.00	0.04
	Rental	0.00	0.02	0.04	0.00	0.00	0.07
	Relocation	0.00	0.01	0.02	0.00	0.01	0.04
	Subtotal	**0.00**	**0.03**	**0.14**	**0.01**	**0.02**	**0.20**
Capital Stock Losses							
	Structural	0.02	0.04	0.05	0.01	0.01	0.14
	Non_Structural	0.51	0.46	0.68	0.29	0.18	2.12
	Content	0.35	0.18	0.52	0.21	0.16	1.42
	Inventory	0.00	0.00	0.02	0.05	0.00	0.07
	Subtotal	**0.88**	**0.68**	**1.28**	**0.56**	**0.35**	**3.75**
	Total	**0.89**	**0.71**	**1.41**	**0.56**	**0.37**	**3.95**

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 12 & 13 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 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	49,433.00	$0.00	0.00
	Bridges	56,989.62	$0.32	0.00
	Tunnels	0.00	$0.00	0.00
	Subtotal	**106422.60**	**0.30**	
Railways	Segments	2,514.21	$0.00	0.00
	Bridges	7.10	$0.00	0.00
	Tunnels	0.51	$0.00	0.00
	Facilities	162.44	$0.57	0.35
	Subtotal	**2684.30**	**0.60**	
Light Rail	Segments	219.67	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	173.10	$0.19	0.11
	Subtotal	**392.80**	**0.20**	
Bus	Facilities	85.06	$0.31	0.36
	Subtotal	**85.10**	**0.30**	
Ferry	Facilities	5.32	$0.09	1.76
	Subtotal	**5.30**	**0.10**	
Port	Facilities	21.97	$0.02	0.11
	Subtotal	**22.00**	**0.00**	
Airport	Facilities	383.44	$1.33	0.35
	Runways	1,974.13	$0.00	0.00
	Subtotal	**2357.60**	**1.30**	
	Total	**111969.60**	**2.80**	

Table 13: 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	723.60	$0.04	0.01
	Distribution Lines	1,841.00	$1.10	0.06
	Subtotal	**2,564.64**	**$1.15**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	14,544.80	$4.19	0.03
	Distribution Lines	1,104.60	$0.55	0.05
	Subtotal	**15,649.39**	**$4.75**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	6.30	$0.00	0.02
	Distribution Lines	736.40	$0.19	0.03
	Subtotal	**742.73**	**$0.19**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.20	$0.00	0.05
	Subtotal	**0.21**	**$0.00**	
Electrical Power	Facilities	12,681.90	$1.58	0.01
	Subtotal	**12,681.90**	**$1.58**	
Communication	Facilities	28.20	$0.01	0.03
	Subtotal	**28.15**	**$0.01**	
	Total	**31,667.02**	**$7.67**	

Table 14. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS		Total	%
First Year			
	Employment Impact	1,285	0.09
	Income Impact	5	0.01
Second Year			
	Employment Impact	345	0.02
	Income Impact	2	0.00
Third Year			
	Employment Impact	6	0.00
	Income Impact	0	0.00
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	0	0.00
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	0	0.00
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	0	0.00

Appendix A: County Listing for the Region

Berkshire,MA

Franklin,MA

Hampden,MA

Hampshire,MA

Middlesex,MA

Worcester,MA

Cheshire,NH

Grafton,NH

Hillsborough,NH

Merrimack,NH

Sullivan,NH

Addison,VT

Bennington,VT

Caledonia,VT

Chittenden,VT

Essex,VT

Franklin,VT

Grand Isle,VT

Lamoille,VT

Orange,VT

Orleans,VT

Rutland,VT

Washington,VT

Windham,VT

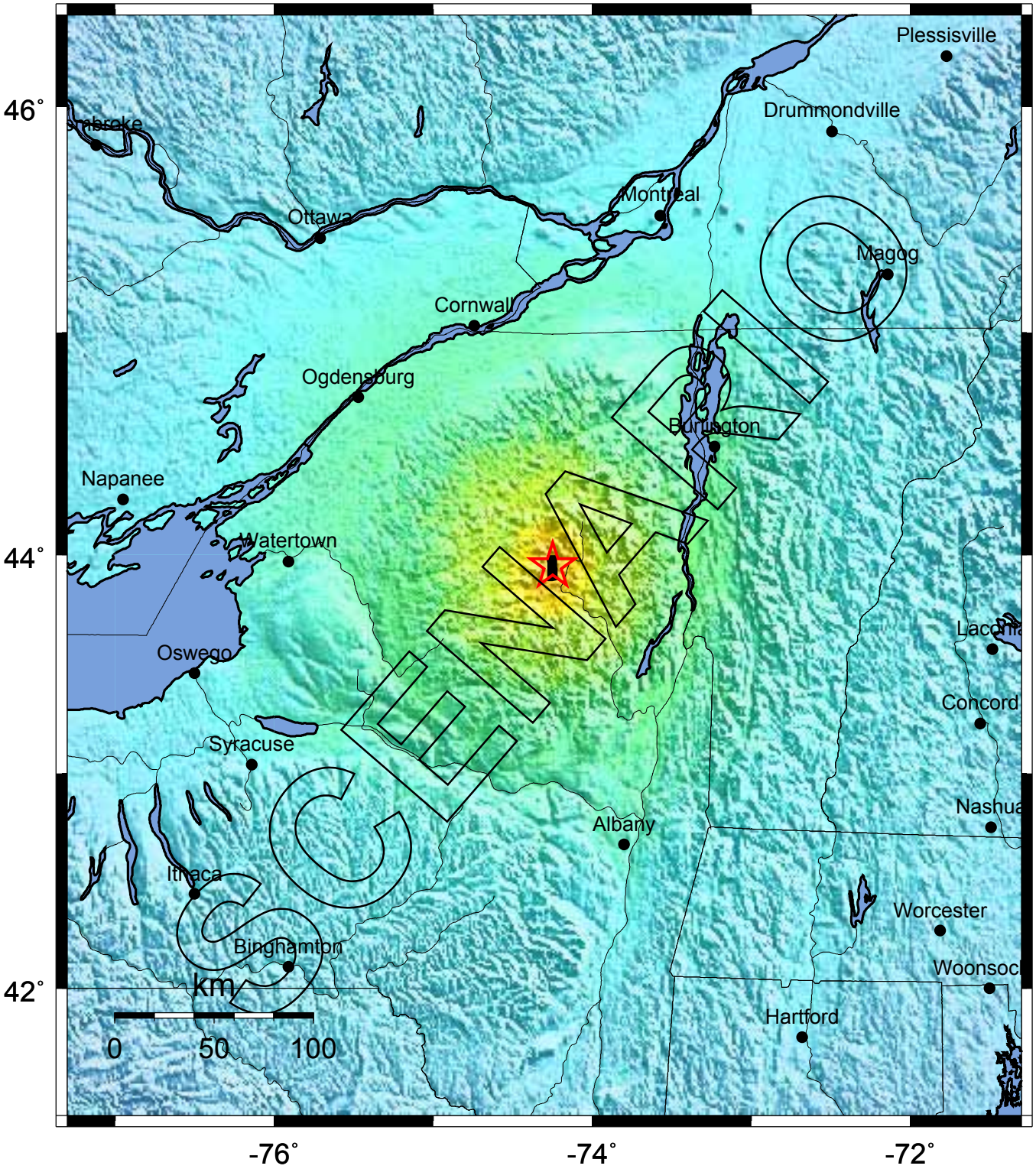
Windsor,VT

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Berkshire	134,953	9,021	3,299	12,320
	Franklin	71,535	4,371	1,677	6,049
	Hampden	456,228	26,881	12,455	39,337
	Hampshire	152,251	9,444	3,164	12,609
	Middlesex	1,465,396	102,752	42,073	144,825
	Worcester	750,963	47,390	19,448	66,838
Total State		**3,031,326**	**199,859**	**82,116**	**281,978**
New Hampshire					
	Cheshire	73,825	3,542	1,488	5,030
	Grafton	81,743	4,393	1,698	6,092
	Hillsborough	380,841	20,779	8,609	29,389
	Merrimack	136,225	6,704	2,996	9,700
	Sullivan	40,458	1,879	652	2,531
Total State		**713,092**	**37,297**	**15,443**	**52,742**
Vermont					
	Addison	35,974	1,871	657	2,528
	Bennington	36,994	2,458	962	3,420
	Caledonia	29,702	1,402	509	1,912
	Chittenden	146,571	7,279	3,361	10,641
	Essex	6,459	370	76	446
	Franklin	45,417	2,016	703	2,719
	Grand Isle	6,901	483	87	571
	Lamoille	23,233	1,230	461	1,691
	Orange	28,226	1,370	395	1,765
	Orleans	26,277	1,232	457	1,689
	Rutland	63,400	3,358	1,241	4,599
	Washington	58,039	3,015	1,374	4,390
	Windham	44,216	2,844	1,187	4,031
	Windsor	57,418	3,206	1,094	4,300
Total State		**608,827**	**32,134**	**12,564**	**44,702**
Total Region		**4,353,245**	**269,290**	**110,123**	**379,422**

-- Earthquake Planning Scenario --
ShakeMap for Ny1983m5.8 Scenario

Scenario Date: Wed Sep 7, 2011 12:00:00 GMT M 5.8 N43.95 W74.25



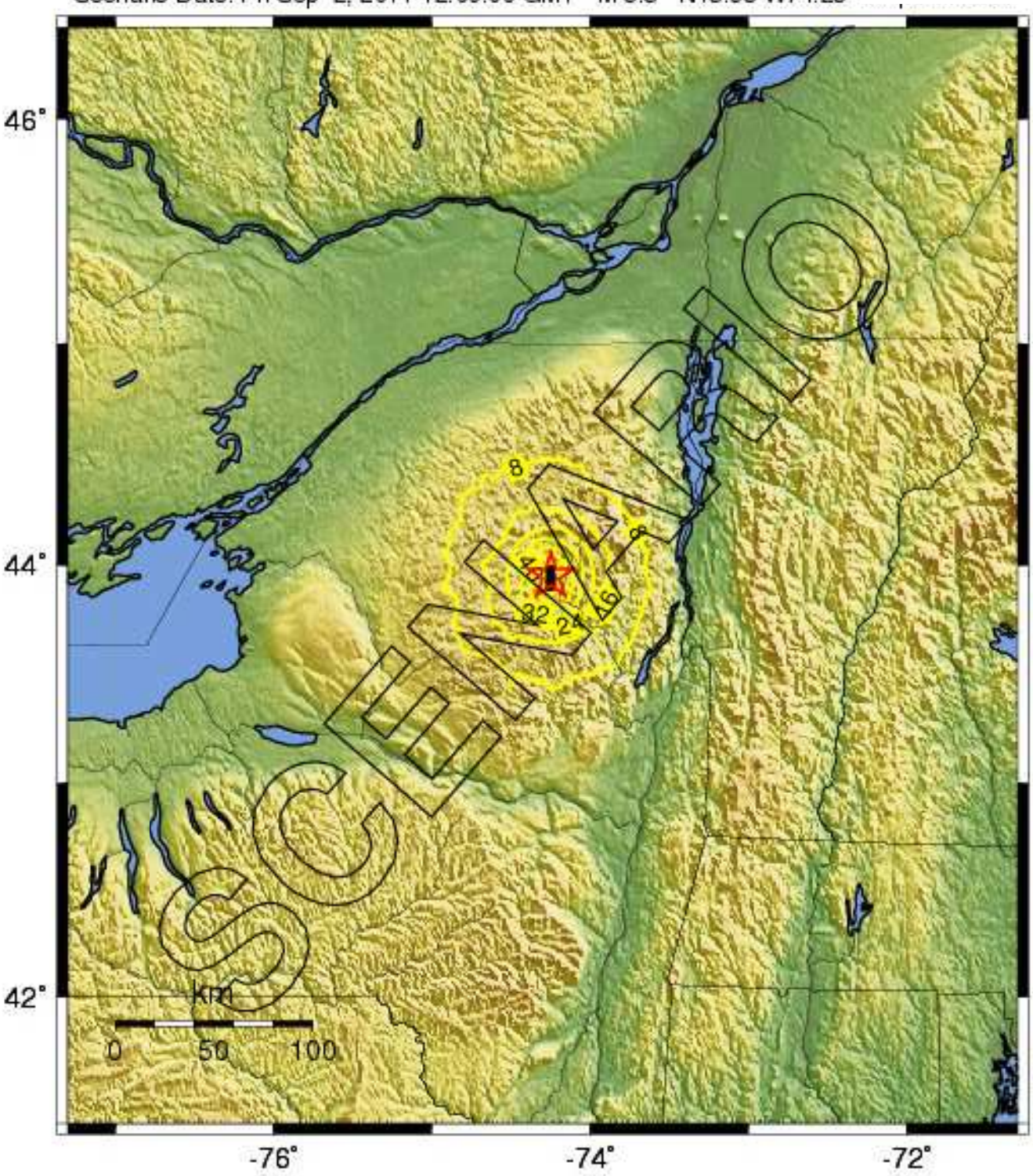
PLANNING SCENARIO ONLY -- Map Version 1 Processed Thu Sep 8, 2011 05:08:27 PM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

-- Earthquake Planning Scenario --

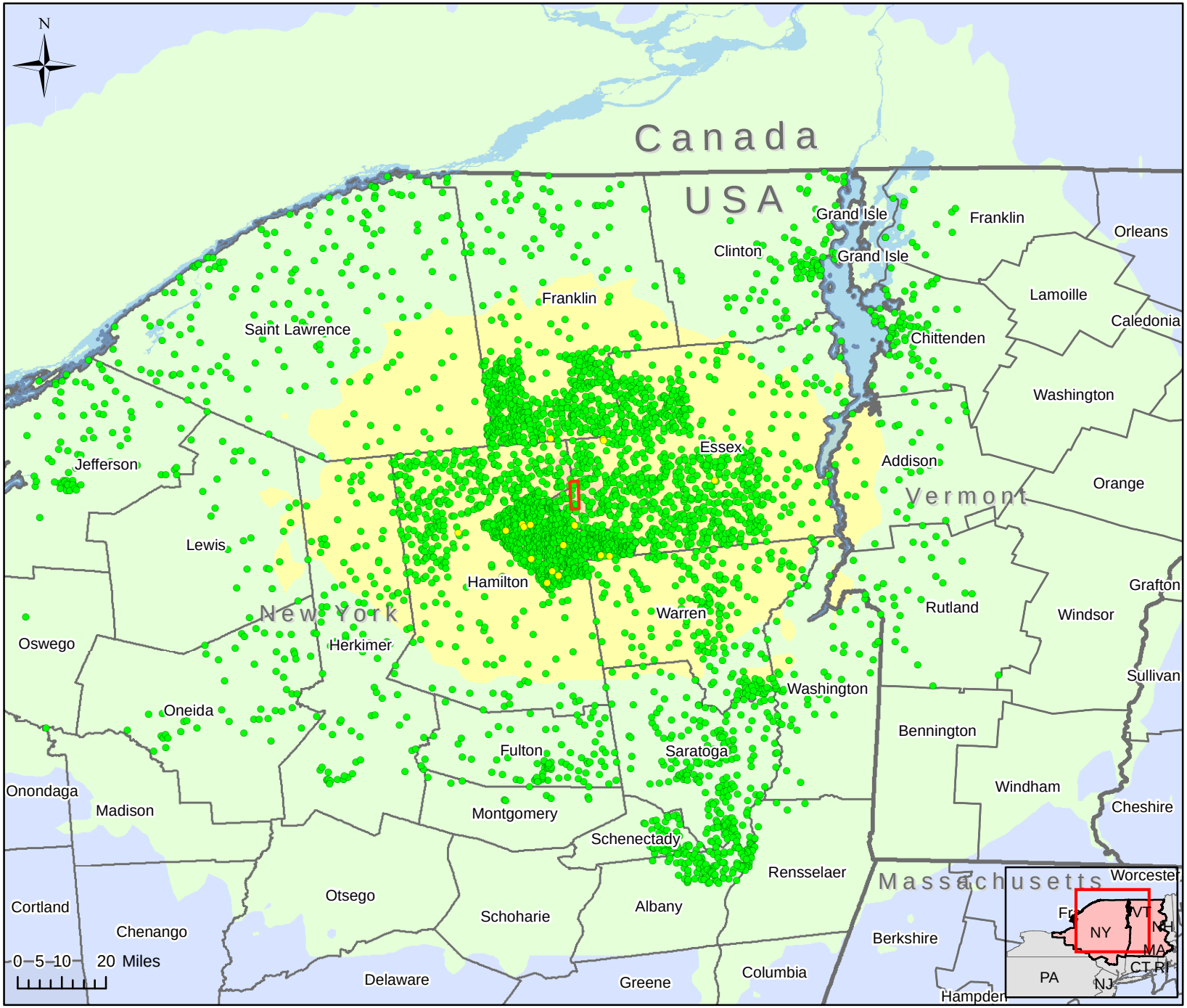
Peak Accel. Map (in %g) for NY1983M5.8 Scenario

Scenario Date: Fri Sep 2, 2011 12:00:00 GMT M 5.8 N43.95 W74.25



PLANNING SCENARIO ONLY -- Map Version 1 Processed Mon Sep 5, 2011 12:37:36 PM MDT

Estimated Building Inspection Needs and Ground Shaking Intensity



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

- **Red Tag (Complete Damage)**
- **YellowTag (Extensive Damage)**
- **GreenTag (Slight/Moderate Damage)**

1 Dot = 1 Building (by census tract)

	Estimated # of Structures	Estimated # of Inspectors
Red (Complete)	**0**	**0**
Yellow (Extensive)	**20**	**1**
Green (Slight/ Moderate)	**4,193**	**28**

* Estimated number of inspectors needed to complete inspections in 30 days

Fault Sources

Instrumental Intensity

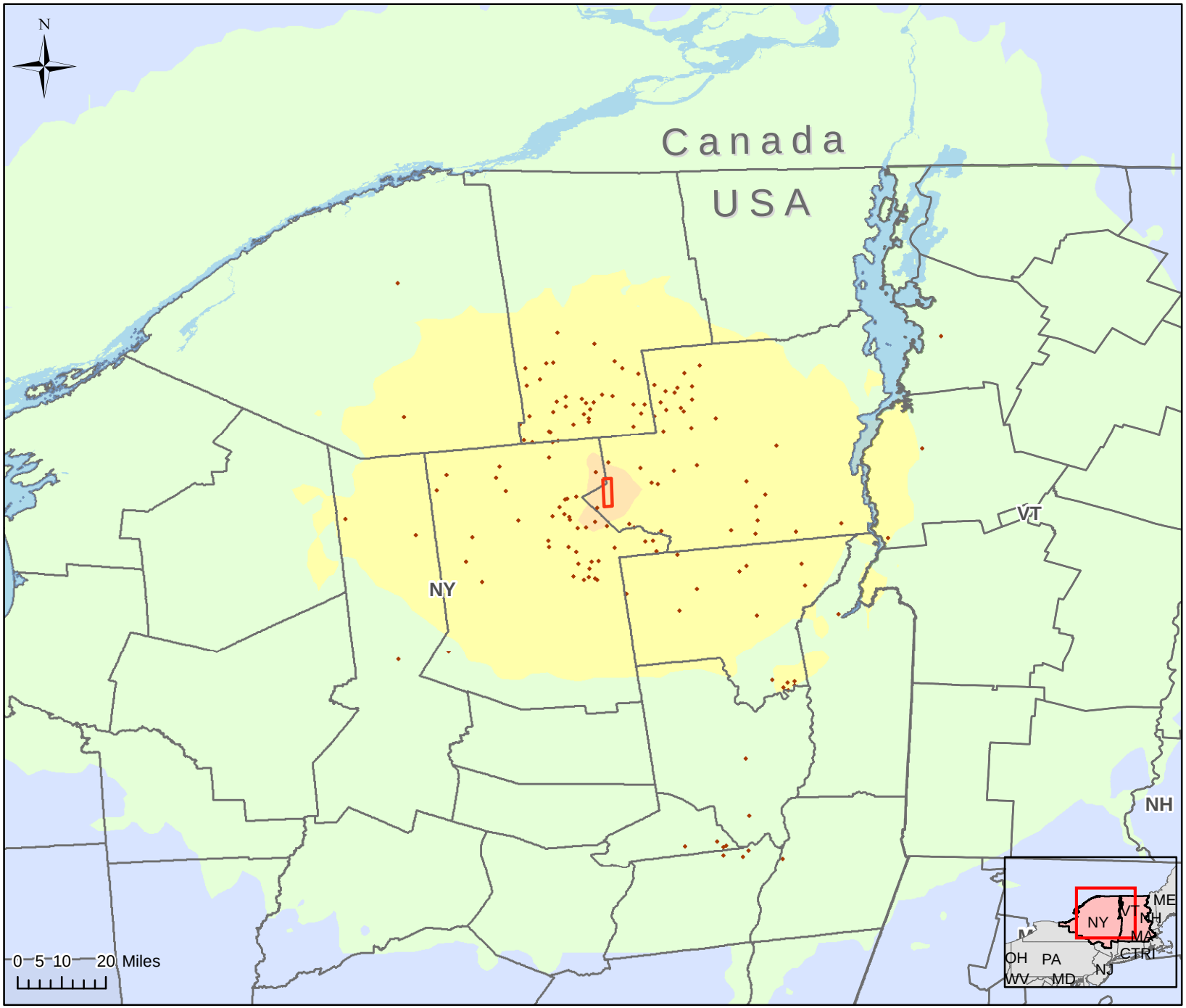
Not felt | Weak | Light | Moderate | Strong | Very strong | Severe | Violent | Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Estimated Building Economic Loss by Census Tract and Ground Shaking Intensity



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Direct Economic Losses

(Losses include all building-related losses)

1 Dot = $1 Million

Fault Sources

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

Cost Structural Damage	Cost Non-Structural Damage	Total Loss (Including Contents)
$3	$33	$58
all values in Millions		
Total Loss $553 Million		

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Displaced Households and Ground Shaking Intensity

Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

1 Dot = 1 Household

1 Dot = 1 Individual

Earthquakes can cause loss of function or habitability of buildings that contain housing units, resulting in approximately predictable numbers of displaced households. Loss of habitability is calculated directly from damage to the residential occupancy inventory, and from loss of water and power.

Shelter Requirements	Total #
Public Shelter Needs (Individuals)	0
Displaced Households	1

Fault Sources

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Electrical, Natural Gas & Oil Facility Damage and Ground Shaking Intensity

Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Utility Facility Damage (at least moderate)

Damage is expressed as the probability that a given facility will realize at least moderate damage.

Electric Power
- Low
- Moderate
- High

Oil Facility
- Low
- Moderate
- High

Natural Gas
- Low
- Moderate
- High

Fault Source

Instrumental Intensity

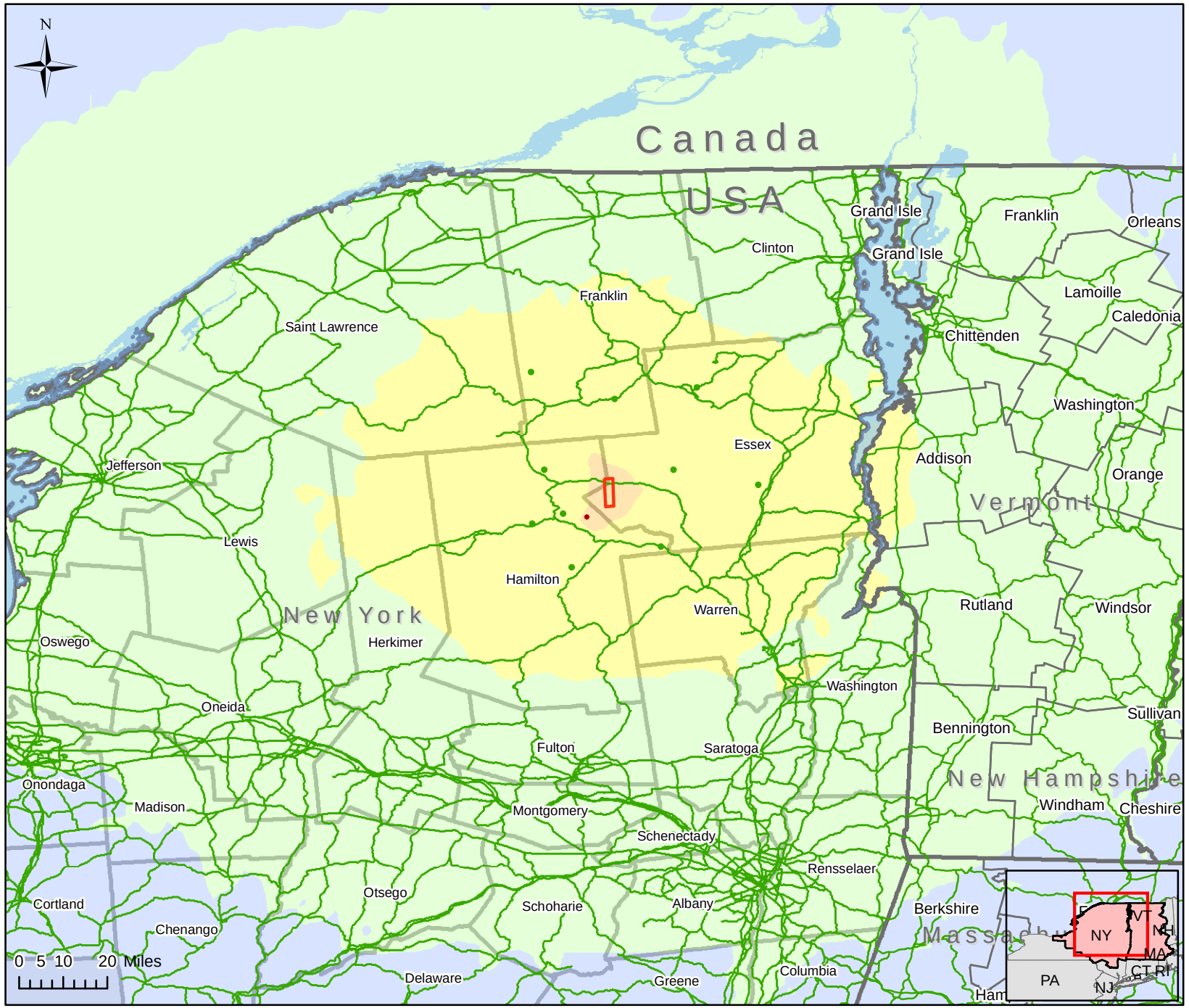
Not felt	Strong
Weak	Very strong
Light	Severe
Moderate	Violent
	Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Estimated Debris and Highway Damage and Ground Shaking Intensity



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

1 dot = 1 thousand tons of Concrete and Steel Debris (by Census Tract)

1 dot = 1 thousand tons of Brick and Wood Debris (by Census Tract)

Debris Totals	Total (in tons)	Estimated Truck Loads*
Brick and Wood	**9,000**	360
Concrete and Steel	**1,000**	40

* Truck loads estimated to be 25 tons per truck.

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Highway Center Impact

- Low
- Moderate
- High

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

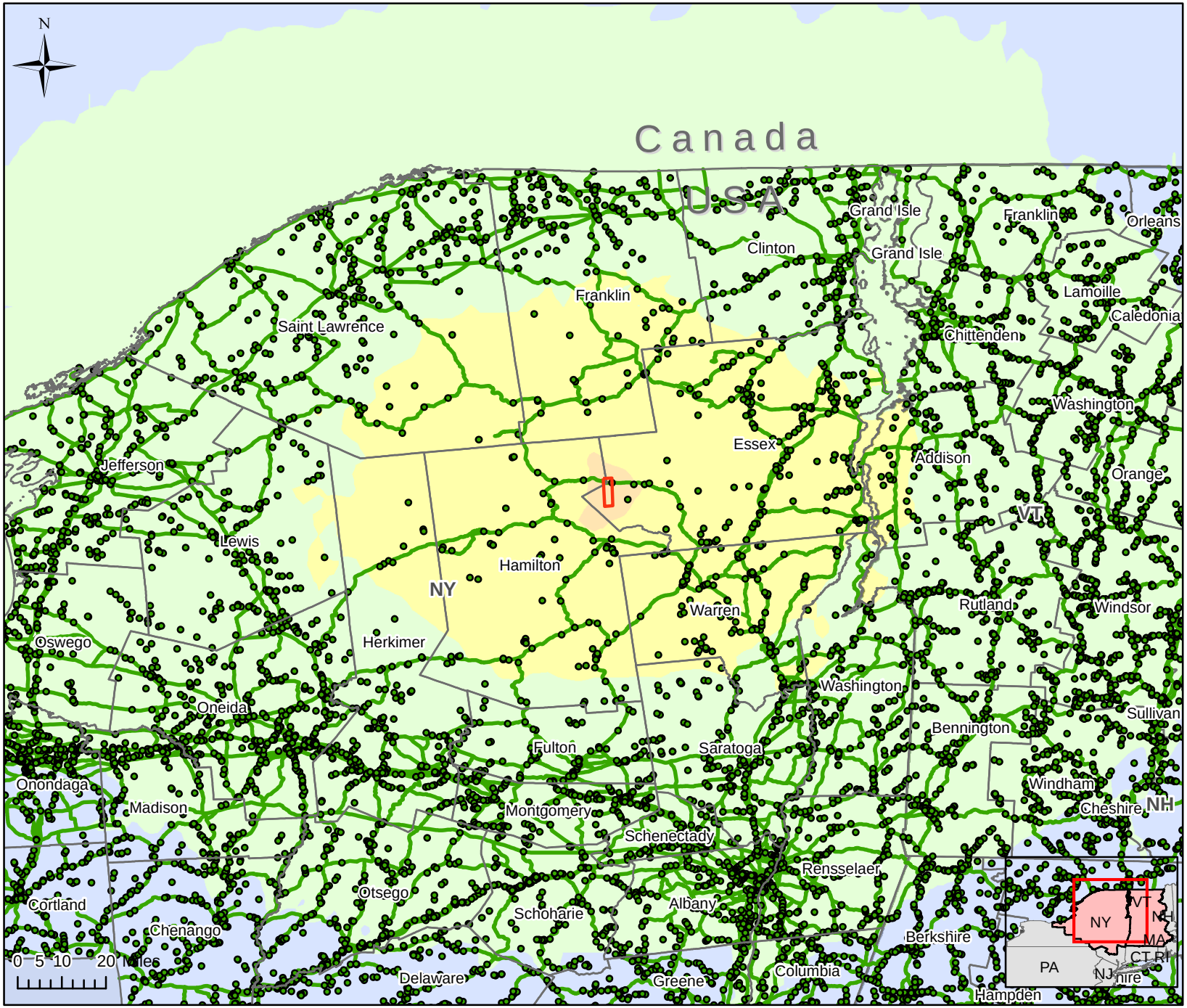
Fault Source

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Estimated Highway Infrastructure Damage and Ground Shaking Intensity



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Major Roadway Bridge Impact

- Low
- Moderate
- High

Highway Segment Impact

- Low
- Moderate
- High

- Fault Sources

Instrumental Intensity

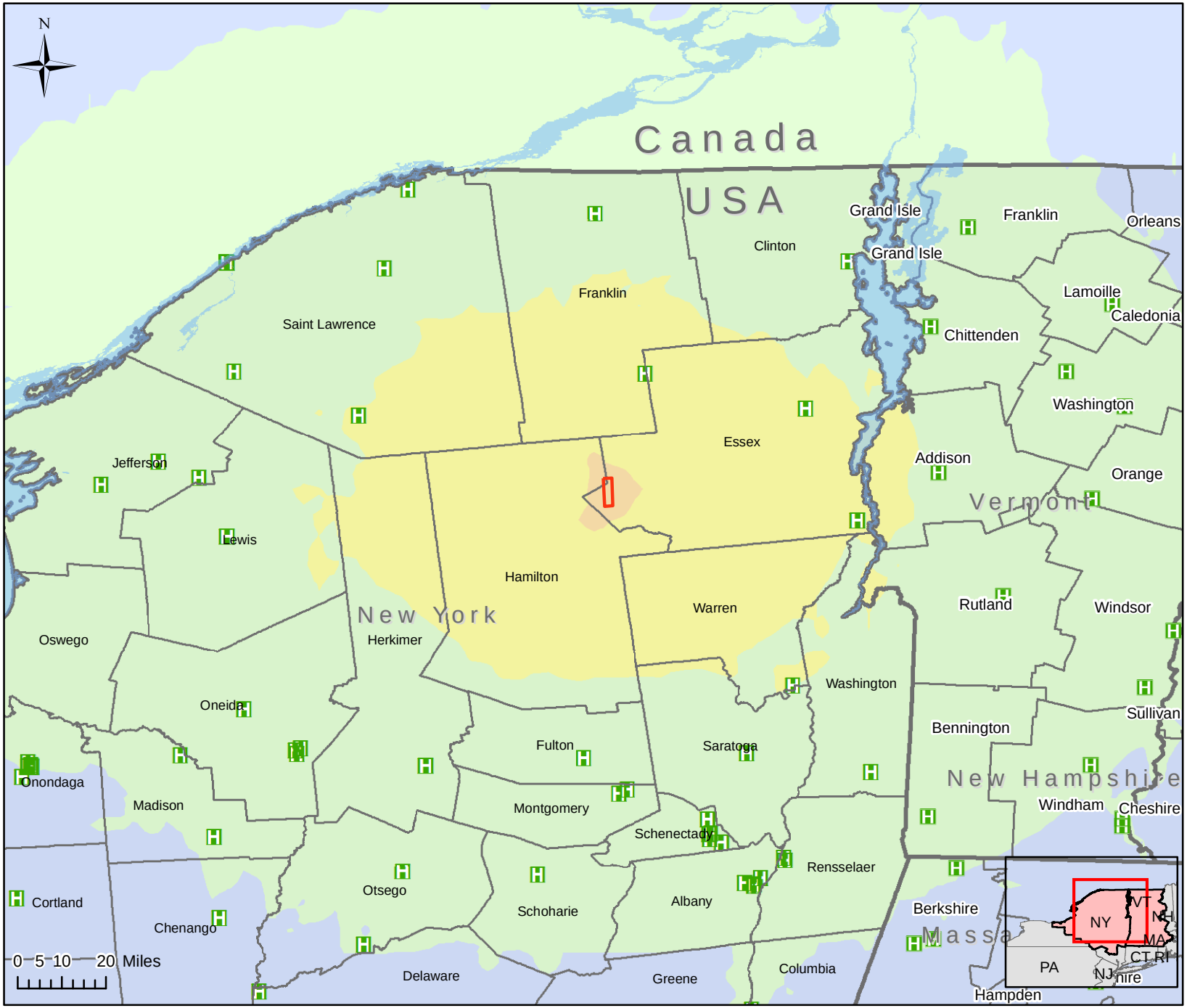
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Impaired Hospitals (Day 1) and Ground Shaking Intensity



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Impaired Hospitals (Day 1)

- High (<25%)
- Moderate (25% to 75%)
- Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event

Fault Sources

Instrumental Intensity

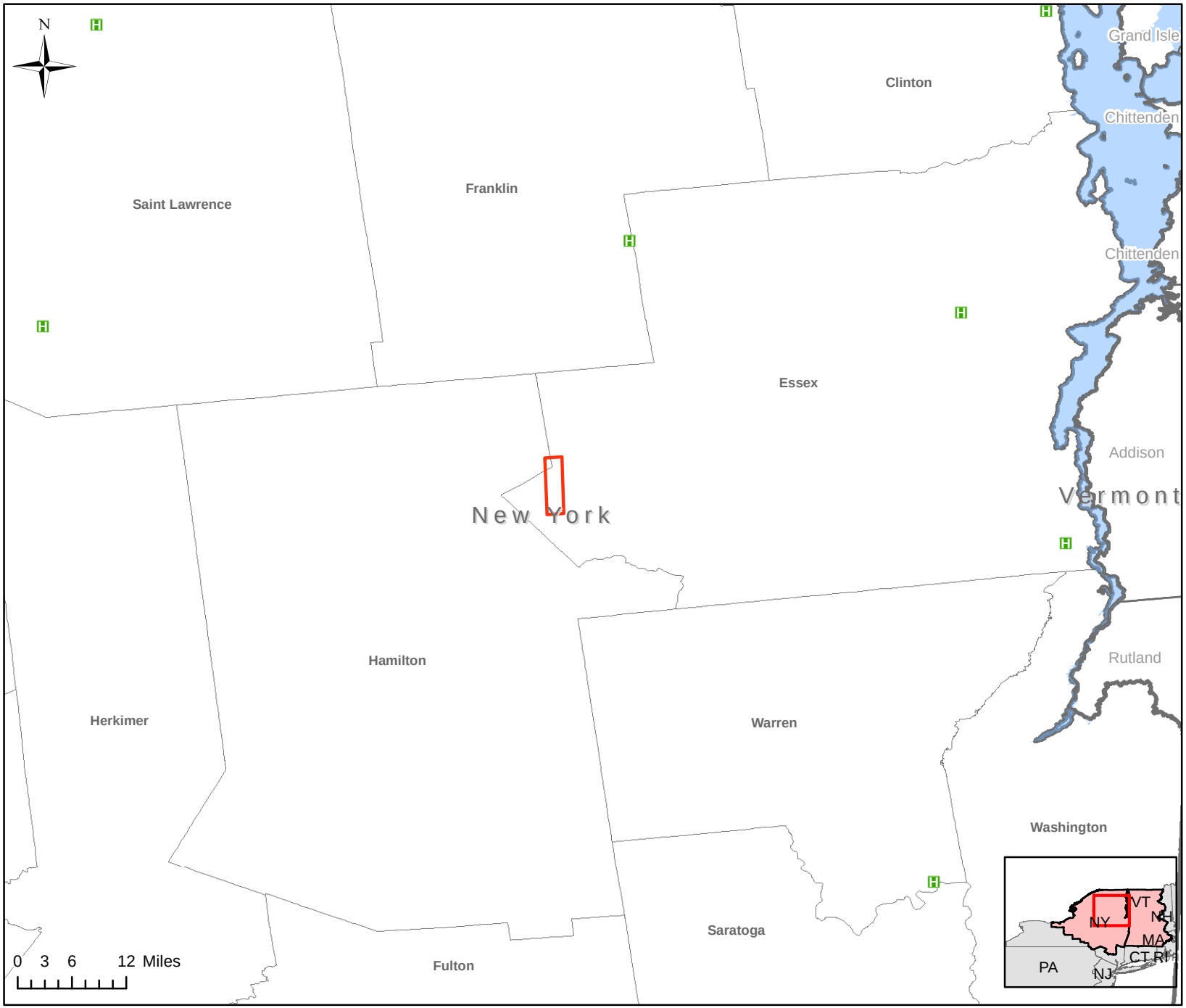
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Injuries Requiring Hospital Treatment 2 p.m. and Impaired Hospitals



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Estimated Number of Persons Requiring Hospital Treatment (2 p.m.)

1 Dot = 5 Persons

Level 2 and 3 Injuries

- 0
- 1 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 500
- 500 or more
- Fault Sources

Impaired Hospitals (Day 1)

- High (<25%)
- Moderate (25% to 75%)
- Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

The estimate od the number of persons requiring hospital treatment includes Severity 2 and Severity 3 levels from Hazus-MH results.

Severity 2 are injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life-threatening status.

Severity 3 are injuries that pose an immediate life-threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

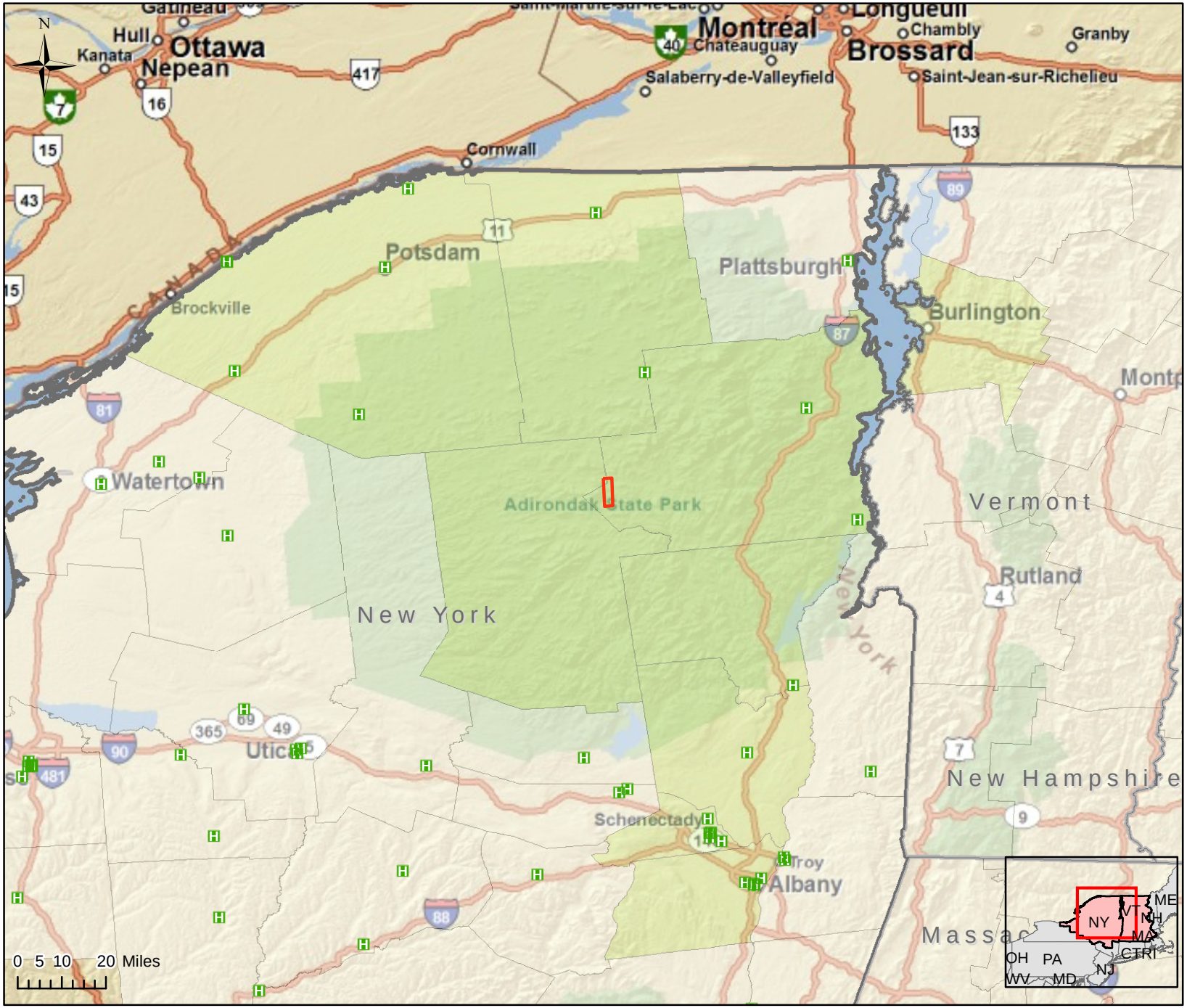
Requiring Hospital Treatment	Immediate Life Threatening Injuries
0	0

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Potential Search and Rescue Needs 2 p.m. and Impaired Hospitals



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Severity 3 are injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

Impaired Hospitals
(Day 1)

- H High (<25%)
- H Moderate (25% to 75%)
- H Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

Fault Sources

Level 3 Injury

0 | 1 - 5 | 5 - 10 | 10 - 50 | 50 - 100 | 100 - 500 | 500 or more

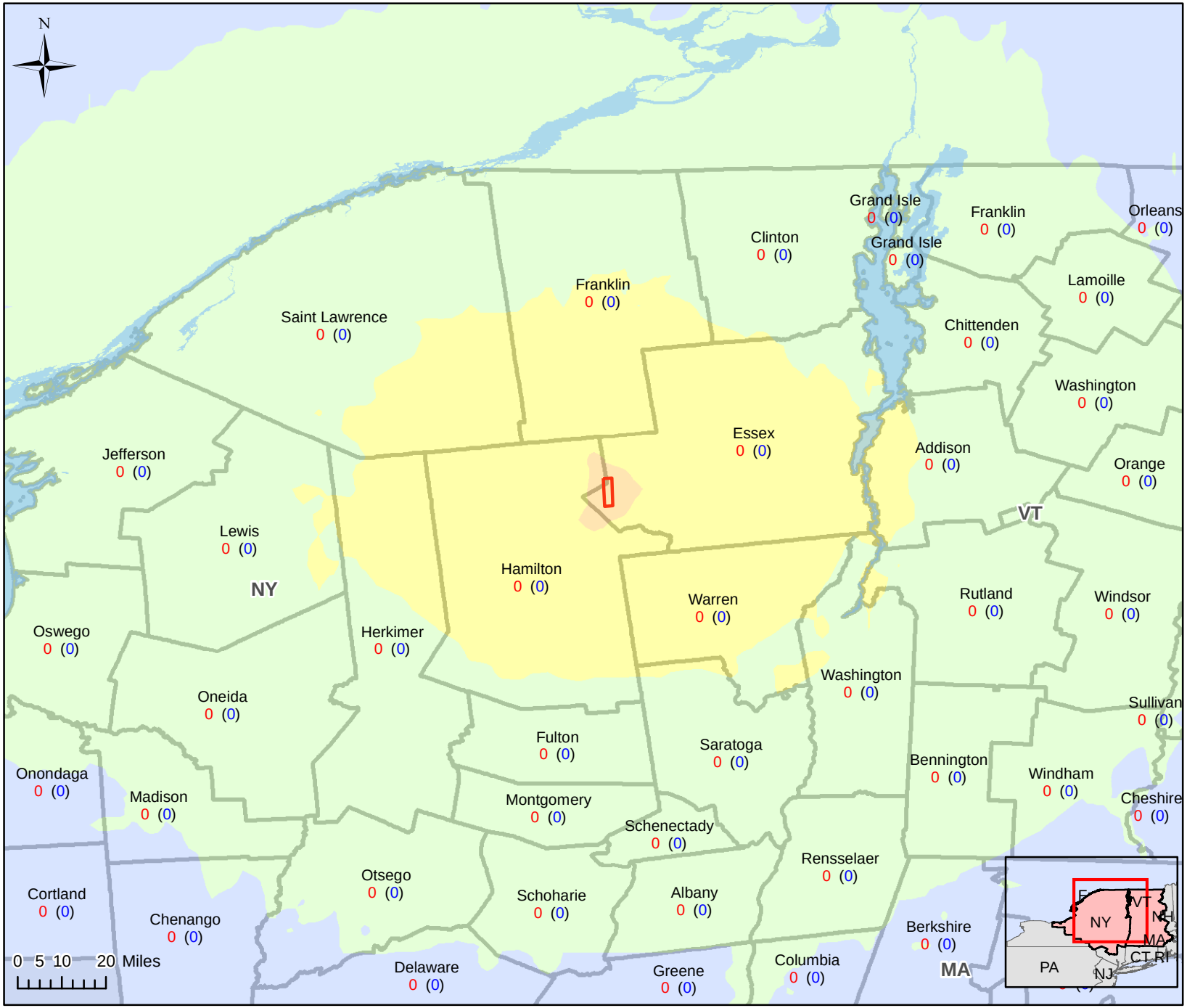
Structure Type	Red (Complete)	Total Collapse
Concrete	0	0
Manufactured Housing	0	0
Precast	0	0
Reinforced Masonry	0	0
Steel	0	0
Unreinforced Masonry	0	0
Wood	0	0
Total	0	0

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Estimated Potable Water Needs by County and Ground Shaking Intensity



Earthquake Scenario:
Goodnow, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Estimated Liters of Potable Water Needed *

Red # = Households without Potable Water (Thousands)

(Blue #) = Daily Potable Water Needs (Thousand liters /day)

* Based on U.S. Army Corp Mission Guidebook (Daily water is based on an estimated 3 people per household).

Fault Sources

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event NY1983M5.8_se, New York 1983 M5.8 Scenario

Plattsburgh, NY
M 5.8

Hazus-MH: Earthquake Event Report

Region Name: NE Scenarios - Plattsburgh Region

Earthquake Scenario: Mw 5.8 Plattsburgh, New York Scenario

Print Date: October 20, 2011

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

Section	Page #
General Description of the Region	3
Building and Lifeline Inventory	4
Building Inventory	
Critical Facility Inventory	
Transportation and Utility Lifeline Inventory	
Earthquake Scenario Parameters	6
Direct Earthquake Damage	7
Buildings Damage	
Critical Facilities Damage	
Transportation and Utility Lifeline Damage	
Induced Earthquake Damage	11
Fire Following Earthquake	
Debris Generation	
Social Impact	12
Shelter Requirements	
Casualties	
Economic Loss	13
Building Losses	
Transportation and Utility Lifeline Losses	
Long-term Indirect Economic Impacts	
Appendix A: County Listing for the Region	
Appendix B: Regional Population and Building Value Data	

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 32 county(ies) from the following state(s):

New Hampshire

New York

Vermont

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

The geographical size of the region is 31,599.53 square miles and contains 597 census tracts. There are over 843 thousand households in the region which has a total population of 2,174,544 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 1,064 thousand buildings in the region with a total building replacement value (excluding contents) of 162,380 (millions of dollars). Approximately 93.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 111,921 and 22,205 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 1,064 thousand buildings in the region which have an aggregate total replacement value of 162,380 (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 71% 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 facilities (HPL). 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 56 hospitals in the region with a total bed capacity of 8,019 beds. There are 1,237 schools, 612 fire stations, 243 police stations and 17 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 1,086 dams identified within the region. Of these, 152 of the dams are classified as 'high hazard'. The inventory also includes 557 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 1 and 2.

The total value of the lifeline inventory is over 134,126.00 (millions of dollars). This inventory includes over 12,443 kilometers of highways, 6,280 bridges, 196,424 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	6,280	43,586.80
	Segments	2,956	63,302.70
	Tunnels	0	0.00
		Subtotal	**106,889.50**
Railways	Bridges	149	20.60
	Facilities	28	74.60
	Segments	1,533	2,783.10
	Tunnels	0	0.00
		Subtotal	**2,878.30**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	42	49.70
		Subtotal	**49.70**
Ferry	Facilities	9	12.00
		Subtotal	**12.00**
Port	Facilities	13	26.00
		Subtotal	**26.00**
Airport	Facilities	30	319.50
	Runways	46	1,746.30
		Subtotal	**2,065.90**
		Total	**111,921.40**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	1,964.20
	Facilities	4	150.20
	Pipelines	0	0.00
		Subtotal	**2,114.40**
Waste Water	Distribution Lines	NA	1,178.50
	Facilities	240	17,723.60
	Pipelines	0	0.00
		Subtotal	**18,902.10**
Natural Gas	Distribution Lines	NA	785.70
	Facilities	2	2.60
	Pipelines	0	0.00
		Subtotal	**788.30**
Oil Systems	Facilities	7	0.80
	Pipelines	0	0.00
		Subtotal	**0.80**
Electrical Power	Facilities	37	4,302.10
		Subtotal	**4,302.10**
Communication	Facilities	242	26.60
		Subtotal	**26.60**
		Total	**26,134.40**

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	Mw 5.8 Plattsburgh, New York Scenario
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	5.80
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Hazus estimates that about 2,573 buildings will be at least moderately damaged. This is over 0.00 % of the buildings in the region. There are an estimated 3 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 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	4,982	0.47	34	0.39	10	0.43	1	0.61	0	0.50
Commercial	49,459	4.69	530	6.14	179	7.44	15	8.85	0	7.83
Education	2,074	0.20	20	0.23	6	0.24	0	0.22	0	0.20
Government	2,987	0.28	25	0.29	9	0.37	1	0.39	0	0.28
Industrial	15,394	1.46	138	1.60	52	2.17	4	2.48	0	1.77
Other Residential	304,533	28.90	3,434	39.83	1,416	58.96	92	54.78	1	35.82
Religion	3,790	0.36	37	0.43	11	0.44	1	0.48	0	0.55
Single Family	670,380	63.63	4,404	51.08	719	29.94	54	32.19	2	53.06
Total	**1,053,600**		**8,622**		**2,402**		**168**		**4**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	749,304	71.12	3996	46.34	296	12.32	2	1.18	0	0.00
Steel	42,265	4.01	334	3.87	141	5.86	11	6.26	0	3.09
Concrete	22,571	2.14	198	2.29	72	3.01	4	2.15	0	0.74
Precast	2,646	0.25	31	0.36	18	0.75	2	1.19	0	0.37
RM	25,790	2.45	142	1.65	78	3.25	6	3.64	0	0.21
URM	127,579	12.11	2036	23.62	758	31.56	80	47.83	3	81.22
MH	83,446	7.92	1885	21.87	1,039	43.25	63	37.75	1	14.36
Total	**1,053,600**		**8,622**		**2,402**		**168**		**4**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 8,019 hospital beds available for use. On the day of the earthquake, the model estimates that only 7,915 hospital beds (99.00%) 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 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	56	0	0	56
Schools	1,237	6	0	1,216
EOCs	17	0	0	17
PoliceStations	243	0	0	243
FireStations	612	2	0	603

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: 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	2,956	0	0	2,956	2,956
	Bridges	6,280	0	0	6,280	6,280
	Tunnels	0	0	0	0	0
Railways	Segments	1,533	0	0	1,533	1,533
	Bridges	149	0	0	149	149
	Tunnels	0	0	0	0	0
	Facilities	28	0	0	28	28
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	42	0	0	42	42
Ferry	Facilities	9	0	0	9	9
Port	Facilities	13	0	0	13	13
Airport	Facilities	30	0	0	30	30
	Runways	46	0	0	46	46

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 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 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 9 provides a summary of the system performance information.

Table 7 : 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	4	0	0	4	4
Waste Water	240	3	0	231	239
Natural Gas	2	0	0	2	2
Oil Systems	7	0	0	7	7
Electrical Power	37	0	0	36	37
Communication	242	5	0	240	242

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	98,212	262	65
Waste Water	58,927	132	33
Natural Gas	39,285	45	11
Oil	0	0	0

Table 9: 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	843,785	0	0	0	0	0
Electric Power		7,205	4,209	1,448	216	9

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 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 47 people and burn about 2 (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 0.04 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 75.00% 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 1,640 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 19 households to be displaced due to the earthquake. Of these, 13 people (out of a total population of 2,174,544) 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 10 provides a summary of the casualties estimated for this earthquake

Table 10: 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	13	1	0	0
	Single Family	13	1	0	0
	Total	**27**	**2**	**0**	**0**
2 PM	Commercial	9	1	0	0
	Commuting	0	0	0	0
	Educational	4	0	0	0
	Hotels	0	0	0	0
	Industrial	2	0	0	0
	Other-Residential	2	0	0	0
	Single Family	3	0	0	0
	Total	**20**	**2**	**0**	**0**
5 PM	Commercial	8	1	0	0
	Commuting	0	0	0	0
	Educational	1	0	0	0
	Hotels	0	0	0	0
	Industrial	1	0	0	0
	Other-Residential	5	0	0	0
	Single Family	5	0	0	0
	Total	**19**	**2**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 465.51 (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 226.09 (millions of dollars); 10 % 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 60 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	0.29	4.17	0.14	0.50	5.10
	Capital-Related	0.00	0.12	3.36	0.08	0.08	3.65
	Rental	0.87	1.54	2.51	0.08	0.14	5.13
	Relocation	3.00	2.26	3.06	0.40	0.94	9.66
	Subtotal	**3.87**	**4.22**	**13.10**	**0.70**	**1.65**	**23.53**
Capital Stock Losses							
	Structural	5.69	3.24	3.45	0.75	1.02	14.14
	Non_Structural	49.25	27.36	23.83	7.71	6.48	114.64
	Content	30.39	10.88	18.83	5.86	5.78	71.73
	Inventory	0.00	0.00	0.63	1.28	0.13	2.04
	Subtotal	**85.33**	**41.47**	**46.74**	**15.60**	**13.41**	**202.55**
	Total	**89.20**	**45.69**	**59.84**	**16.30**	**15.06**	**226.09**

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 12 & 13 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 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	63,302.70	$0.00	0.00
	Bridges	43,586.80	$8.64	0.02
	Tunnels	0.00	$0.00	0.00
	Subtotal	**106889.50**	**8.60**	
Railways	Segments	2,783.15	$0.00	0.00
	Bridges	20.58	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	74.56	$2.61	3.50
	Subtotal	**2878.30**	**2.60**	
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	49.75	$1.37	2.74
	Subtotal	**49.70**	**1.40**	
Ferry	Facilities	11.98	$1.11	9.28
	Subtotal	**12.00**	**1.10**	
Port	Facilities	25.96	$0.05	0.17
	Subtotal	**26.00**	**0.00**	
Airport	Facilities	319.53	$10.13	3.17
	Runways	1,746.34	$0.00	0.00
	Subtotal	**2065.90**	**10.10**	
	Total	**111921.40**	**23.90**	

Table 13: 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	150.20	$0.00	0.00
	Distribution Lines	1,964.20	$1.18	0.06
	Subtotal	**2,114.42**	**$1.18**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	17,723.60	$178.84	1.01
	Distribution Lines	1,178.50	$0.59	0.05
	Subtotal	**18,902.14**	**$179.43**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	2.60	$0.00	0.00
	Distribution Lines	785.70	$0.20	0.03
	Subtotal	**788.27**	**$0.20**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.80	$0.00	0.60
	Subtotal	**0.81**	**$0.00**	
Electrical Power	Facilities	4,302.10	$34.39	0.80
	Subtotal	**4,302.10**	**$34.39**	
Communication	Facilities	26.60	$0.32	1.19
	Subtotal	**26.62**	**$0.32**	
	Total	**26,134.36**	**$215.52**	

Table 14. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS		Total	%
First Year			
	Employment Impact	3,706	0.71
	Income Impact	11	0.05
Second Year			
	Employment Impact	1,133	0.22
	Income Impact	1	0.00
Third Year			
	Employment Impact	19	0.00
	Income Impact	(5)	-0.02
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(6)	-0.02
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(6)	-0.02
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(6)	-0.02

Appendix A: County Listing for the Region

Coos,NH

Grafton,NH

Sullivan,NH

Clinton,NY

Essex,NY

Franklin,NY

Fulton,NY

Hamilton,NY

Herkimer,NY

Jefferson,NY

Lewis,NY

Montgomery,NY

Oneida,NY

Rensselaer,NY

Saint Lawrence,NY

Saratoga,NY

Schenectady,NY

Warren,NY

Washington,NY

Addison,VT

Bennington,VT

Caledonia,VT

Chittenden,VT

Essex,VT

Franklin,VT

Grand Isle,VT

Lamoille,VT

Orange,VT

Orleans,VT

Rutland,VT

Washington,VT

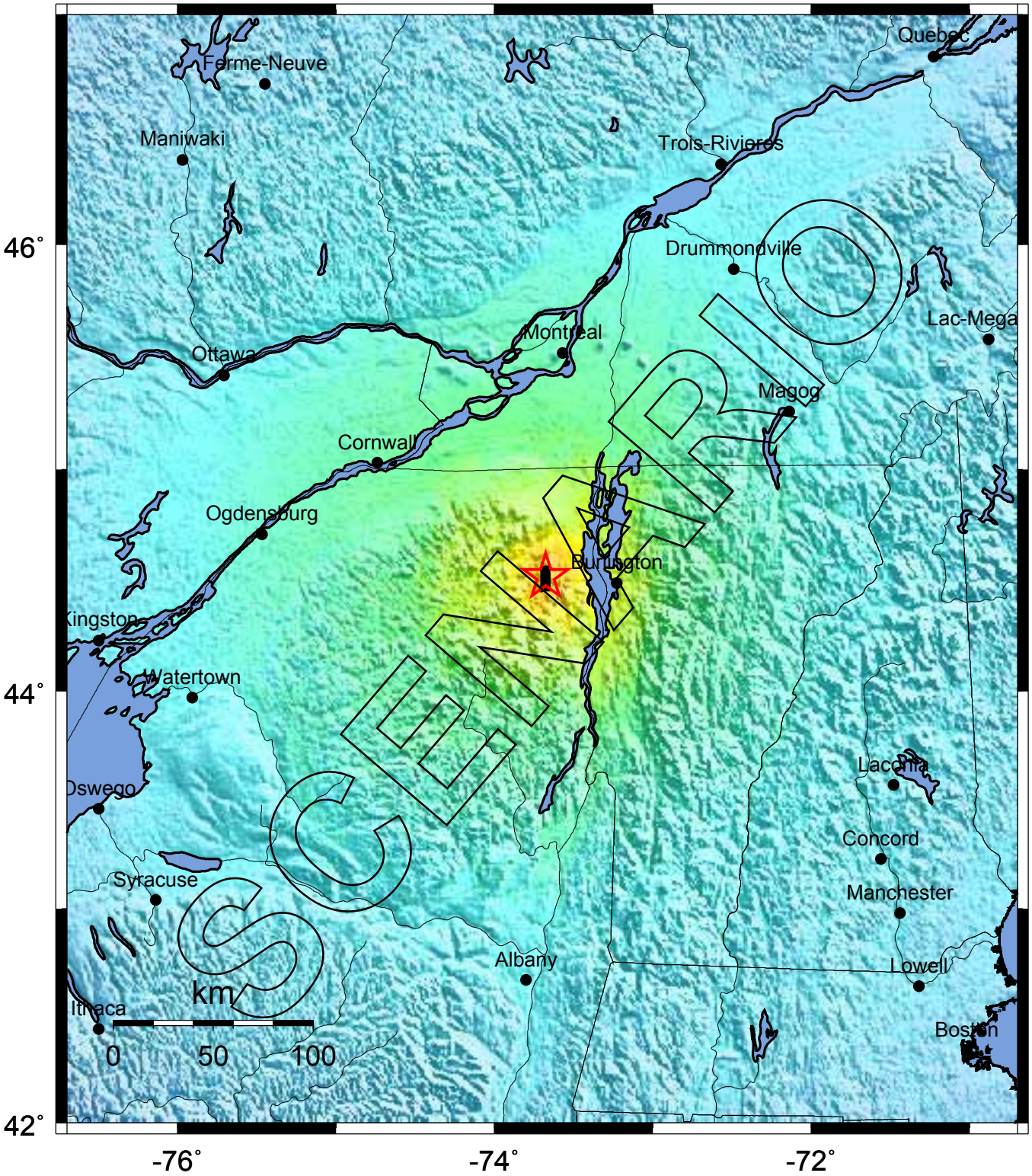
Windsor,VT

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
New Hampshire					
	Coos	33,111	1,760	653	2,413
	Grafton	81,743	4,393	1,698	6,092
	Sullivan	40,458	1,879	652	2,531
Total State		**155,312**	**8,032**	**3,003**	**11,036**
New York					
	Clinton	79,894	3,862	1,555	5,417
	Essex	38,851	2,512	659	3,171
	Franklin	51,134	2,511	784	3,295
	Fulton	55,073	3,136	961	4,098
	Hamilton	5,379	777	120	897
	Herkimer	64,427	3,411	1,085	4,496
	Jefferson	111,738	6,251	1,976	8,228
	Lewis	26,944	1,576	381	1,958
	Montgomery	49,708	2,470	1,004	3,475
	Oneida	235,469	12,862	4,368	17,230
	Rensselaer	152,538	8,846	2,825	11,671
	Saint Lawrence	111,931	5,390	1,606	6,996
	Saratoga	200,635	11,741	3,408	15,149
	Schenectady	146,555	9,138	5,606	14,745
	Warren	63,303	4,410	1,550	5,961
	Washington	61,042	3,048	821	3,869
Total State		**1,454,621**	**81,941**	**28,709**	**110,656**
Vermont					
	Addison	35,974	1,871	657	2,528
	Bennington	36,994	2,458	962	3,420
	Caledonia	29,702	1,402	509	1,912
	Chittenden	146,571	7,279	3,361	10,641
	Essex	6,459	370	76	446
	Franklin	45,417	2,016	703	2,719
	Grand Isle	6,901	483	87	571
	Lamoille	23,233	1,230	461	1,691
	Orange	28,226	1,370	395	1,765
	Orleans	26,277	1,232	457	1,689
	Rutland	63,400	3,358	1,241	4,599
	Washington	58,039	3,015	1,374	4,390
	Windsor	57,418	3,206	1,094	4,300
Total State		**564,611**	**29,290**	**11,377**	**40,671**
Total Region		**2,174,544**	**119,263**	**43,089**	**162,363**

-- Earthquake Planning Scenario --
ShakeMap for Plattsburgh5.8 Scenario

Scenario Date: Wed Sep 7, 2011 12:00:00 GMT M 5.8 N44.52 W73.68



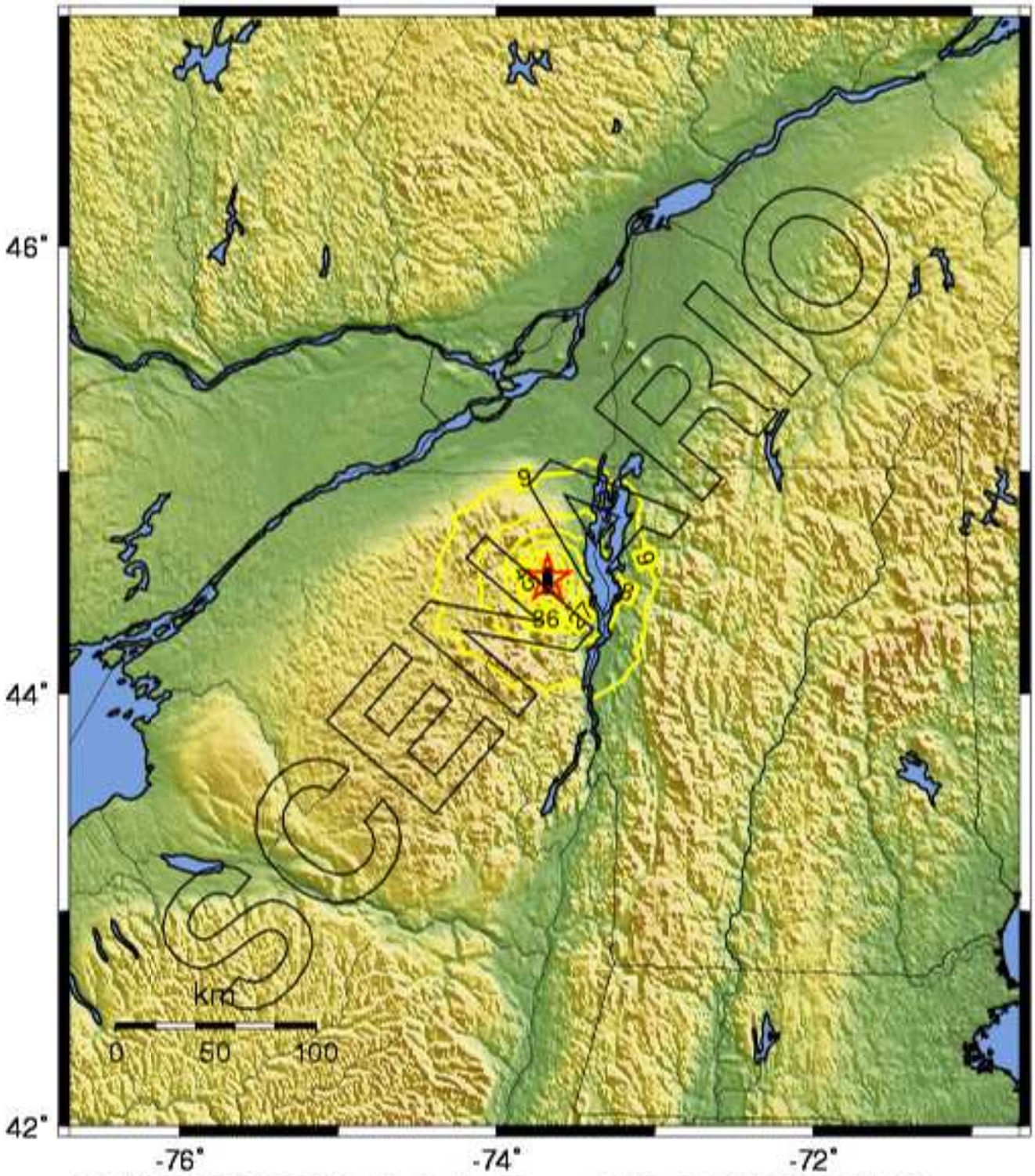
PLANNING SCENARIO ONLY -- Map Version 1 Processed Fri Sep 9, 2011 11:19:23 AM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

-- Earthquake Planning Scenario --

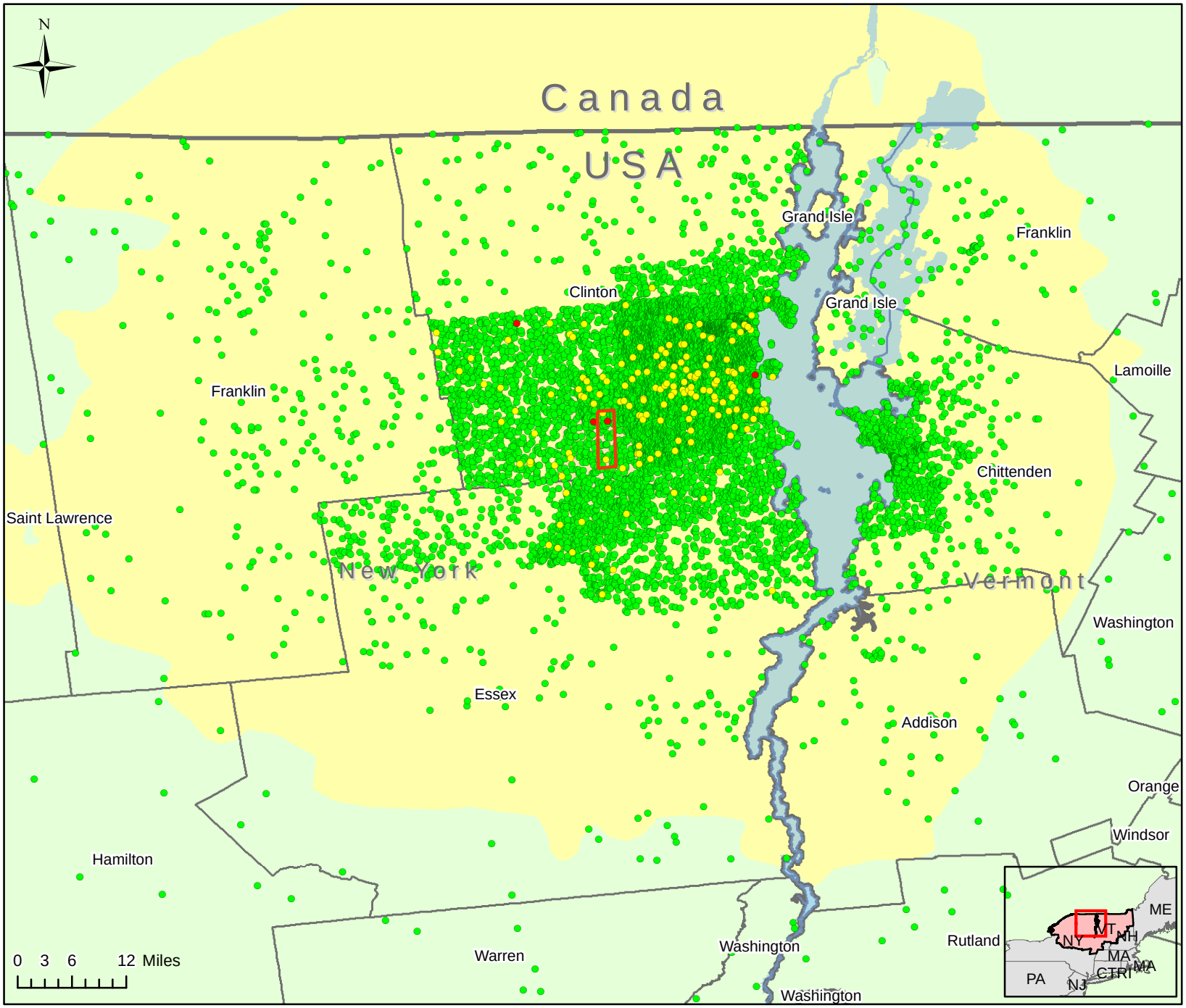
Peak Accel. Map (in %g) for Plattsburgh5.8 Scenario

Scenario Date: Wed Sep 7, 2011 12:00:00 GMT M 5.8 N44.52 W73.68



PLANNING SCENARIO ONLY -- Map Version 1 Processed Fri Sep 9, 2011 11:19:23 AM MDT

Estimated Building Inspection Needs and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

- **Red Tag (Complete Damage)**
- **YellowTag (Extensive Damage)**
- **GreenTag (Slight/Moderate Damage)**

1 Dot = 1 Building (by census tract)

	Estimated # of Structures	Estimated # of Inspectors
Red (Complete)	**4**	**1**
Yellow (Extensive)	**168**	**2**
Green (Slight/ Moderate)	**11,024**	**73**

* Estimated number of inspectors needed to complete inspections in 30 days

Fault Source

Instrumental Intensity

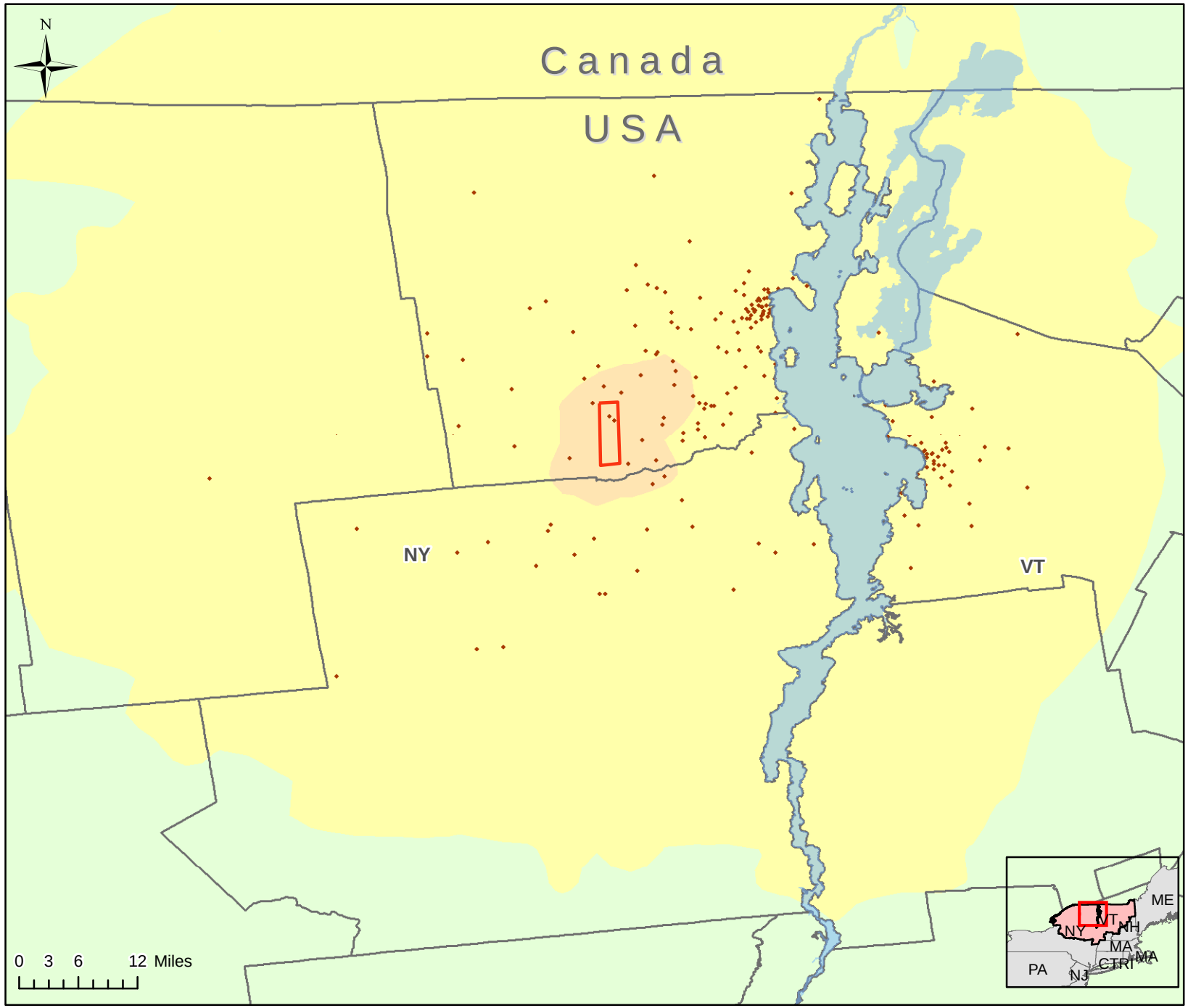
Not felt | Weak | Light | Moderate | Strong | Very strong | Severe | Violent | Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Estimated Building Economic Loss by Census Tract and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Direct Economic Losses

(Losses include all building-related losses)

1 Dot = $1 Million

Fault Source

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

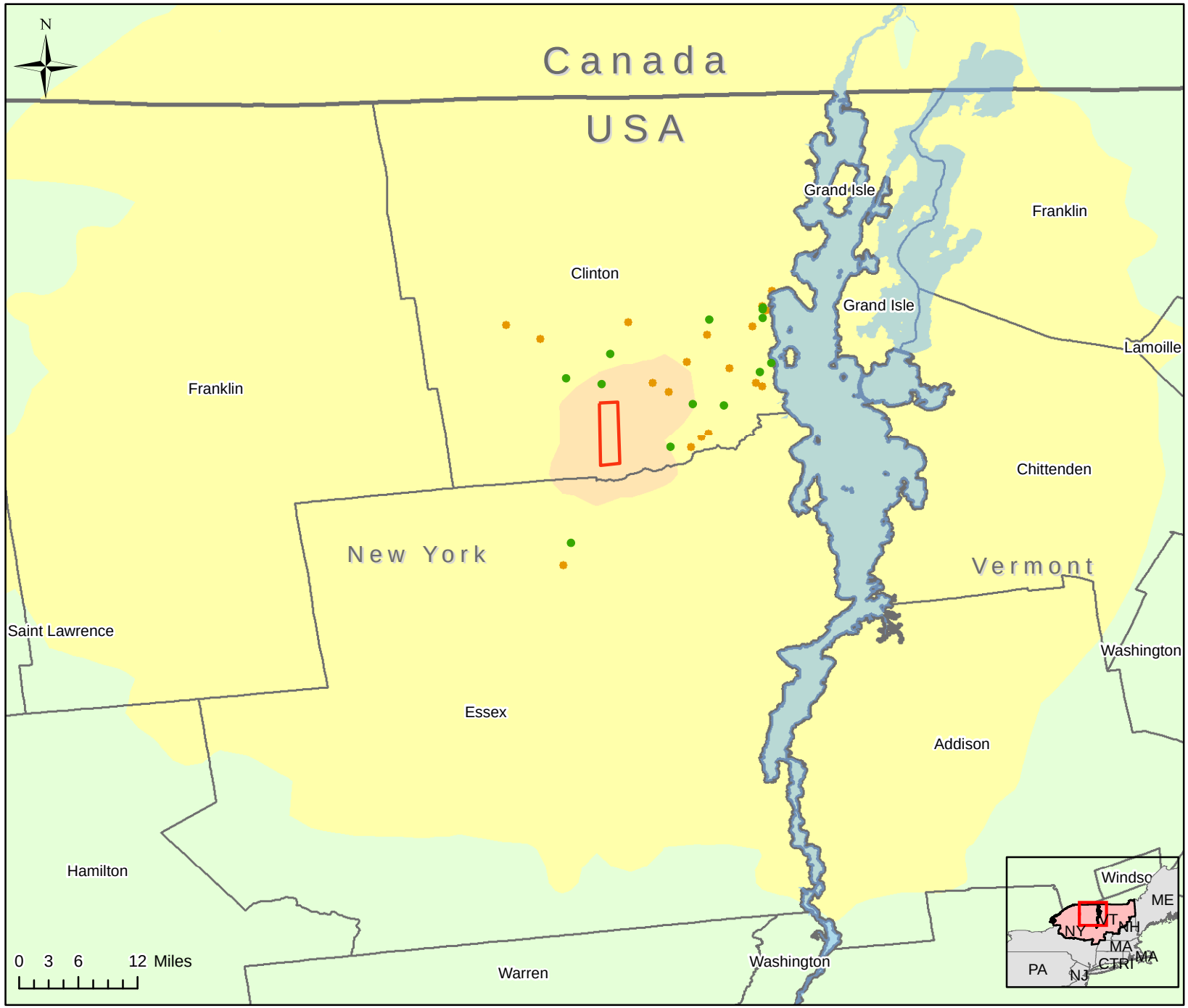
Cost Structural Damage	Cost Non-Structural Damage	Total Loss (Including Contents)
$14	$115	$203
all values in Millions		
Total Loss $203 Million		

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Displaced Households and Short Term Shelter and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

1 Dot = 1 Household

1 Dot = 1 Individual

Earthquakes can cause loss of function or habitability of buildings that contain housing units, resulting in approximately predictable numbers of displaced households. Loss of habitability is calculated directly from damage to the residential occupancy inventory, and from loss of water and power.

Fault Source

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

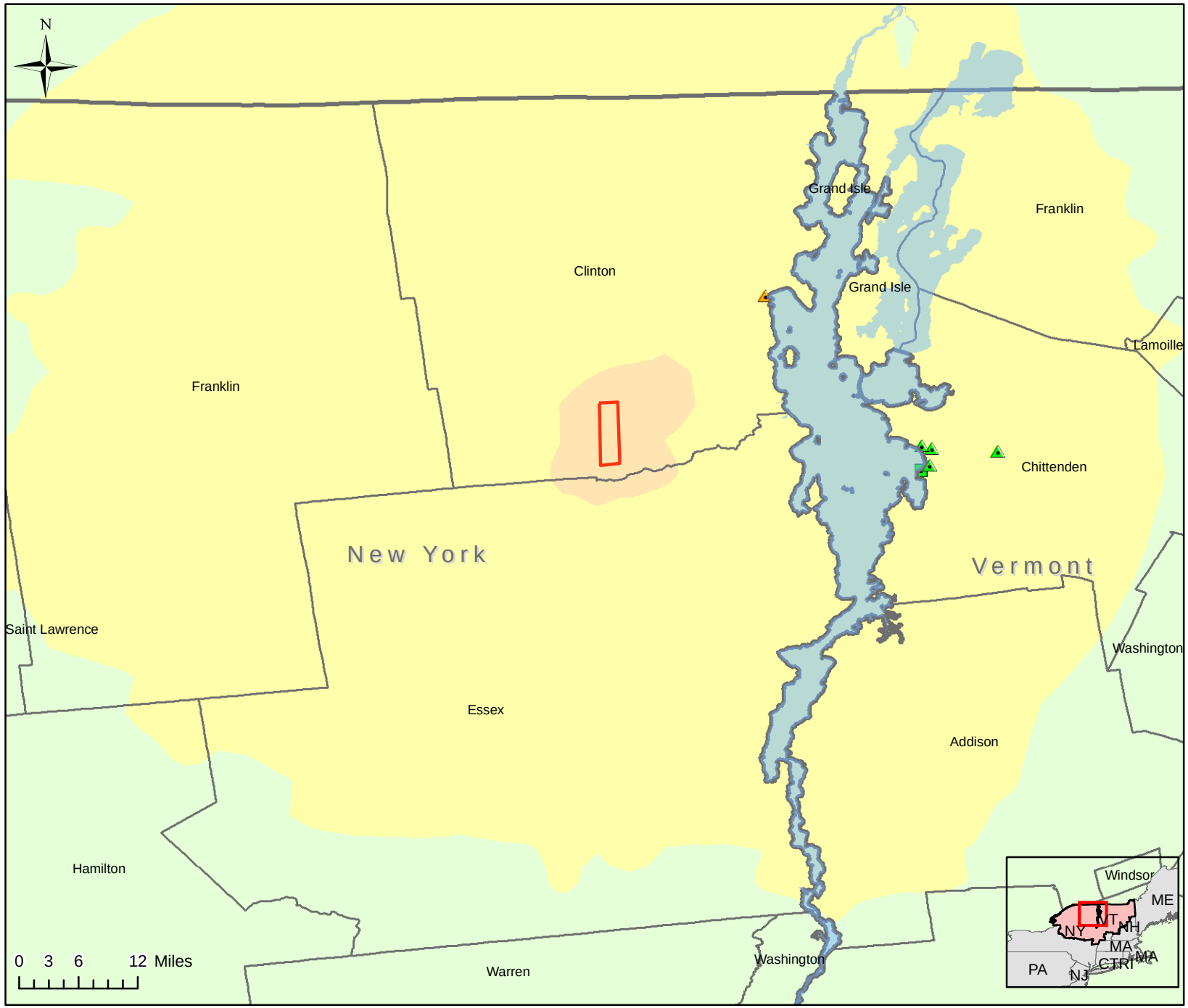
Shelter Requirements	Total #
Public Shelter Needs (Individuals)	13
Displaced Households	19

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Electrical & Oil Facility Damage and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Utility Facility Damage (at least moderate)

Damage is expressed as the probability that a given faclity will realize at least moderate damage.

Electric Power

- Low
- Moderate
- High

Oil Facility

- Low
- Moderate
- High

Instrumental Intensity

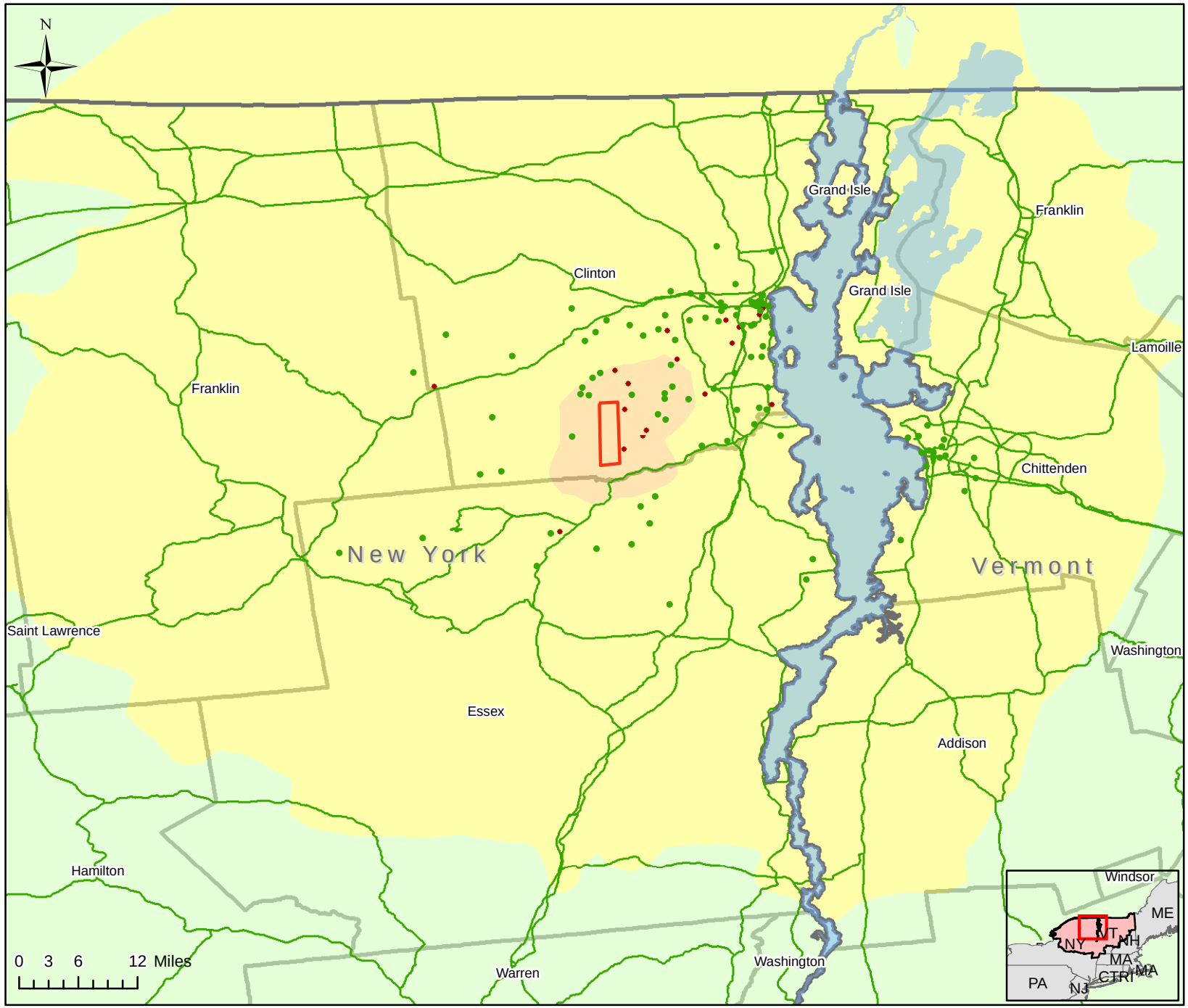
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Estimated Debris and Highway Damage and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

- **1 dot = 1 thousand tons of Concrete and Steel Debris (by Census Tract)**
- **1 dot = 1 thousand tons of Brick and Wood Debris (by Census Tract)**

Debris Totals	Total (in tons)	Estimated Truck Loads*
Brick and Wood	**31,000**	1,240
Concrete and Steel	**10,000**	400

* Truck loads estimated to be 25 tons per truck.

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Highway Center Impact

- Low
- Moderate
- High

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

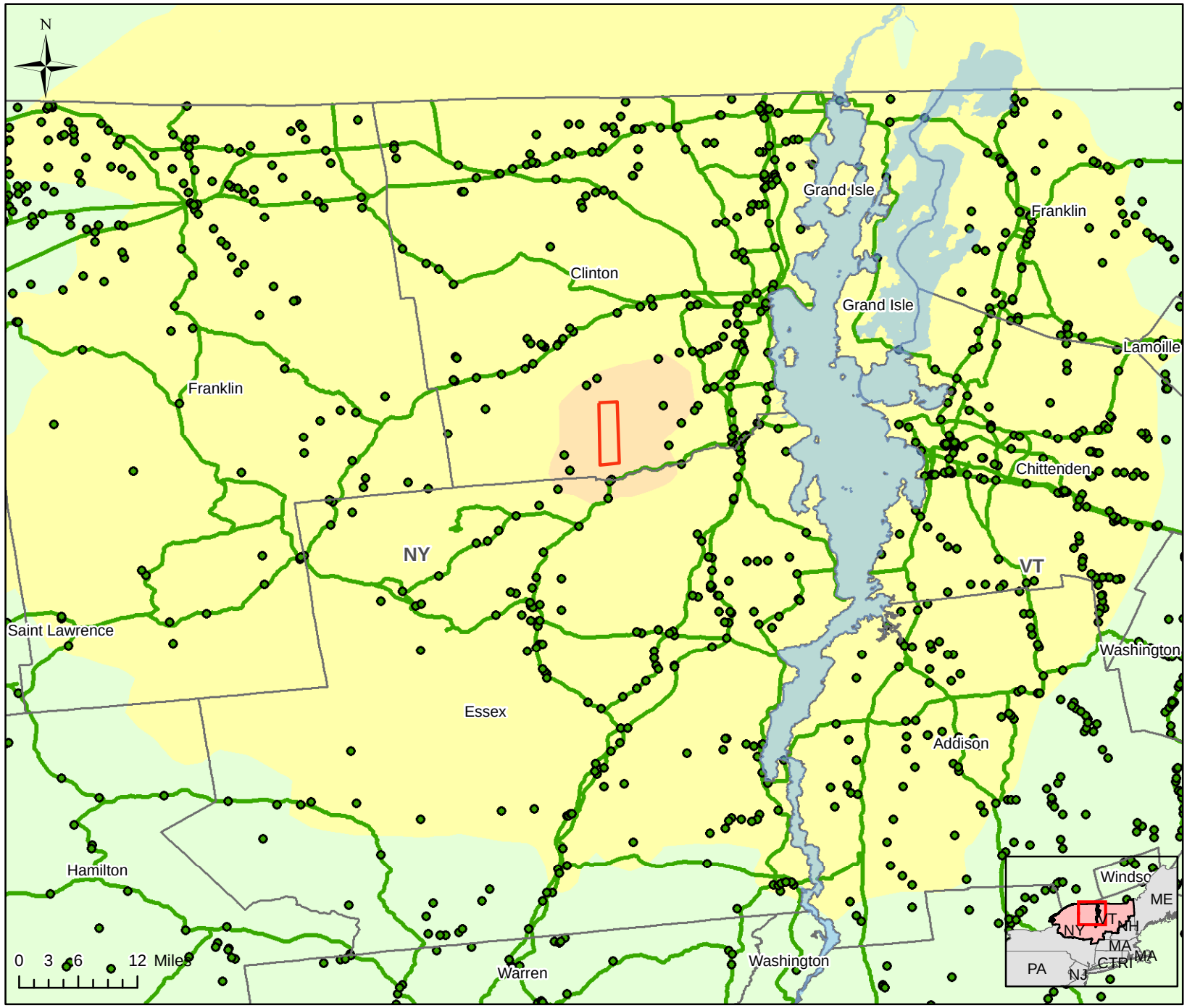
Fault Source

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Estimated Highway Infrastructure Damage and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Highway Damage

Damage is expressed as the probability that a given bridge or highway segment will realize at least moderate damage.

Major Roadway Bridge Impact

- Low
- Moderate
- High

Highway Segment Impact

- Low
- Moderate
- High

- Fault Source

Instrumental Intensity

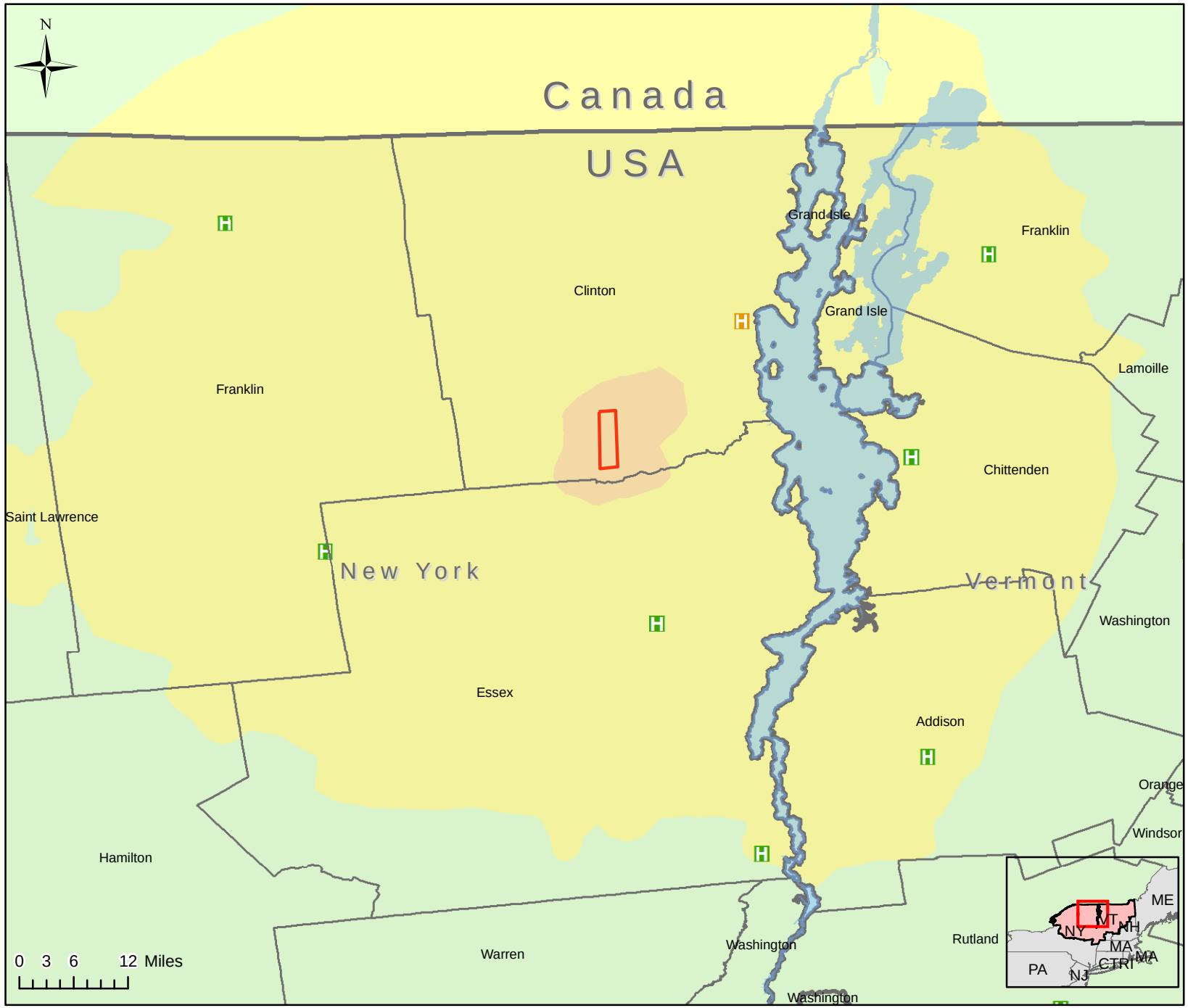
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Impaired Hospitals (Day 1) and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Impaired Hospitals (Day 1)

H	High	(<25%)
H	Moderate	(25% to 75%)
H	Low	(>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

Fault Source

Instrumental Intensity

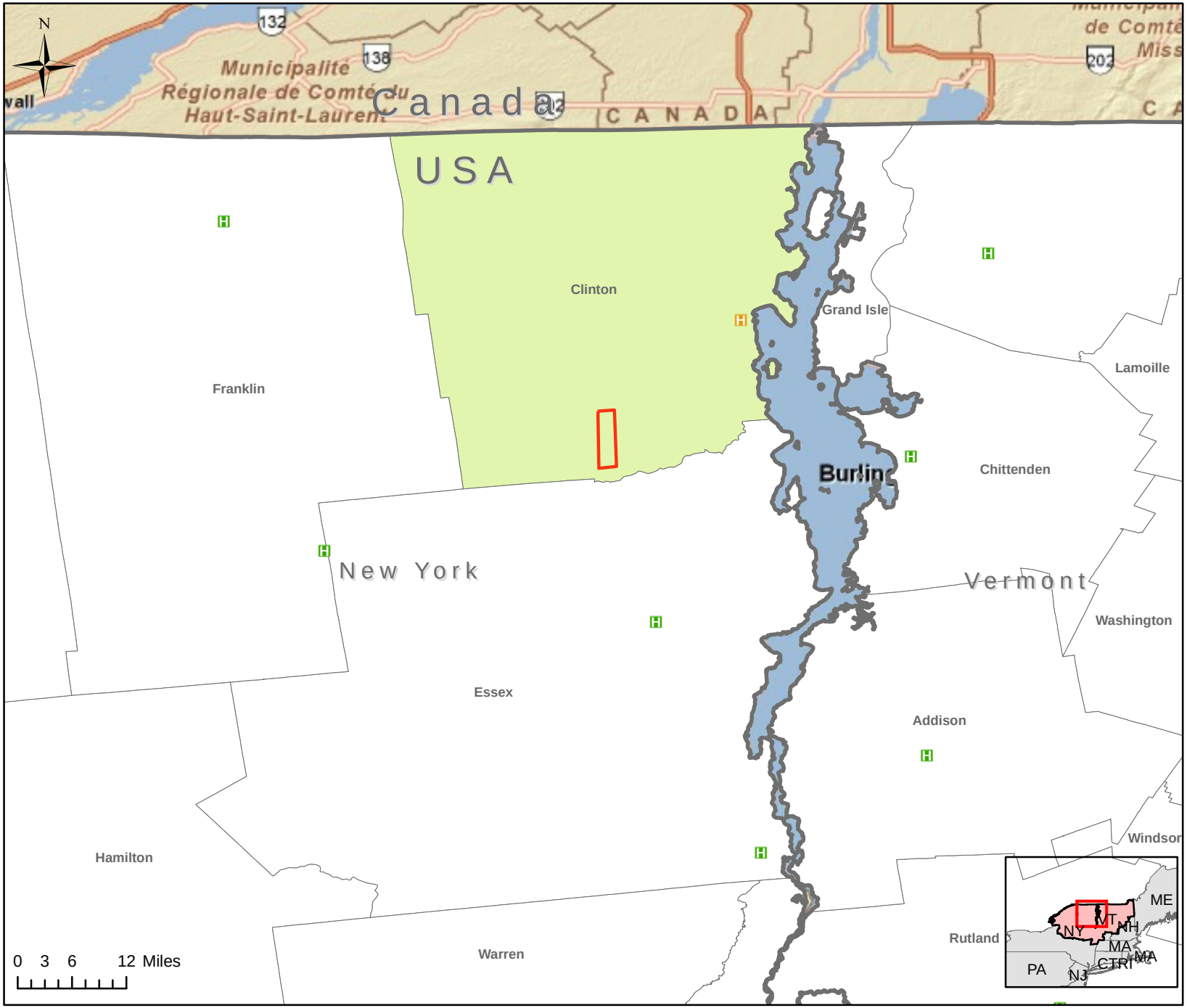
- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Injuries Requiring Hospital Treatment 2 p.m. and Impaired Hospitals



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Estimated Number of Persons Requiring Hospital Treatment (2 p.m.)

Level 2 and 3 Injuries

- 0
- 1 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 500
- 500 or more
- Fault Source

Impaired Hospitals (Day 1)

- High (<25%)
- Moderate (25% to 75%)
- Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

The estimate od the number of persons requiring hospital treatment includes Severity 2 and Severity 3 levels from Hazus-MH results.

Severity 2 are injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life-threatening status.

Severity 3 are injuries that pose an immediate life-threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

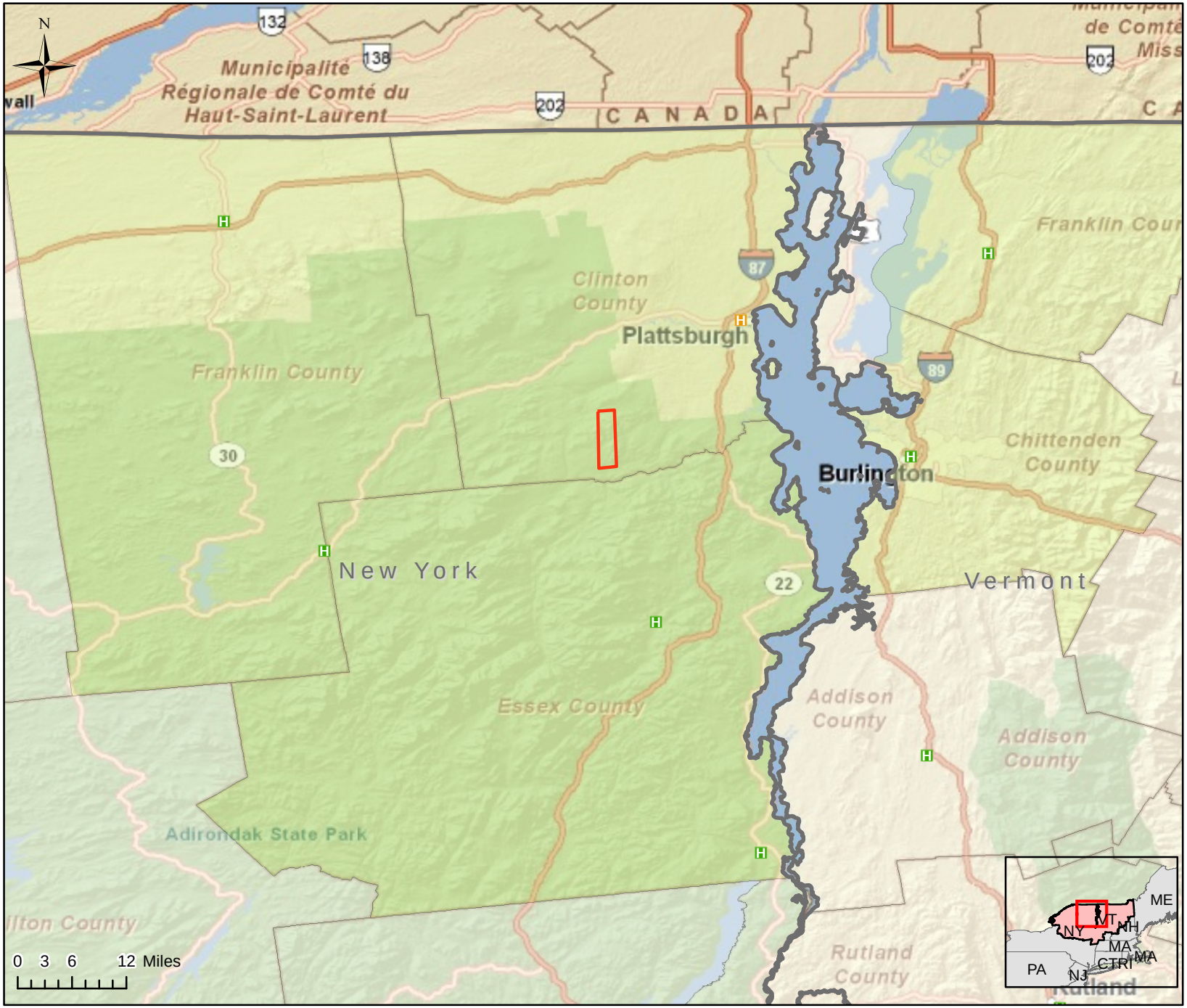
Requiring Hospital Treatment	Immediate Life Threatening Injuries
1	0

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Potential Search and Rescue Needs 2 p.m. and Impaired Hospitals



Earthquake Scenario:
Plattsburgh, NY
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Severity 3 are injuries that pose an immediate life-threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

Impaired Hospitals
(Day 1)

- H High (<25%)
- H Moderate (25% to 75%)
- H Low (>75%)

Hospital impairments based on the probability that a given hospital will be functional on day 1 after the event.

Fault Source

Level 3 Injury

0 | 1 - 5 | 5 - 10 | 10 - 50 | 50 - 100 | 100 - 500 | 500 or more

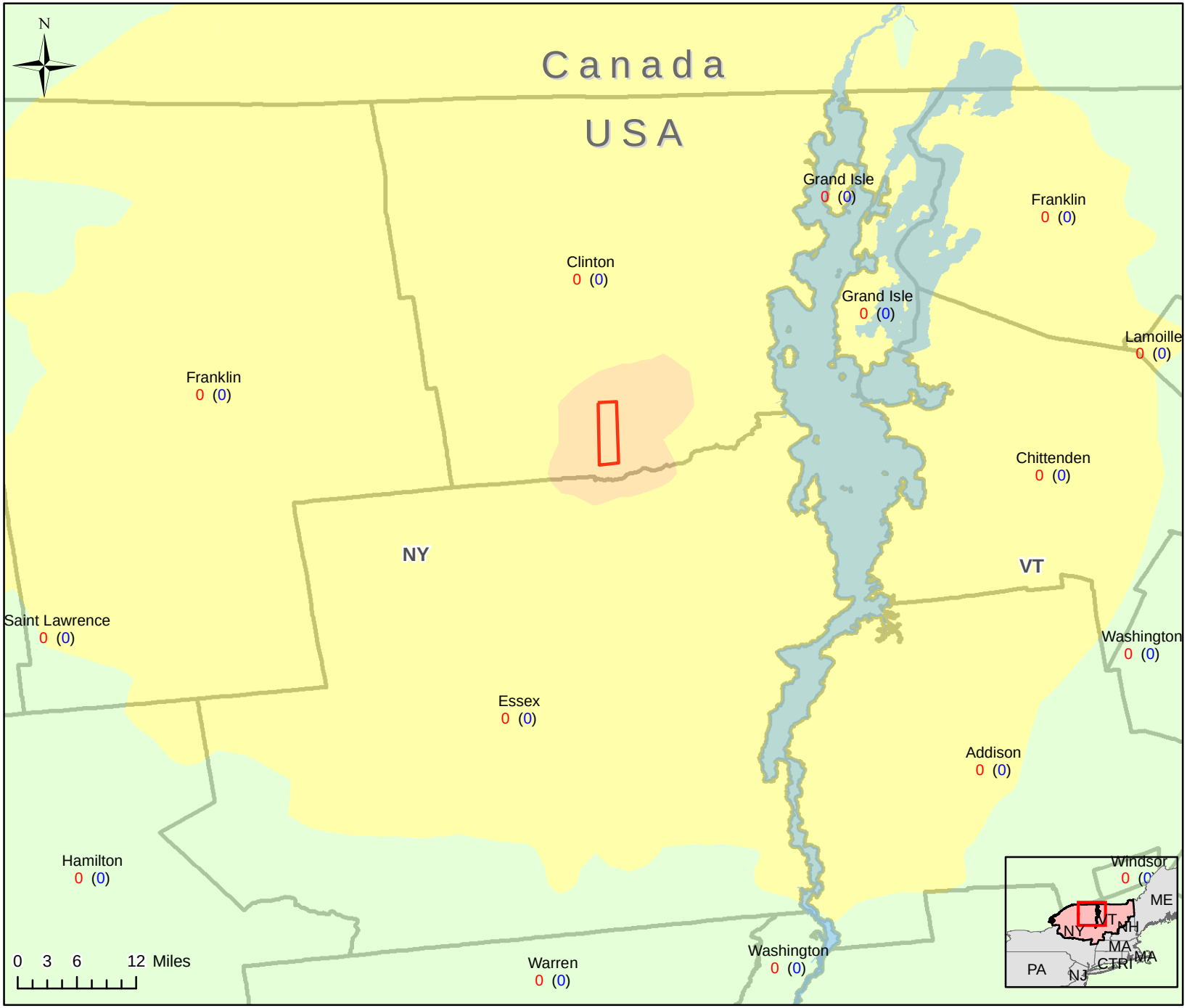
Structure Type	Red (Complete)	Total Collapse
Concrete	0	0
Manufactured Housing	1	0
Precast	0	0
Reinforced Masonry	0	0
Steel	0	0
Unreinforced Masonry	3	0
Wood	0	0
Total	4	0

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario

Estimated Potable Water Needs by County and Ground Shaking Intensity



Earthquake Scenario:
Plattsburgh M5.8
Magnitude 5.8
Date: May 2012 (URS and FEMA)

Estimated Liters of Potable Water Needed *

Red # = Households without Potable Water (Thousands)

(Blue #) = Daily Potable Water Needs (Thousand liters /day)

* Based on U.S. Army Corp Mission Guidebook (Daily water is based on an estimated 3 people per household).

Fault Source

Instrumental Intensity

- Not felt
- Weak
- Light
- Moderate
- Strong
- Very strong
- Severe
- Violent
- Extreme

FOR OFFICIAL USE ONLY

Disclaimer:
The estimates of social and economic impacts illustrated on this map were produced using FEMA's HAZUS loss estimation software and the USGS's ShakeMap ground motions. There are uncertainties inherent in any loss estimation technique; therefore, there may be significant differences between the modeled results and actual losses following a specific earthquake.

Shakemap Description: Shakemap Version 1 - Maps of ground shaking and intensity for event Plattsburgh5.8_se, Plattsburgh M5.8 Scenario