EARTHQUAKE LOSS ESTIMATION STUDY
FOR
PASSAIC COUNTY, NEW JERSEY:

GEOLOGIC COMPONENT

Prepared for the
New Jersey State Police
Office of Emergency Management

by the
New Jersey Geological Survey

September 2004

CONTENTS

FINAL REPORT

GEOLOGIC COMPONENT OF THE EARTHQUAKE LOSS ESTIMATION STUDY FOR PASSAIC COUNTY, NEW JERSEY

Prepared for the New Jersey State Police, Office of Emergency Management

by
Scott D. Stanford, Ronald S. Pristas, David W. Hall, and Jeffrey S. Waldner
New Jersey Geological Survey

September 2004

Summary: Geologic, topographic, and test-boring data were acquired and analyzed in order to map seismic soil class, liquefaction susceptibility, and landslide susceptibility for Passaic County (maps folded in pocket). The soil class, liquefaction susceptibility, and landslide susceptibility data were entered into the HAZUS model for each census tract in the county (Appendix A). The HAZUS model was run with the full upgraded geologic data and with the default geologic data for earthquake magnitudes of 5.5 and 6. To assess the effect of landslides, runs were also made with full upgraded geology and with upgraded geology without landslide hazard for magnitudes 5.5, 6, and 7. Selected outputs from these runs are attached in Appendices B through K. The upgraded geology changed both the spatial distribution of damage and the total damage estimates compared to default geology. The upgraded geology produced greater building damage in the Pompton River valley, Preakness Valley, and parts of the Passaic River valley (Figure 1), where glacial-lake and alluvial soils are more liquefiable than the default, and less building damage in most other areas, where till, bedrock, and glacial gravel are stronger than the default and have low liquefaction susceptibility.

In addition to the HAZUS data upgrades and runs, shear-wave velocity was measured on four soil types (alluvium, glacial sand, glacial gravel, and till) at a total of 12 locations. These measurements were made to check the soil-class assignments, which use test-drilling data as a proxy for shear-wave velocity. The measured velocities confirmed the assignments.

Geologic Data Acquired: Surficial materials in Passaic County include till, glacial-lake and glacial-river sand and gravel deposits, glacial-lake silt and clay deposits, postglacial floodplain and stream-terrace deposits, peat and organic silt and clay deposited in wetlands, and bedrock with thin or no soil cover. The distribution and thickness of these materials were mapped between 1989 and 2002 at 1:24,000 scale using stereo-airphoto interpretation, field observations, archival geologic map data on file at the NJGS, and logs of about 1100 wells and test borings . Geologic-map references are listed on the map sheets (folded in pocket).

Till is a compact silty sand to sandy silt with gravel and a few boulders, deposited directly beneath glacial ice. It discontinuously veneers the bedrock surface and is as much as 200

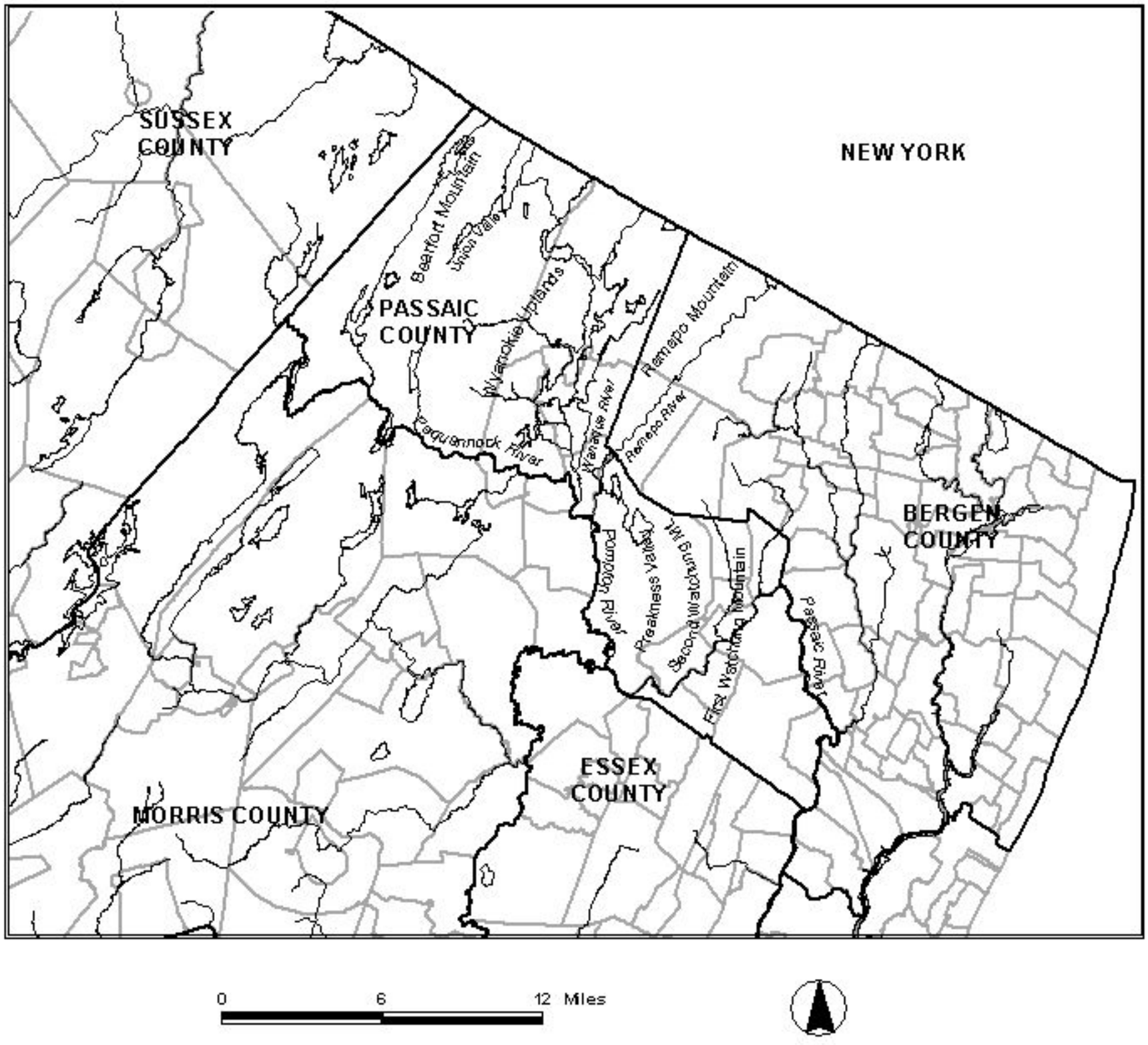


Figure 1. Passaic County, showing features named in text. Gray lines are municipal boundaries.

feet thick. Glacial-lake deposits fill the bottoms of Preakness and Union valleys, and the Passaic, Pompton, Ramapo, and lower Wanaque river valleys. The lake deposits include sand and gravel as much as 100 feet thick and fine sand, silt and clay as much as 200 feet thick. Glacial-river sand and gravel forms terraces and small plains in the Pequannock and upper Wanaque river valleys. The glacial-river deposits are as much as 50 feet thick. Ridgetops and uplands in the Watchung Mountains and in the Highlands part of the county (west and north of the Ramapo River), particularly on Ramapo Mountain, the Wyanokie uplands, and Bearfort Mountain, were scoured by glacial erosion and have widespread areas of exposed bedrock with little or no soil or glacial-sediment cover. Alluvial sediment, chiefly silt and sand, was deposited in floodplains along all the main streams in the county after the glacier retreated. It is as much as 20 feet thick. Peat and organic silt and clay were deposited in marshes and swamps in glacially created basins and poorly drained areas throughout the county after glacial retreat.

Bedrock includes basalt, sandstone, and shale in the southeastern part of the county (south and east of the Ramapo River), and granite and gneiss north and west of the Ramapo River. A downfaulted belt of shale and quartzite is inset in the gneiss in the Bearfort Mountain-Union Valley area. Basalt, gneiss, and quartzite are extensively exposed on ridges and uplands, Sandstone and shale largely underlie valleys and are mostly covered by glacial sediment.

Data Analysis: Shaking behavior and liquefaction susceptibility of soils are determined by their grain size, thickness, compaction, and degree of saturation. These properties, in turn, are determined by the geologic origin of the soils and their topographic position. Soils can be classed into the HAZUS categories using Standard Penetration Test (SPT) data, which are acquired during the drilling of test borings. SPT tests report the number of blows of a 140-pound hammer falling 30 inches that are required to drive a sampling tube 12 inches into the test material.

Data on 1,731 SPT tests from 442 borings in Passaic County were obtained from test-boring logs on file at the N. J. Geological Survey and N. J. Department of Environmental Protection, Bureau of Water Allocation (Table 1). These data complement earlier data on similar glacial and postglacial soils. The earlier data include approximately 300 borings in the Hudson County-Newark area, with a total of 4,777 SPT tests; 60 borings, with a total of 688 SPT tests, collected for western Essex County; 193 borings, with a total of 944 SPT tests, collected for Union County; and 50 borings, with a total of 234 SPT tests, collected for Bergen County.

SPT data from the Passaic County borings yield means, ranges, and standard deviations that are similar to those from the Hudson, Essex, Union, and Bergen data for the same soil types. The only significant discrepancy is alluvium in Bergen and Hudson counties, which yields a mean SPT of 24 compared to 13 for alluvium in Passaic County. The alluvium sampled in Bergen and Hudson is predominantly sand and gravelly sand, which is more resistant to penetration than the silt and silty sand that comprise the alluvial deposits along the Pompton and Passaic rivers in Passaic County, where the Passaic data were obtained. The relatively small number of tests in Passaic County may also not fully represent the range of composition of alluvium in the county.

Table 1.--Standard Penetration Test (SPT) data for surficial materials in Passaic County.

Material	Number of Borings	Number of Tests	Range of SPT Values	Mean ± Standard Deviation
fill	110	209	1-152	22±26
alluvium	20	48	1-44	13±12
glacial gravel	52	169	3-260	59±48
glacial sand	121	332	0-86	19±12
glacial-lake silt and clay	64	213	4-64	14±9
till	290	760	3-560	74±63

For each surficial unit, a mean SPT value, and standard deviation, were calculated. This mean value is then applied to the mapped extent of the surficial unit to prepare the soil class map. Where more than one surficial material is present overlying bedrock, the appropriate mean SPT value is applied to the thickness of each layer. Fill includes a variety of materials ranging from demolition debris and excavated bedrock to trash and silt and sand. Because of the variable composition of fill it is inappropriate to apply a mean SPT value, and fill was not included in the soil classification determinations. The behavior of fill under seismic shaking should be assessed on a site-specific basis. HAZUS soil classes were assigned according to the procedures described in sections 4.1.2.1, 4.1.2.2, and 4.1.2.3 of the 1997 National Earthquake Hazards Reduction Program (NEHRP) Provisions. These procedures assign a soil class by using a weighting formula to sum the soil and rock layers to a depth of 100 feet.

Liquefaction susceptibility was assigned based on Table 9.1 of the HAZUS Users Manual, with some modifications to the classification scheme based on local penetration-test data and field observations. For example, low compaction and penetration resistance of some saturated glacial-lake, glacial-river, and postglacial alluvial deposits of Pleistocene age indicate a moderate-to-high liquefaction susceptibility, rather than the low susceptibility for Pleistocene lake and river deposits provided in Table 9.1.

Landslide susceptibility depends on slope angle and the geologic material underlying the slope. Slope angles for Passaic County were calculated from 1:24,000 topographic maps with 10- or 20-foot contour interval and slope materials were determined in the field (data sources are listed on the landslide map, folded in pocket). In places, particularly in the Watchung Mountains, quarry operations have significantly changed the topography from that shown on the topographic maps. In these places, slope angles were estimated from aerial photography and field observations. Landslide susceptibility was assigned according to the classification in Table 9.2 of the HAZUS User's Manual (refer to landslide map, folded in pocket). Areas of potential landsliding include steep slopes on basalt bedrock and till in the Watchung Mountains, steep slopes on gneiss and till in the Highlands, and a few steep slopes cut into glacial deposits by

postglacial river erosion in the Pequannock, Wanaque, Passaic, and Preakness valleys.

Shear-wave Velocity Measurements: To test the accuracy of using SPT tests as a proxy for shear-wave velocity, seismic velocities were collected at twelve sites in Passaic County. The tested soil types include alluvium (3 sites), glacial sand (3 sites), glacial gravel (3 sites), and till (3 sites) (Table 2). The measurements were made at sites where the natural deposit was undisturbed and not covered or mixed with man-made fill. At each site, hand-auger holes were drilled to a depth of 5 feet to test for soil disturbance and fill. The seismic data were collected using a Bison 9000 digital engineering seismograph. Both shear wave (horizontal component) and compression (P) wave data were acquired (Appendix L). P-waves are much faster than shear waves and help in isolating the shear-wave signal in the seismic record. P-wave data generally show two velocity layers. The uppermost layer is unsaturated sediment and the lower layer is saturated sediment. The boundary between the two layers is the water table. The water table is not detectable in shear wave data because liquids do not transmit shear waves.

Twelve shear geophones were used with a 6-foot spacing. The source was located 6 feet from the first geophone. Each geophone was oriented with its axis of movement parallel to the generating source. The source is a 6-inch channel steel beam that is 5 feet long and has triangular teeth welded to the bottom. A 10-pound sledgehammer is used to impact either side of the source. Two people stand on the source while it is being hit to improve ground coupling.

Compressional (P-wave) data were collected using the standard seismic refraction line type setup. Twelve 8-hertz geophones were used in-line at 6-foot spacing. A 10-pound sledgehammer and a strike plate are used as a source.

The first seismic break on the raw records from both the shear and compressional data is picked on the records much like picking first breaks for seismic refraction data. The regression velocity is calculated using the inverse slope on the time-distance curves. The data are also presented numerically as the interval velocity between consecutive geophones along each line and as an average of the interval velocities (Appendix L). This is done to check for lateral velocity variation along each seismic line. A large difference between the average velocity and the regression velocity is indicative of lateral heterogeneity within the soil. The regression velocity is statistically more accurate as a bulk soil property.

At 8 of the 12 sites the shear-wave measurements record a low-velocity layer overlying a higher-velocity layer (Appendix L). At 3 of these 8 sites there is a thin (6-10 feet thick) deposit of alluvium or glacial sand overlying till. In these cases, the low-velocity (layer 1 in Table 2) is the alluvium or glacial sand, and the high-velocity layer (layer 2) is the till. At the other 5 sites the low-velocity layer is very thin (<3 feet) and likely represents topsoil. In these cases, the high-velocity layer records the geologic soil beneath the topsoil and is the value shown in Table 2.

Table 2 shows that 14 of the 15 velocity measurements at the 12 sites fall within, or very close to, the range predicted from the county-wide SPT data for the layer in question. The one significant discrepancy is the McDonald Road site, where the till yields a velocity that is about 1200 feet per second faster than predicted. This discrepancy may be due to the abundance of gneiss and quartzite boulders in the till at this site. Boulders increase shear-wave velocity, particularly if they are in contact or closely spaced in a sediment.

Table 2. Shear-wave velocity measurements. Complete data provided in Appendix L.

Site	Location (latitude; longitude)	Material	Measured shear-wave velocity (feet/second)	Shear-wave velocity range predicted from SPT data (feet/second)	Comments
Buttonwood	40E54'28"; 74E16'12"	alluvium	535	<600	agrees
Farmingdale	40E57'36"; 74E16'38"	alluvium (layer 1) overlying till (layer 2)	461 (layer 1) 1768 (layer 2)	<600 (layer 1) 1200-2500 (layer 2)	agrees
Ryerson	40E55'23"; 74E16'38"	alluvium	476	<600	agrees
North Cove	40E54'29"; 74E15'12"	glacial sand (layer 1) over till (layer 2)	827 (layer 1) 2308 (layer 2)	600-1200 (layer 1) 1200-2500 (layer 2)	agrees
Echo Lake	41E03'22"; 74E23'35"	glacial sand	573	600-1200	slightly lower than predicted
Hewitt	41E07'09"; 74E15'36"	glacial sand (layer 1) over till (layer 2)	1111 (layer 1) 2571 (layer 2)	600-1200 (layer 1) 1200-2500 (layer 2)	layer 1 agrees; layer 2 slightly higher than predicted
Long Pond	41E08'28"; 74E19'11"	glacial gravel	1222	1200-2500	agrees
Kanouse Road	41E02'21"; 74E25'52"	glacial gravel	1869	1200-2500	agrees
Back Beach Park	41E02'03"; 74E17'07"	glacial gravel	1424	1200-2500	agrees
McDonald Road	40E55'44"; 74E14'18"	till	3773	1200-2500	higher than predicted range due to abundant boulders
LaRue Road	41E03'56"; 74E25'55"	till	1968	1200-2500	agrees
Oak Ridge	41E03'37"; 74E29'14"	till	2396	1200-2500	agrees

HAZUS Simulations: To evaluate the effect of upgraded geology and landslide hazard, a total of ten simulations were run. Earthquake magnitudes of 5.5 and 6, with an epicenter at the county centroid (Appendix A) and a focal depth of 10 km, were simulated using the upgraded soil, liquefaction, and landslide data. The magnitude 5.5 and 6.0 earthquakes were also run using the default geologic data. To test the effect of landslide hazard on damage, the magnitude 5.5, 6.0, and 7.0 earthquakes were also run with upgraded soil and liquefaction data, but with no landslide hazard. The selected magnitudes span the range of potential damaging earthquakes in the region. The largest local earthquake in historic records was an estimated magnitude 5.2 event in 1884 with an epicenter offshore from Brooklyn, and earthquakes with magnitudes between 6 and 7 have been recorded or estimated from historical accounts in South Carolina, the Boston area, southern Quebec, and the St. Lawrence Valley.

The geologic data were upgraded by modifying soil type, liquefaction susceptibility, and landslide susceptibility for each census tract using the seismic soil class, liquefaction susceptibility, and landslide susceptibility maps (folded in pocket). Many census tracts spanned two or more soil types. In these cases, the dominant soil under the most densely built part of the census tract was selected. Also, areas subject to landsliding cover only a small part of the census tracts that were assigned a landslide hazard. In these census tracts, however, highways and local roads, and some buildings, adjoin slopes that are landslide-prone, so the landslide hazard was judged significant. The default geology assigned a uniform soil type (class D), and no liquefaction or landslide susceptibility, for the entire county. Maps of the upgraded and default geology, by census tract, are provided in Appendix A.

Building damage best illustrates the effect of geology on the simulations, because it does not directly incorporate economic and demographic patterns. Appendices B through K provide tables showing the number of the buildings (classed by use) in various states of damage. The appendices also provide maps showing the percent moderate or greater building damage by census tract for the various simulations. The moderate-or-greater cutoff was used because buildings with moderate damage must be evacuated and inspected prior to reoccupancy. Thus, moderate damage requires significant population disruption and emergency response. A loss estimation sheet summarizing damage, economic loss, casualties, and population displacement for each HAZUS run is also provided. The total economic loss includes repair and replacement costs, contents damage, business inventory damage, relocation costs, capital-related income costs, wage loss, and rental loss. The economic loss, building damage, and displaced households estimates for each run are summarized in Table 3.

Evaluation of Simulations: The upgraded geologic data produced increased damage estimates for census tracts on vulnerable soils in the Pompton River valley, Preakness Valley, and in parts of the lower Passaic River valley, and decreased damage elsewhere, compared to the default data. This pattern reflects the softer alluvial and glacial-lake soils in these valleys, which are more liquefiable than the default conditions, and the compact till soil and exposed bedrock on most of the upland areas of the county, which are of stronger soil class than the default.

Tracts with high liquefaction hazard show as much as a 20% increase in buildings experiencing moderate-or-greater damage. Tracts that are chiefly on till (soil class C) rather than the default class of D show up to 20% fewer buildings experiencing moderate-or-greater

damage.

Table 3. Comparison of total economic loss (TEL, in billions of dollars), major building damage (MBD, in thousands of buildings), and displaced households (DH, actual number of households requiring shelter) for the HAZUS runs. Total economic loss includes building damage plus loss of building contents plus loss due to business interruption. Major building damage includes buildings of any type damaged to the "extensive" and "complete" state.

Magnitude	default			full upgrade			upgrade without landslide		
	TEL	MBD	DH	TEL	MBD	DH	TEL	MBD	DH
5.0	-	-	-	0.3-1.2	<1	800-2000	-	-	-
5.5	0.6-2.6	1-3	900-4000	0.9-3.6	1-6	2000-9000	0.9-3.6	1-6	2000-9000
6.0	1.8-7.0	4-17	4000-18,000	2.0-8.1	4-17	2000-9000	2.0-8.1	4-17	2000-9000
6.5	-	-	-	3.6-14.4	9-40	11,000-45,000	-	-	-
7.0	-	-	-	5.6-22.6	15-60	19,000-76,000	5.6-22.3	15-60	19,000-74,000

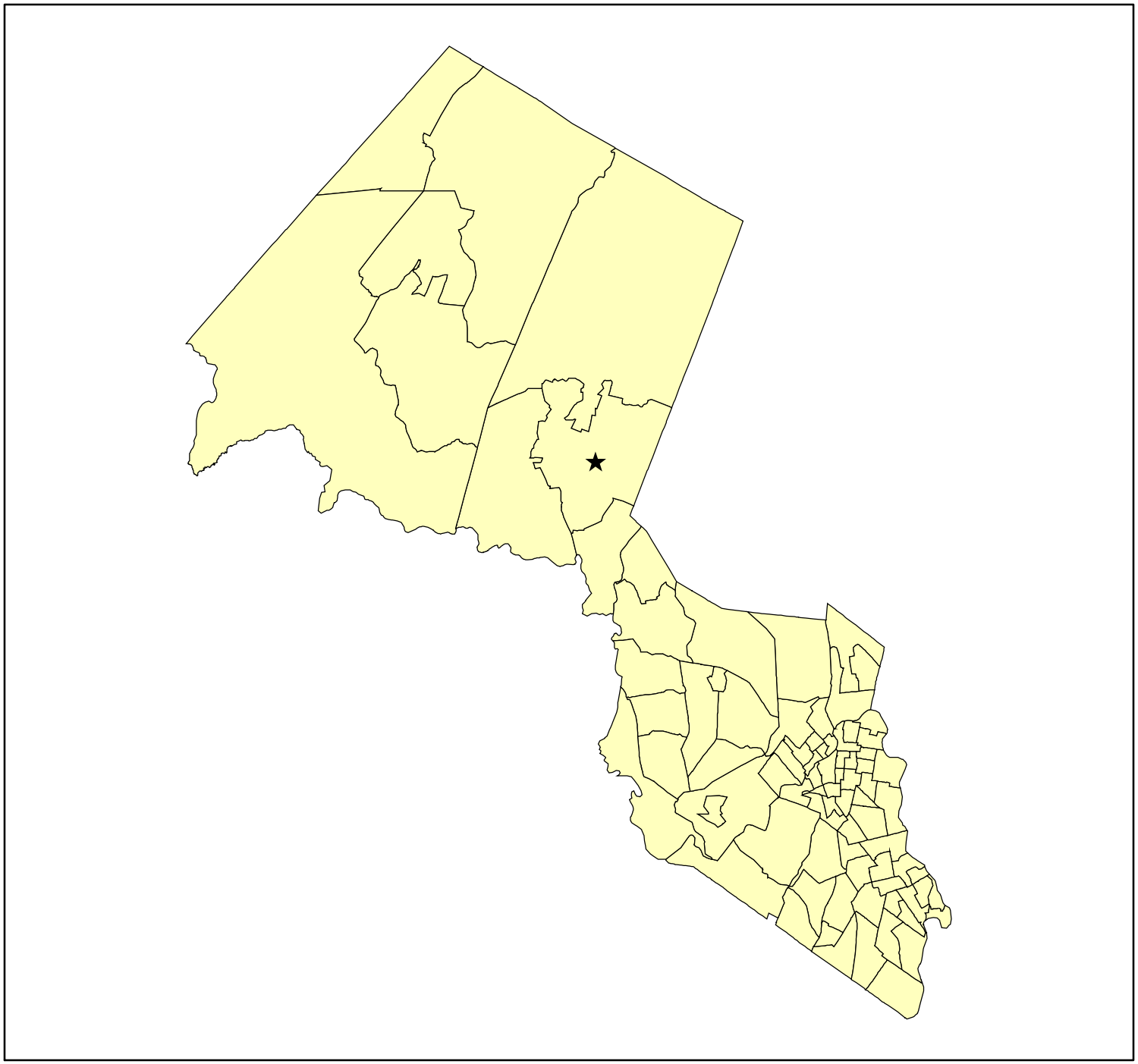
Note that the hourglass shape of the county, with the epicenter of the earthquake near the neck of the hourglass, means that much of the damage from the simulated events occurs in neighboring Bergen and Morris counties. The total loss estimates for these simulations are thus minimum values to a greater degree than the simulations for other counties. Also, the full effect of the geologic upgrades are more muted, since most census tracts, particularly the most densely built tracts in the southeastern corner of the county, are a considerable distance from the epicenter.

Landslide hazard has no discernable impact on building damage or economic loss at magnitudes 5.5 and 6.0. At magnitude 7.0 a few census tracts with high landslide hazard show a 20% increase in buildings damaged to a moderate-or-greater extent compared to upgraded geology with no landslide hazard. These results suggest that landsliding is not a significant hazard for the maximum earthquakes possible in this area. However, isolated landsliding has occurred in the northeastern United States at earthquake magnitudes less than 5.5 (for example, the magnitude 5.3 Ausable Forks, New York earthquake of April 20, 2002), and it is likely that a census-tract analysis of damage is inadequate for assessing the specific hazards associated with particular highway and railroad cuts and utility lines traversing steep slopes. Deep cuts in rock may be susceptible to rockfall, and deep cuts in glacial sediment or steep embankments in fill may be susceptible to landsliding at earthquake magnitudes possible here.

APPENDIX A

Maps of Passaic County, with census tracts, showing:

Epicenter location
Default soil type
Default liquefaction susceptibility
Default landslide susceptibility
Upgraded soil type
Upgraded liquefaction susceptibility
Upgraded landslide susceptibility



5 2.5 0 5 10 15 Miles

Study Region:
Passaic County

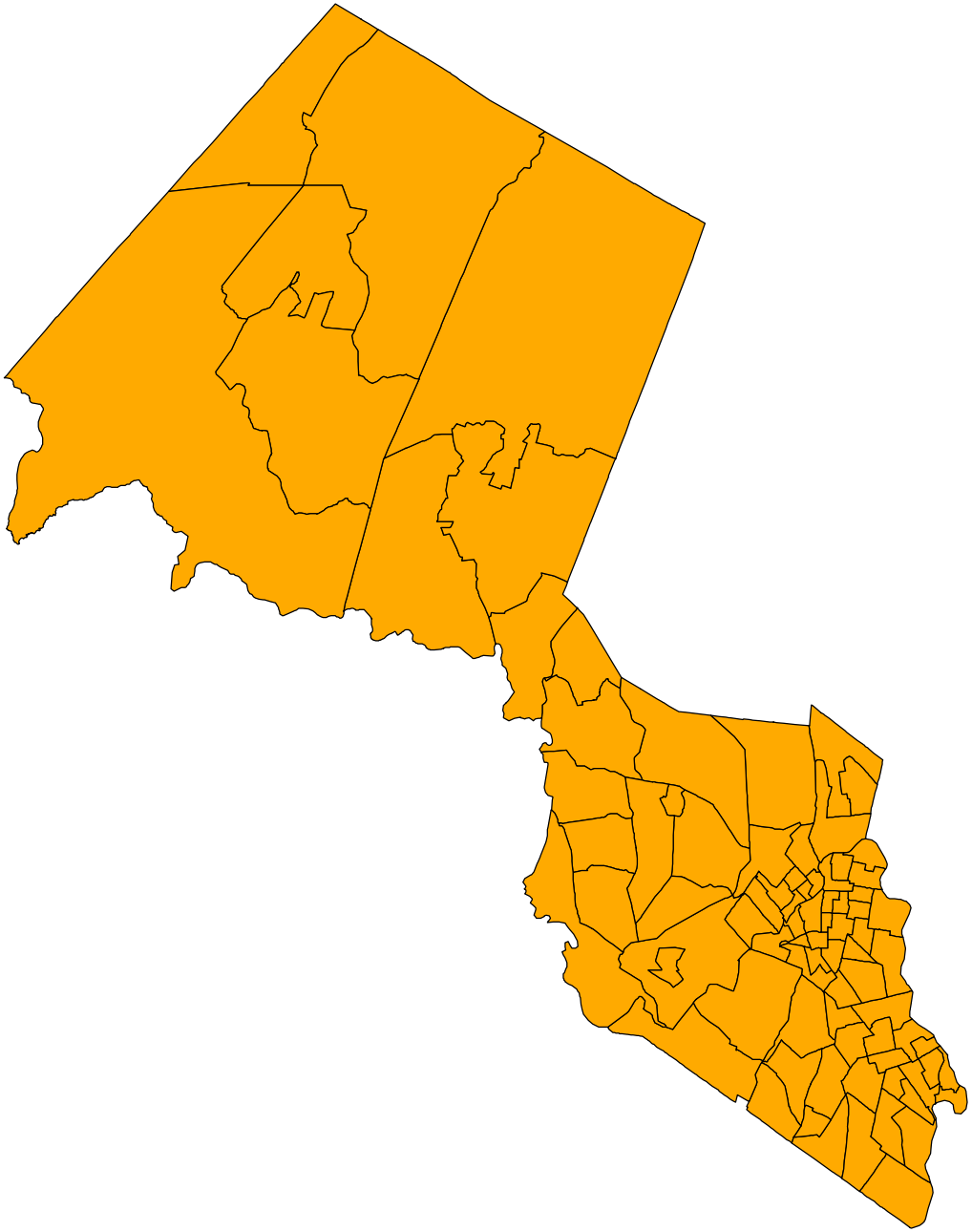
Study Region Epicenter

★ **Epicenter (Arbitrary)**
74.29 degrees longitude
41.039 degrees latitude

NEW JERSEY GEOLOGICAL SURVEY
1835

Data from the HAZUS-MH GIS software.
July 21, 2004

Study Region:
Passaic County
Default Soils Map

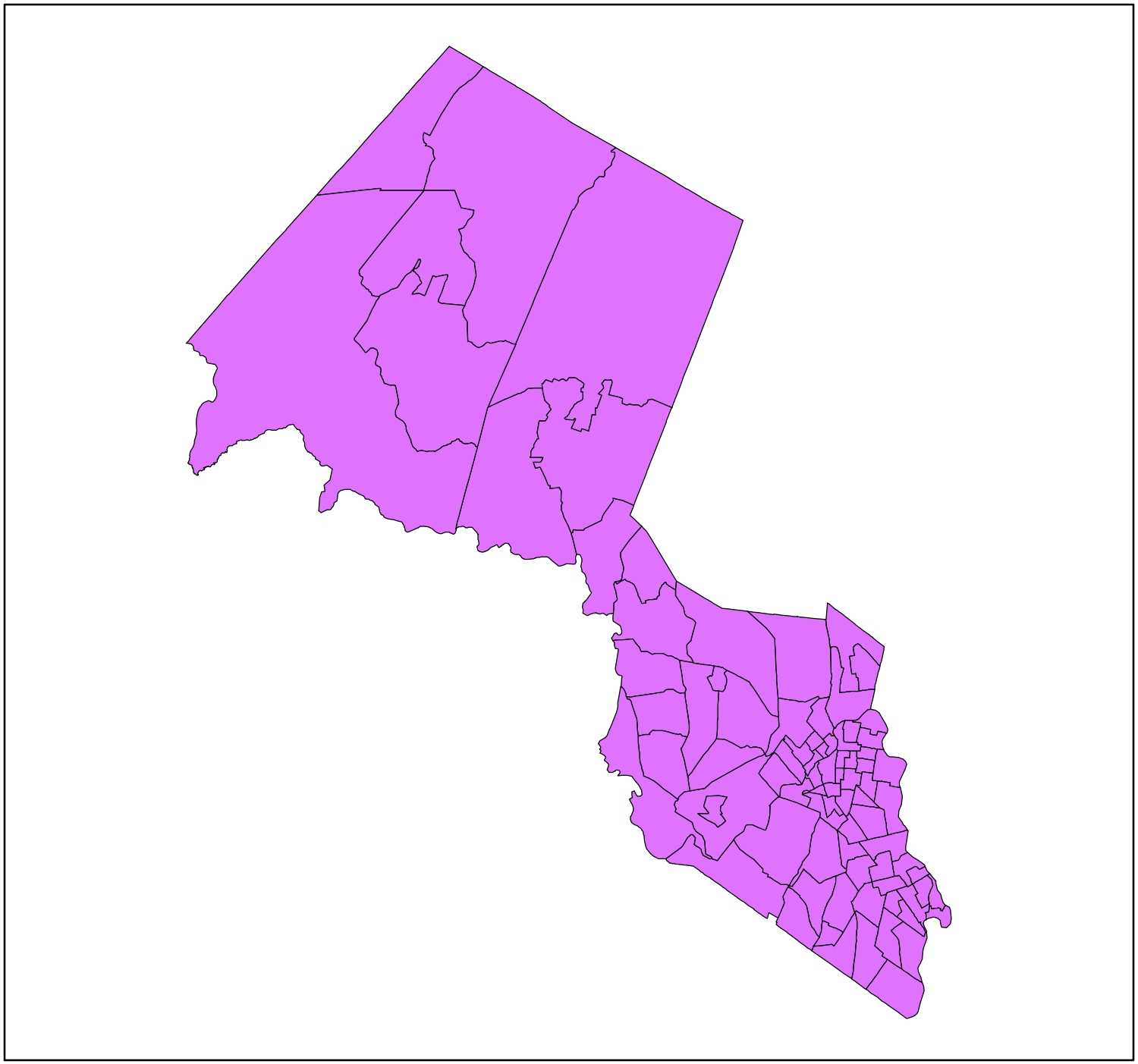


Soil Type

Class D

5 2.5 0 5 10 15 Miles

Data from the HAZUS-MH GIS software.
July 21, 2004



5 2.5 0 5 10 15 Miles

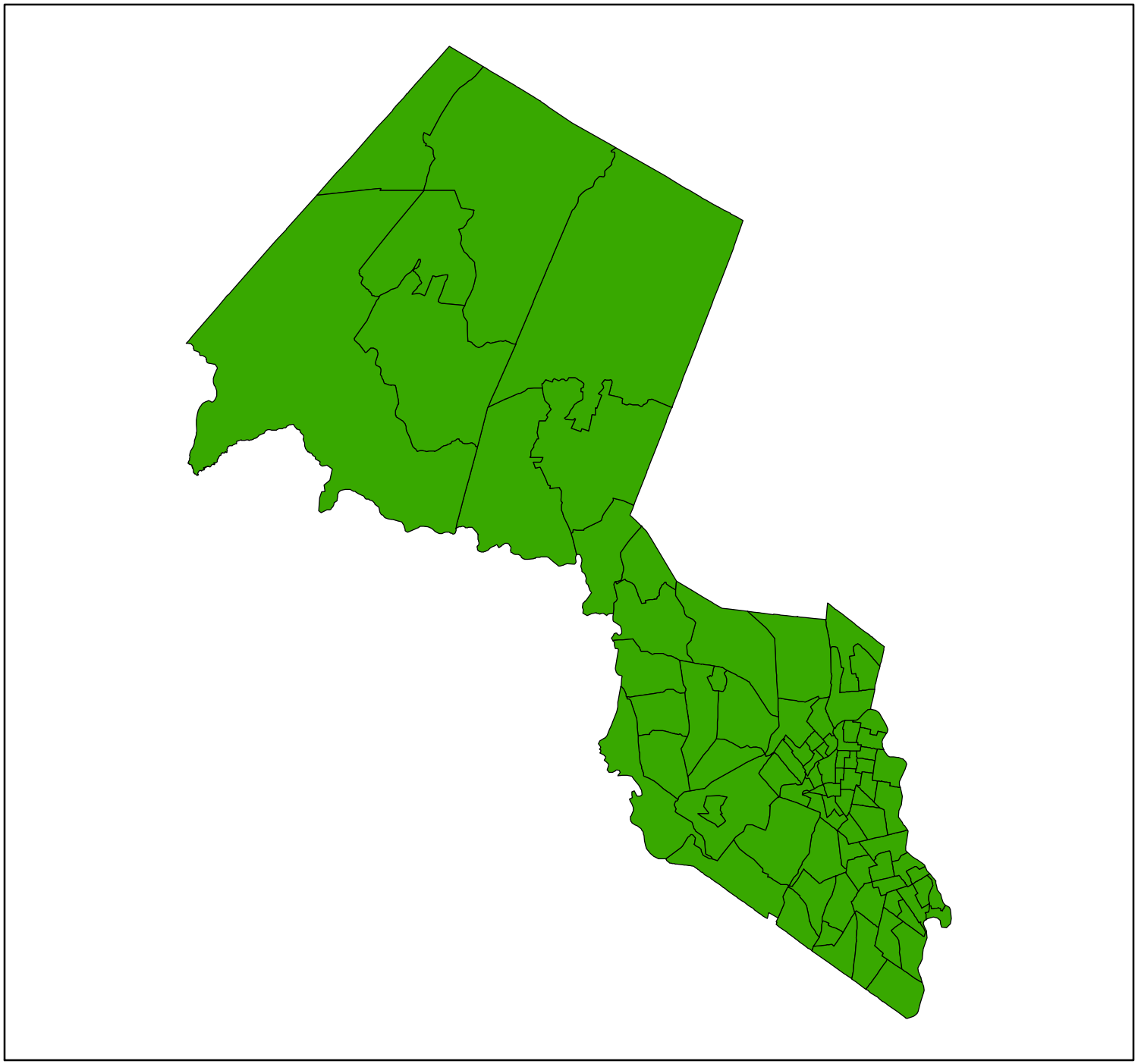
Study Region:
Passaic County

Default Liquefaction Map

Liquefaction Susceptibility
None

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
July 22, 2004



5 2.5 0 5 10 15 Miles

Study Region:
Passaic County

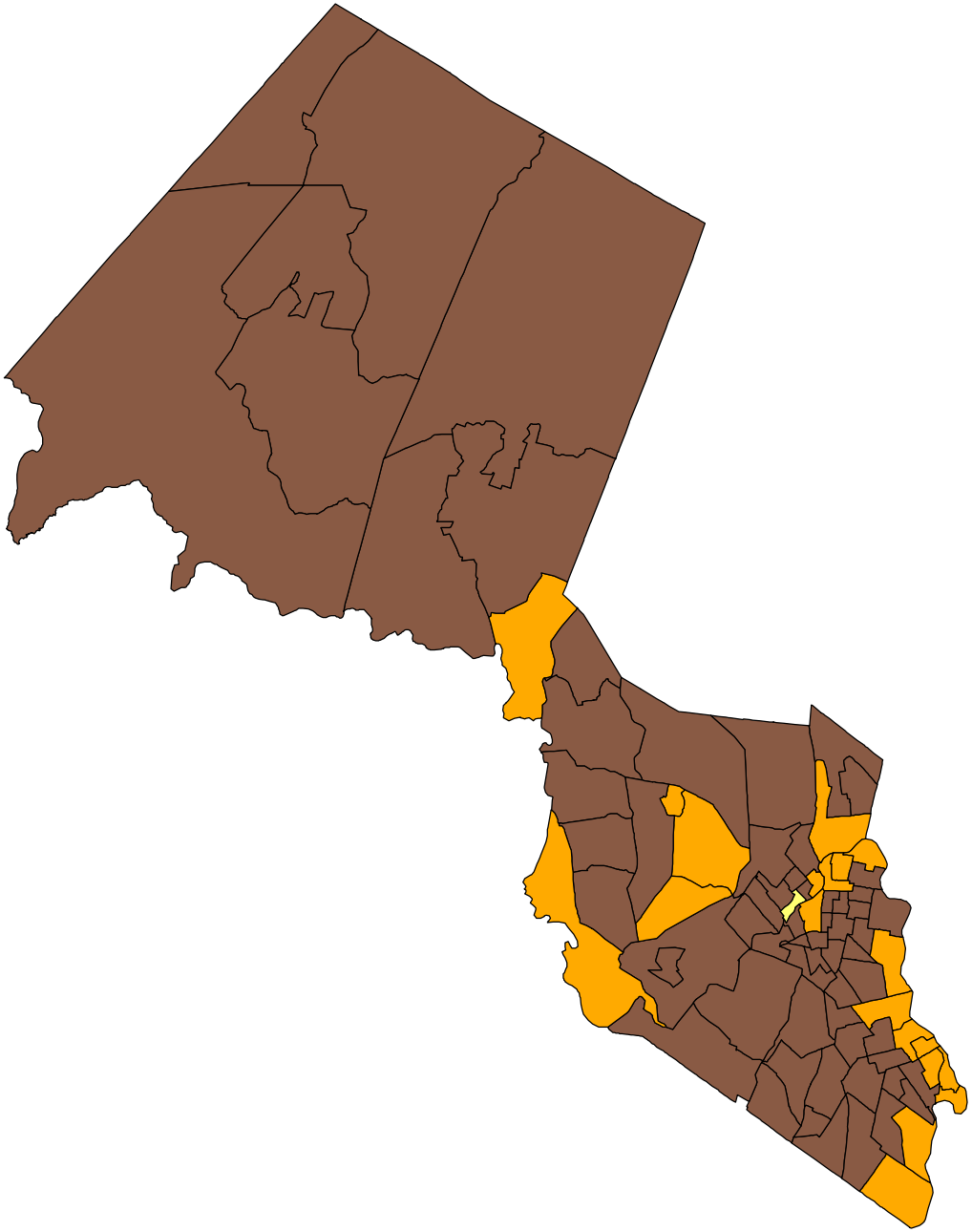
Default Landslide Map

Landslide Susceptibility

- None

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
July 22, 2004



5 2.5 0 5 10 15 Miles

Study Region:

Passaic County

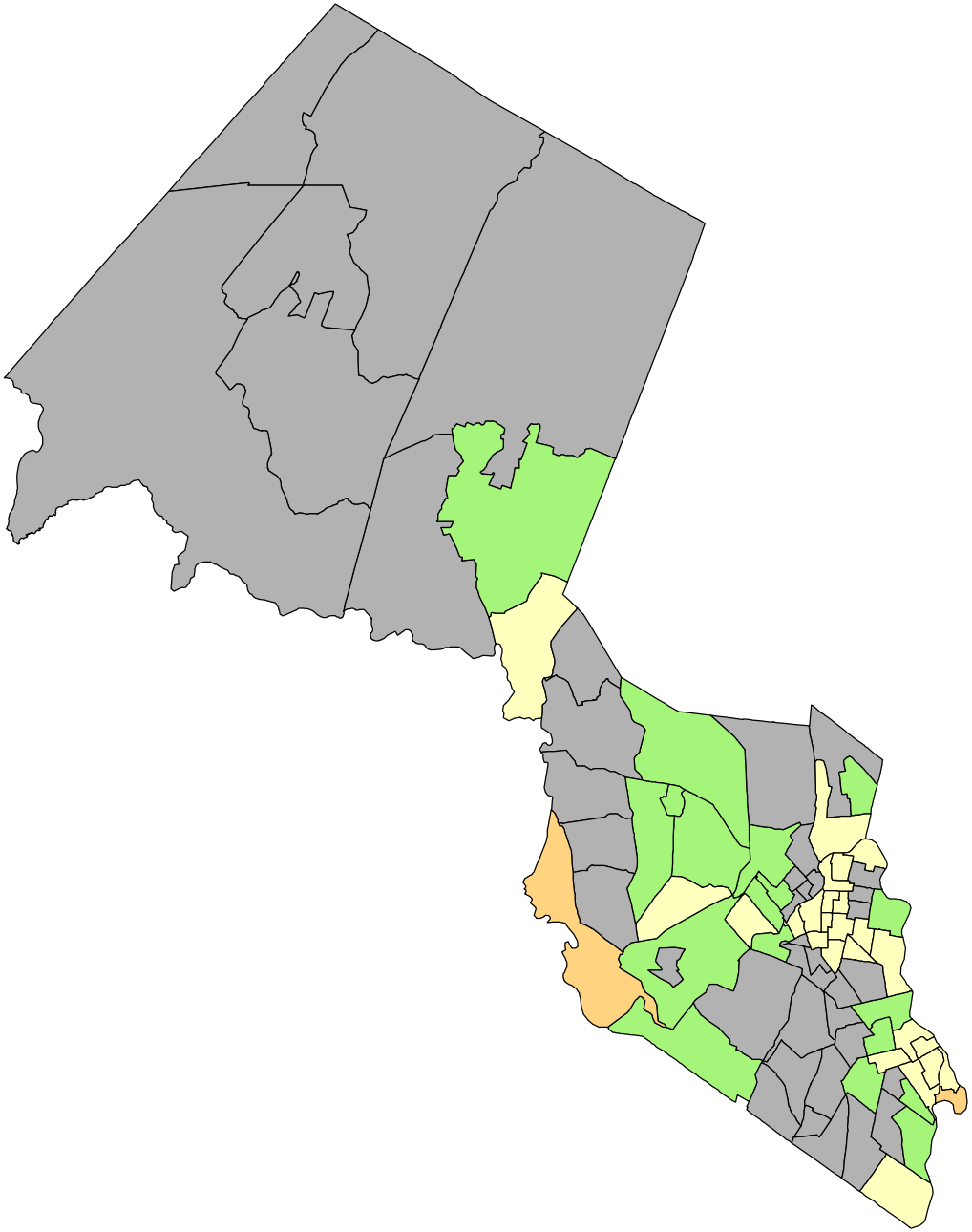
New Jersey Geological Survey Soils Map

Soil Type

- Class A
- Class C
- Class D

NEW JERSEY GEOLOGICAL SURVEY 1835

Data generated by the New Jersey Geological Survey.
July 21, 2004



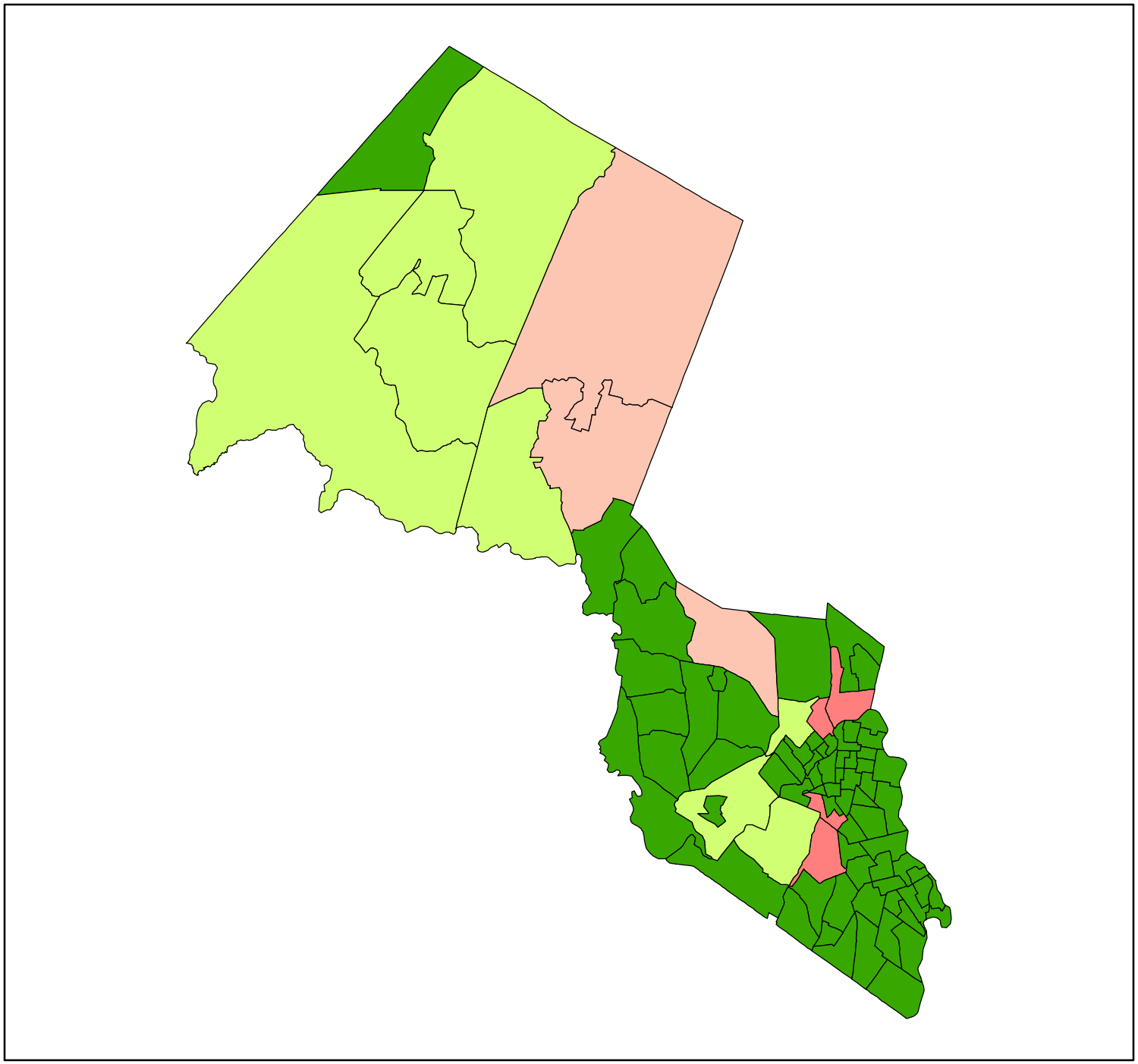
Study Region:
Passaic County

New Jersey Geological Survey Liquefaction Map

Liquefaction Susceptibility
- Very Low
- Low
- Moderate
- High

5 2.5 0 5 10 15 Miles

Data generated by the New Jersey Geological Survey.
July 22, 2004



5 2.5 0 5 10 15 Miles

Study Region:

Passaic County

New Jersey Geological Survey Landslide Map

Landslide Susceptibility

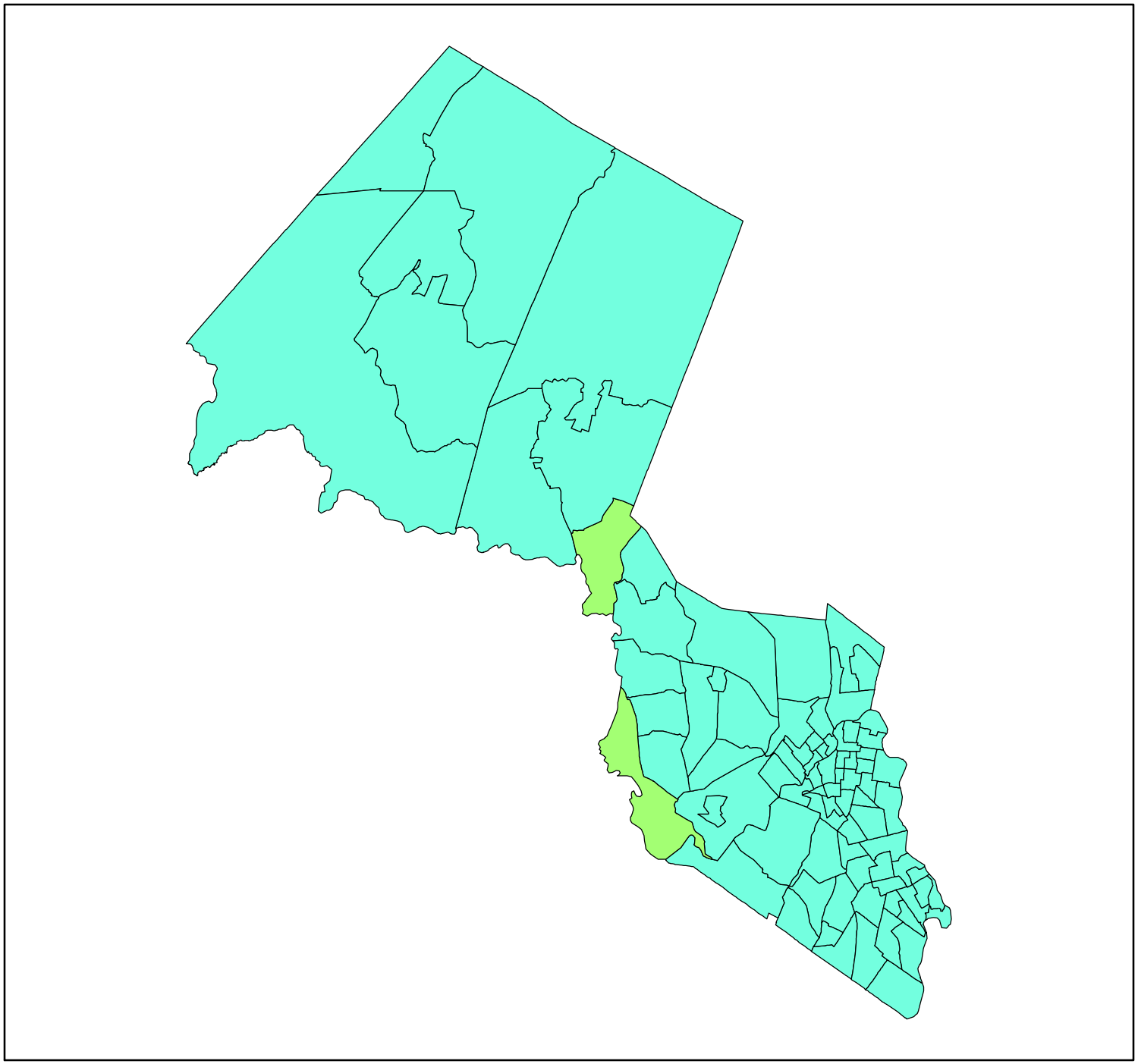
- None
- Very Low
- Low
- High

NEW JERSEY GEOLOGICAL SURVEY 1835

Data generated by the New Jersey Geological Survey.
July 21, 2004

APPENDIX B

Magnitude 5 with full upgraded geology



Study Region:
Passaic County

5.0 Upgrade Scenario

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
July 21, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.20 - 0.80
	Building Contents	0.00 - 0.10
	Business Interruption	0.00 - 0.10
Infrastructure	Lifelines Damage	
	Total	0.30 - 1.20

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	1 - 7	< 1.0	< 1.0	2 - 8
Major	0 - 1	< 1.0	< 1.0	0 - 1
Total	2 - 9	< 1.0	< 1.0	2 - 9

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	130 - 500
Level 2	Hospital Care	40 - 160
Level 3	Life-threatening	< 20
Level 4	Fatalities	10 - 50

Estimated Shelter Needs

Type	Households	People
Displaced Households	600 - 2,000	
Public Shelter		130 - 500

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 5.00

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 02, 2004 2:03 pm

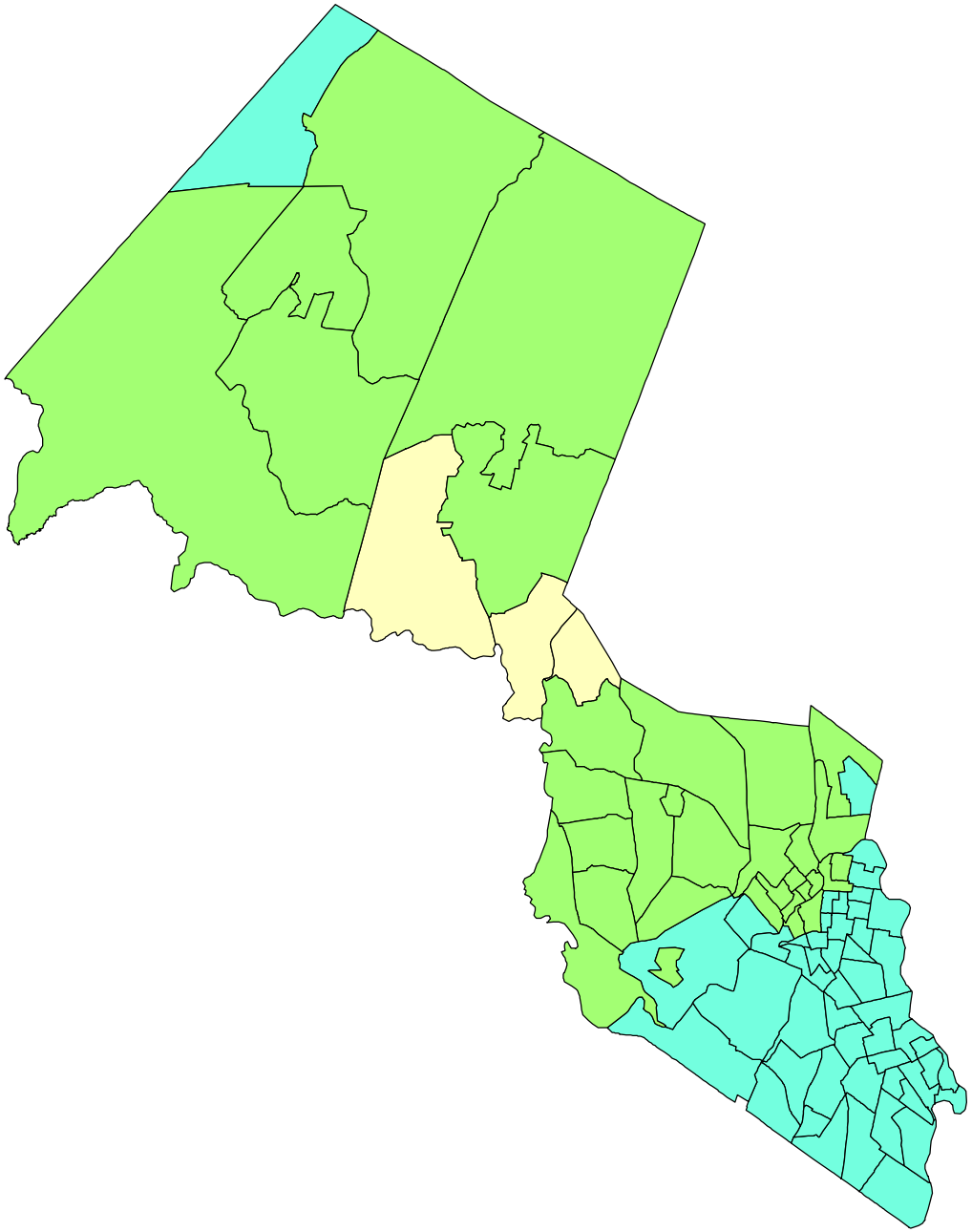
Building Damage by Count by General Occupancy

August 02, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*3*	*0*	*0*	*0*	*0*	*3*
Commercial	*1,450*	*66*	*27*	*8*	*19*	*1,571*
Education	*4*	*0*	*0*	*0*	*0*	*4*
Government	*81*	*3*	*1*	*0*	*0*	*87*
Industrial	*388*	*16*	*7*	*2*	*5*	*419*
Religion	*71*	*4*	*2*	*0*	*0*	*77*
Other Residential	*23,562*	*674*	*228*	*59*	*88*	*24,611*
Single Family	*69,586*	*2,416*	*579*	*171*	*587*	*73,339*
Total State	**95,146**	**3,180**	**844**	**242**	**700**	**100,111**
Study region	**95,146**	**3,180**	**844**	**242**	**700**	**100,111**

APPENDIX C

Magnitude 5.5 with default geology



Study Region:
Passaic County

5.5 Default Scenario

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.40 - 1.70
	Building Contents	0.00 - 0.10
	Business Interruption	0.00 - 0.20
Infrastructure	Lifelines Damage	
	Total	0.60 - 2.60

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	14 - 60	< 1.0	< 1.0	14 - 60
Major	0 - 3	< 1.0	< 1.0	1 - 3
Total	15 - 60	0 - 1	< 1.0	15 - 60

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	140 - 600
Level 2	Hospital Care	30 - 100
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

Estimated Shelter Needs

Type	Households	People
Displaced Households	900 - 4,000	
Public Shelter		200 - 900

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 5.50

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 02, 2004 4:01 pm

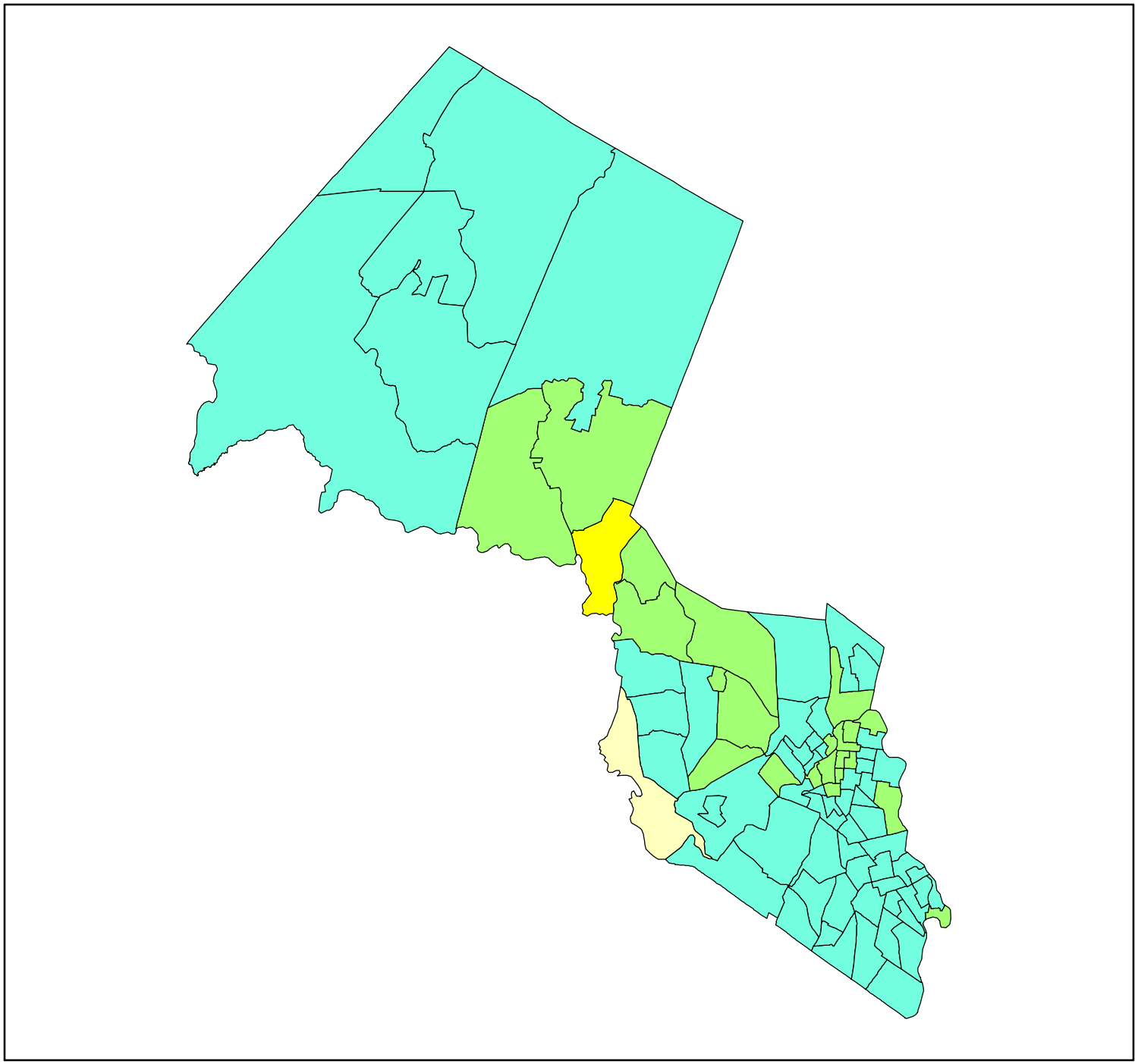
Building Damage by Count by General Occupancy

August 02, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*2*	*1*	*0*	*0*	*0*	*3*
Commercial	*1,089*	*255*	*174*	*47*	*7*	*1,571*
Education	*3*	*1*	*0*	*0*	*0*	*4*
Government	*64*	*13*	*8*	*2*	*0*	*87*
Industrial	*307*	*60*	*41*	*10*	*1*	*419*
Religion	*50*	*15*	*9*	*3*	*1*	*77*
Other Residential	*18,169*	*4,110*	*1,864*	*405*	*63*	*24,611*
Single Family	*49,129*	*16,420*	*6,417*	*1,166*	*206*	*73,339*
Total State	**68,813**	**20,873**	**8,514**	**1,632**	**279**	**100,111**
Study region	**68,813**	**20,873**	**8,514**	**1,632**	**279**	**100,111**

APPENDIX D

Magnitude 5.5 with full upgraded geology



Study Region:
Passaic County

5.5 Upgrade Scenario

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.60 - 2.40
	Building Contents	0.10 - 0.20
	Business Interruption	0.10 - 0.30
Infrastructure	Lifelines Damage	
	Total	0.90 - 3.60

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	10 - 40	< 1.0	< 1.0	10 - 40
Major	1 - 6	< 1.0	< 1.0	1 - 6
Total	11 - 50	< 1.0	< 1.0	11 - 50

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	400 - 1,700
Level 2	Hospital Care	120 - 500
Level 3	Life-threatening	20 - 70
Level 4	Fatalities	30 - 140

Estimated Shelter Needs

Type	Households	People
Displaced Households	2,000 - 9,000	
Public Shelter		600 - 2,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 5.50

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 02, 2004 2:18 pm

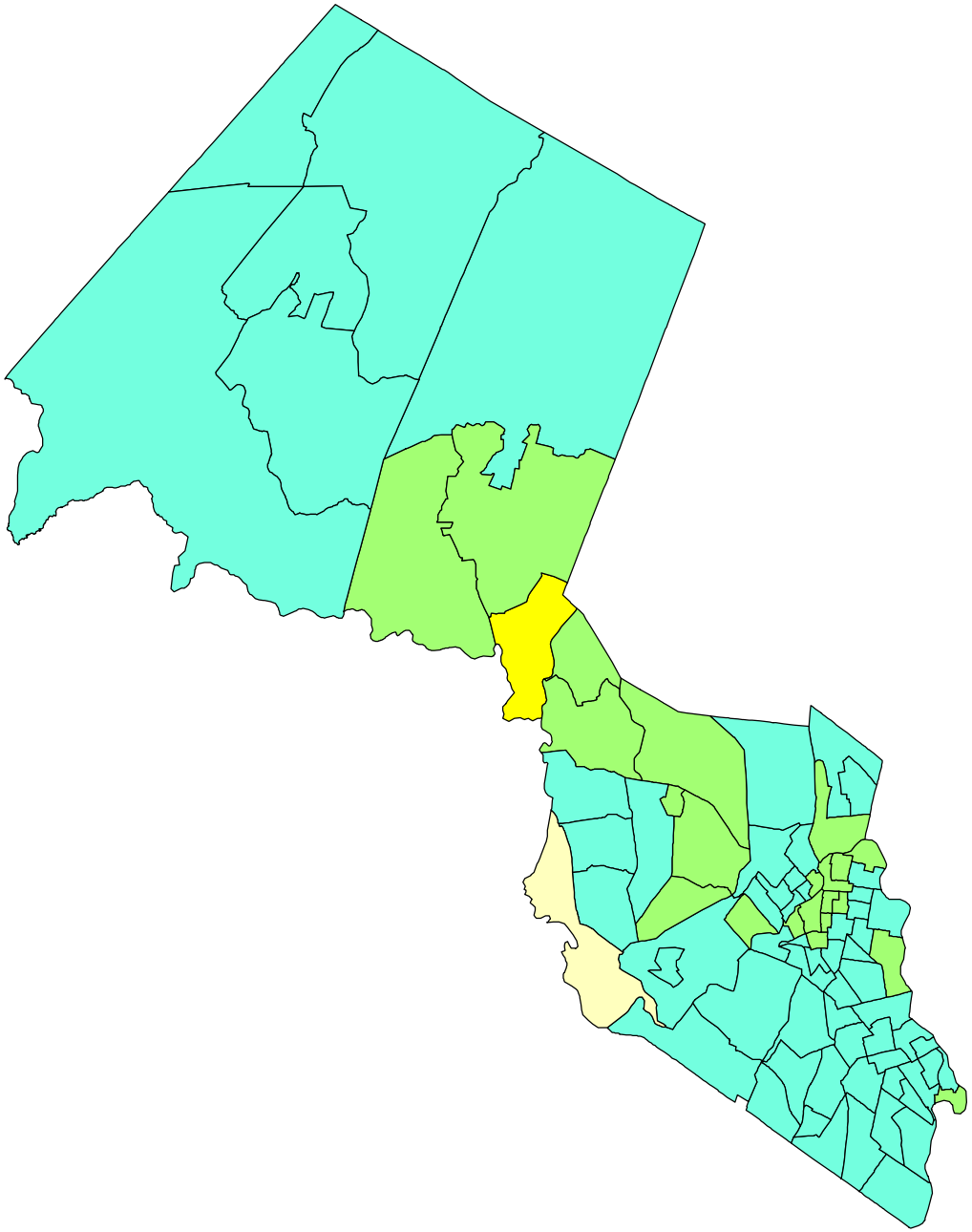
Building Damage by Count by General Occupancy

August 02, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*2*	*0*	*0*	*0*	*0*	*3*
Commercial	*1,156*	*203*	*123*	*32*	*57*	*1,571*
Education	*3*	*1*	*0*	*0*	*0*	*4*
Government	*66*	*10*	*6*	*1*	*3*	*87*
Industrial	*312*	*49*	*31*	*8*	*18*	*419*
Religion	*54*	*12*	*7*	*2*	*2*	*77*
Other Residential	*19,531*	*2,978*	*1,251*	*307*	*545*	*24,611*
Single Family	*55,409*	*11,841*	*3,952*	*737*	*1,399*	*73,339*
Total State	**76,533**	**15,094**	**5,371**	**1,088**	**2,025**	**100,111**
Study region	**76,533**	**15,094**	**5,371**	**1,088**	**2,025**	**100,111**

APPENDIX E

Magnitude 5.5 with no landslide hazard



Study Region:
Passaic County

5.5 Upgrade Scenario With Default Landslide Data

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.60 - 2.40
	Building Contents	0.10 - 0.20
	Business Interruption	0.10 - 0.30
Infrastructure	Lifelines Damage	
	Total	0.90 - 3.60

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	10 - 40	< 1.0	< 1.0	10 - 40
Major	1 - 6	< 1.0	< 1.0	1 - 6
Total	11 - 50	< 1.0	< 1.0	11 - 50

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	400 - 1,700
Level 2	Hospital Care	120 - 500
Level 3	Life-threatening	20 - 70
Level 4	Fatalities	30 - 140

Estimated Shelter Needs

Type	Households	People
Displaced Households	2,000 - 9,000	
Public Shelter		600 - 2,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 5.50

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 03, 2004 9:54 am

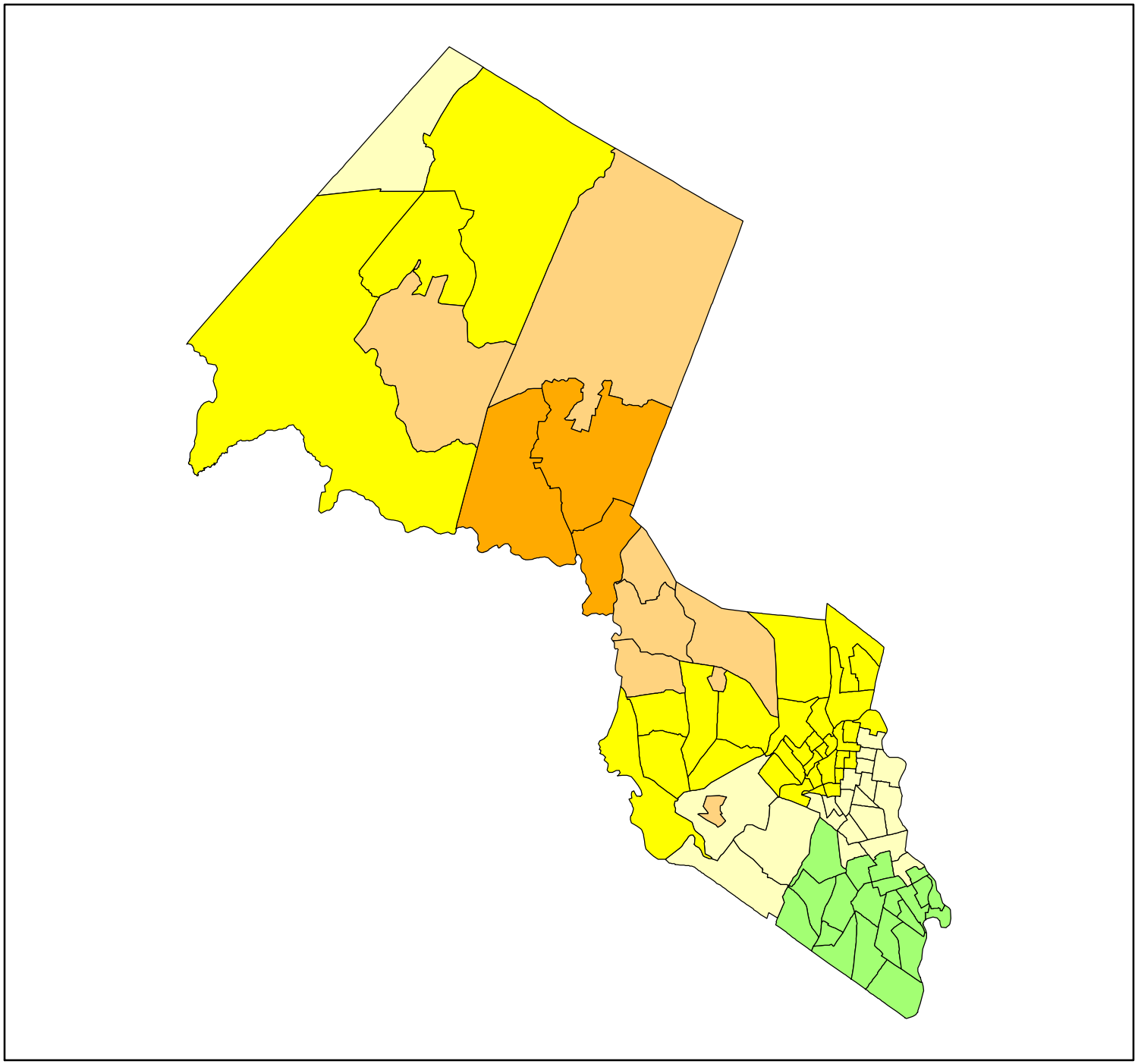
Building Damage by Count by General Occupancy

August 03, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*2*	*0*	*0*	*0*	*0*	*3*
Commercial	*1,156*	*203*	*123*	*32*	*57*	*1,571*
Education	*3*	*1*	*0*	*0*	*0*	*4*
Government	*66*	*10*	*6*	*1*	*3*	*87*
Industrial	*312*	*49*	*31*	*8*	*18*	*419*
Religion	*54*	*12*	*7*	*2*	*2*	*77*
Other Residential	*19,531*	*2,978*	*1,251*	*307*	*545*	*24,611*
Single Family	*55,409*	*11,841*	*3,952*	*737*	*1,399*	*73,339*
Total State	**76,533**	**15,094**	**5,371**	**1,088**	**2,025**	**100,111**
Study region	**76,533**	**15,094**	**5,371**	**1,088**	**2,025**	**100,111**

APPENDIX F

Magnitude 6 with default geology



Study Region:
Passaic County

6.0 Default Scenario

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	1.20 - 4.80
	Building Contents	0.10 - 0.30
	Business Interruption	0.20 - 0.80
Infrastructure	Lifelines Damage	
	Total	1.80 - 7.00

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	30 - 110	0 - 1	< 1.0	30 - 110
Major	4 - 16	< 1.0	< 1.0	4 - 17
Total	30 - 120	0 - 2	< 1.0	30 - 130

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	700 - 3,000
Level 2	Hospital Care	180 - 700
Level 3	Life-threatening	30 - 100
Level 4	Fatalities	50 - 190

Estimated Shelter Needs

Type	Households	People
Displaced Households	4,000 - 18,000	
Public Shelter		1,200 - 5,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 6.00

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

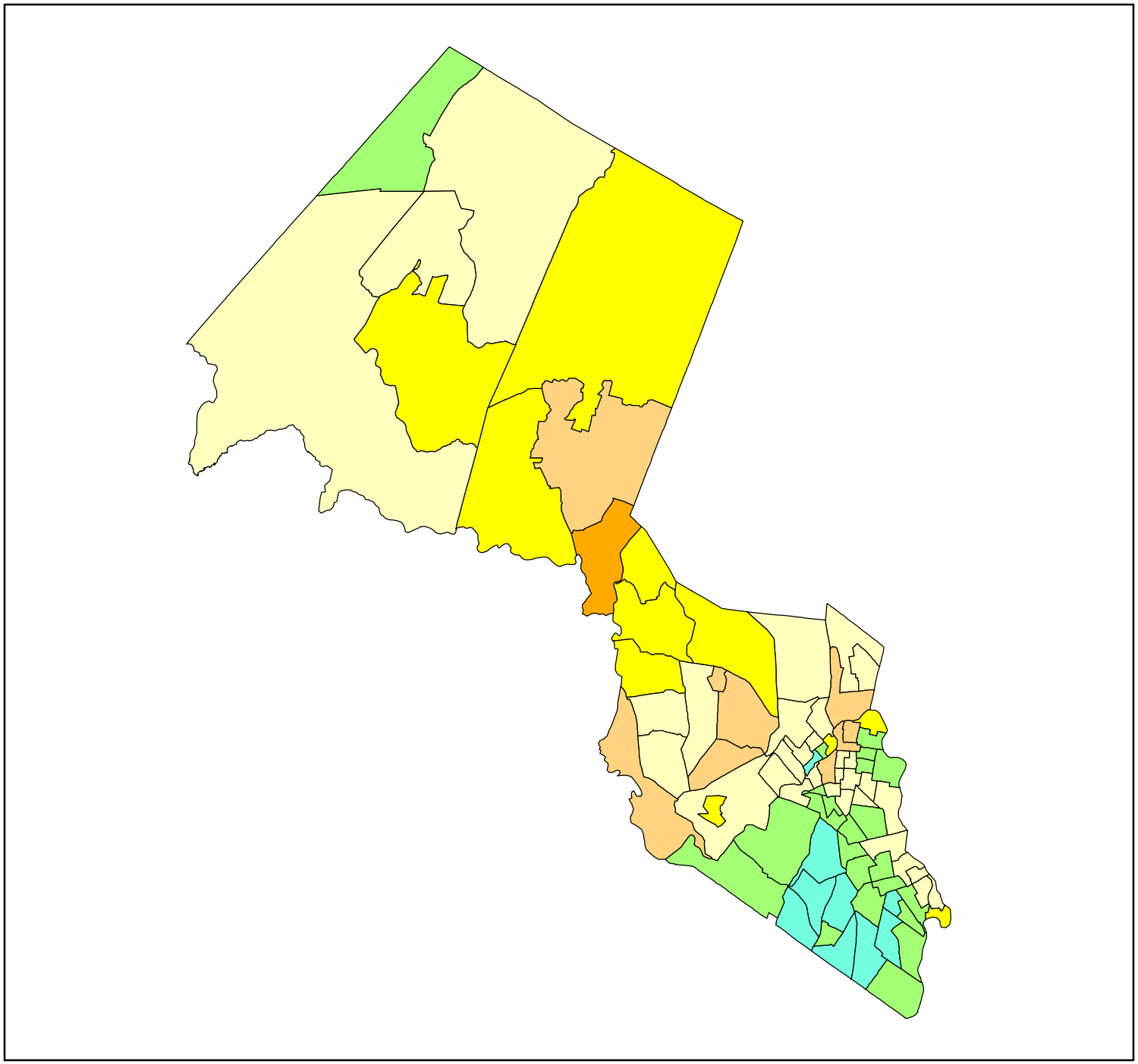
Building Damage by Count by General Occupancy

August 03, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*1*	*1*	*1*	*0*	*0*	*3*
Commercial	*508*	*338*	*437*	*216*	*72*	*1,571*
Education	*1*	*1*	*1*	*0*	*0*	*4*
Government	*31*	*18*	*24*	*11*	*3*	*87*
Industrial	*151*	*86*	*115*	*54*	*15*	*419*
Religion	*24*	*19*	*20*	*10*	*4*	*77*
Other Residential	*10,402*	*6,797*	*5,112*	*1,819*	*480*	*24,611*
Single Family	*26,285*	*23,896*	*17,022*	*4,814*	*1,323*	*73,339*
Total State	**37,402**	**31,156**	**22,732**	**6,925**	**1,896**	**100,111**
Study region	**37,402**	**31,156**	**22,732**	**6,925**	**1,896**	**100,111**

APPENDIX G

Magnitude 6 with full upgraded geology



Study Region:
Passaic County

6.0 Upgrade Scenario

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	1.40 - 5.40
	Building Contents	0.10 - 0.40
	Business Interruption	0.20 - 0.80
Infrastructure	Lifelines Damage	
	Total	2.00 - 8.10

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	20 - 80	0 - 1	< 1.0	20 - 90
Major	4 - 16	< 1.0	< 1.0	4 - 17
Total	30 - 100	0 - 1	< 1.0	30 - 100

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	1,000 - 4,000
Level 2	Hospital Care	300 - 1,100
Level 3	Life-threatening	40 - 160
Level 4	Fatalities	80 - 300

Estimated Shelter Needs

Type	Households	People
Displaced Households	2,000 - 9,000	
Public Shelter		600 - 2,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 6.00

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 02, 2004 11:22 am

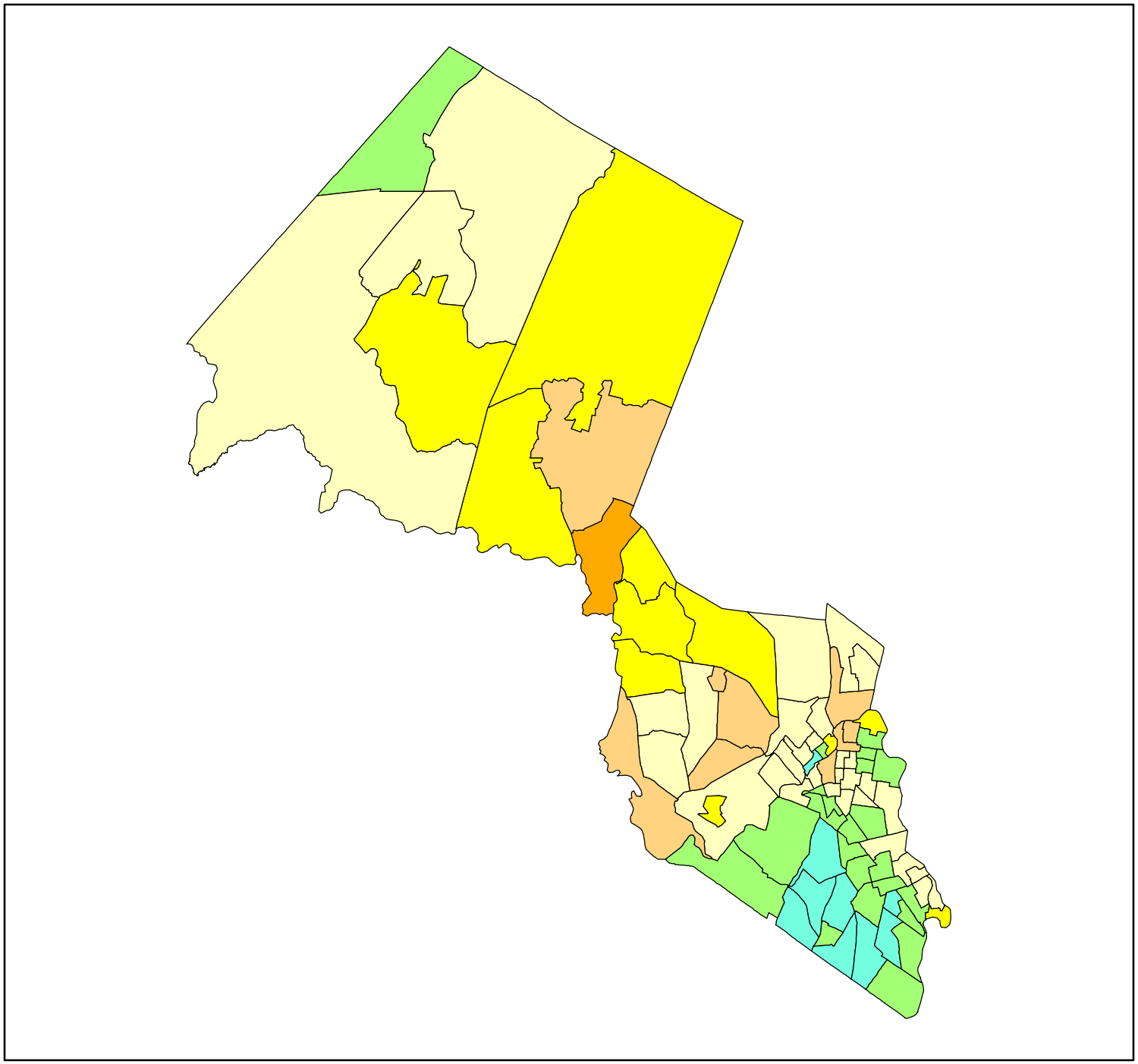
Building Damage by Count by General Occupancy

August 02, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*1*	*1*	*1*	*0*	*0*	*3*
Commercial	*638*	*320*	*346*	*145*	*122*	*1,571*
Education	*1*	*1*	*1*	*0*	*0*	*4*
Government	*37*	*16*	*19*	*7*	*7*	*87*
Industrial	*173*	*78*	*91*	*39*	*38*	*419*
Religion	*30*	*18*	*16*	*7*	*5*	*77*
Other Residential	*12,963*	*5,591*	*3,571*	*1,138*	*1,348*	*24,611*
Single Family	*34,708*	*21,036*	*11,951*	*2,938*	*2,706*	*73,339*
Total State	**48,552**	**27,061**	**15,996**	**4,275**	**4,227**	**100,111**
Study region	**48,552**	**27,061**	**15,996**	**4,275**	**4,227**	**100,111**

APPENDIX H

Magnitude 6 with no landslide hazard



Study Region:
Passaic County

6.0 Upgrade Scenario With Default Landslide Data

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	1.40 - 5.40
	Building Contents	0.10 - 0.40
	Business Interruption	0.20 - 0.80
Infrastructure	Lifelines Damage	
	Total	2.00 - 8.10

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	20 - 80	0 - 1	< 1.0	20 - 90
Major	4 - 16	< 1.0	< 1.0	4 - 17
Total	30 - 100	0 - 1	< 1.0	30 - 100

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	1,000 - 4,000
Level 2	Hospital Care	300 - 1,100
Level 3	Life-threatening	40 - 160
Level 4	Fatalities	80 - 300

Estimated Shelter Needs

Type	Households	People
Displaced Households	6,000 - 23,000	
Public Shelter		1,500 - 6,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 6.00

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 03, 2004 10:26 am

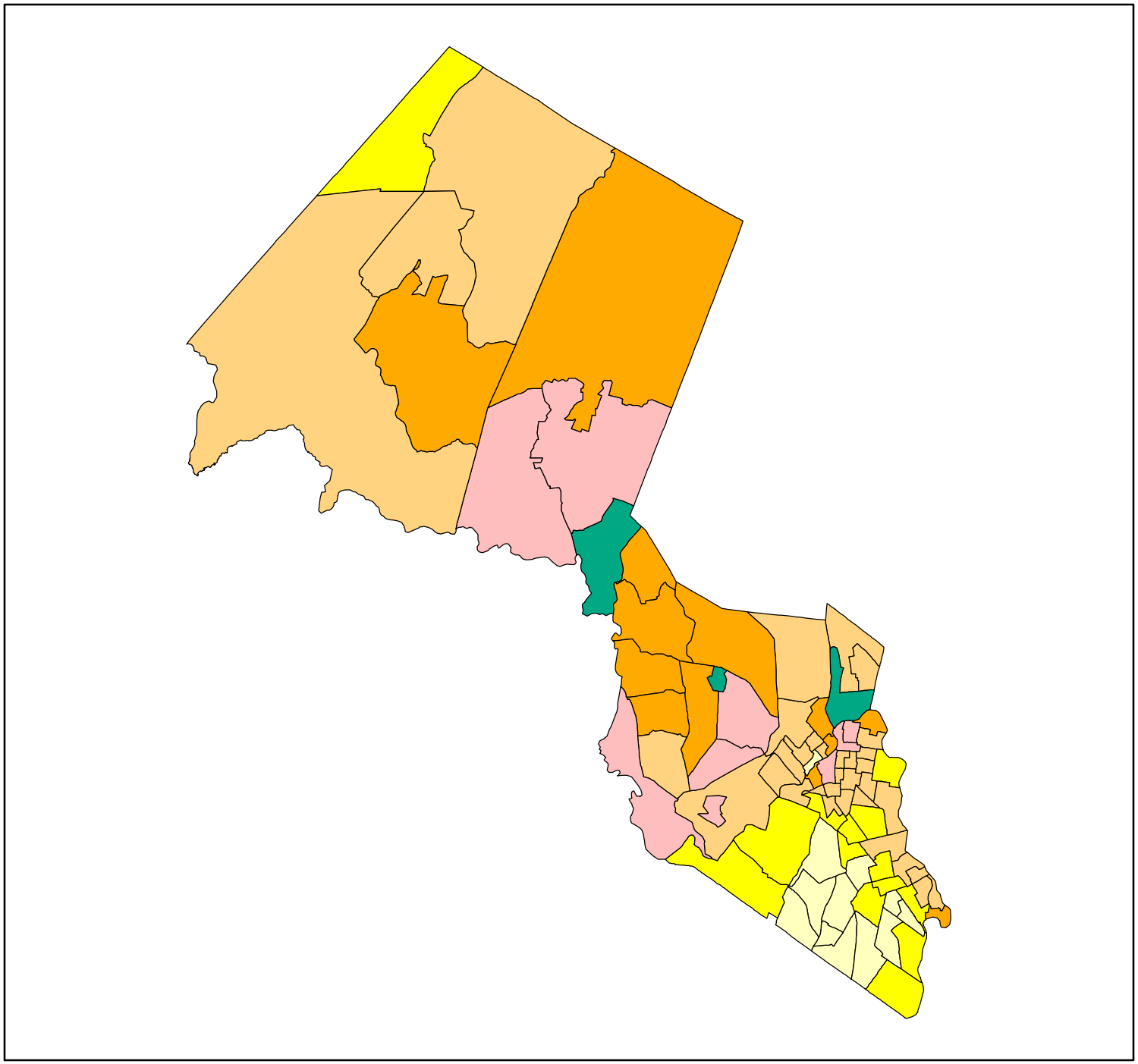
Building Damage by Count by General Occupancy

August 03, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*1*	*1*	*1*	*0*	*0*	*3*
Commercial	*638*	*321*	*346*	*145*	*122*	*1,571*
Education	*1*	*1*	*1*	*0*	*0*	*4*
Government	*37*	*16*	*19*	*7*	*7*	*87*
Industrial	*173*	*78*	*91*	*39*	*38*	*419*
Religion	*30*	*18*	*16*	*7*	*5*	*77*
Other Residential	*12,959*	*5,593*	*3,572*	*1,139*	*1,348*	*24,611*
Single Family	*34,703*	*21,038*	*11,953*	*2,939*	*2,706*	*73,339*
Total State	**48,543**	**27,065**	**15,999**	**4,276**	**4,227**	**100,111**
Study region	**48,543**	**27,065**	**15,999**	**4,276**	**4,227**	**100,111**

APPENDIX I

Magnitude 6.5 with full upgraded geology



Study Region:
Passaic County

6.5 Upgrade Scenario

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	2.50 - 9.80
	Building Contents	0.20 - 0.70
	Business Interruption	0.40 - 1.50
Infrastructure	Lifelines Damage	
	Total	3.60 - 14.40

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	30 - 110	0 - 1	< 1.0	30 - 120
Major	8 - 30	0 - 1	< 1.0	9 - 40
Total	40 - 150	0 - 2	< 1.0	40 - 150

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	2,000 - 8,000
Level 2	Hospital Care	600 - 2,000
Level 3	Life-threatening	80 - 300
Level 4	Fatalities	160 - 600

Estimated Shelter Needs

Type	Households	People
Displaced Households	11,000 - 45,000	
Public Shelter		3,000 - 12,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 6.50

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 02, 2004 12:57 pm

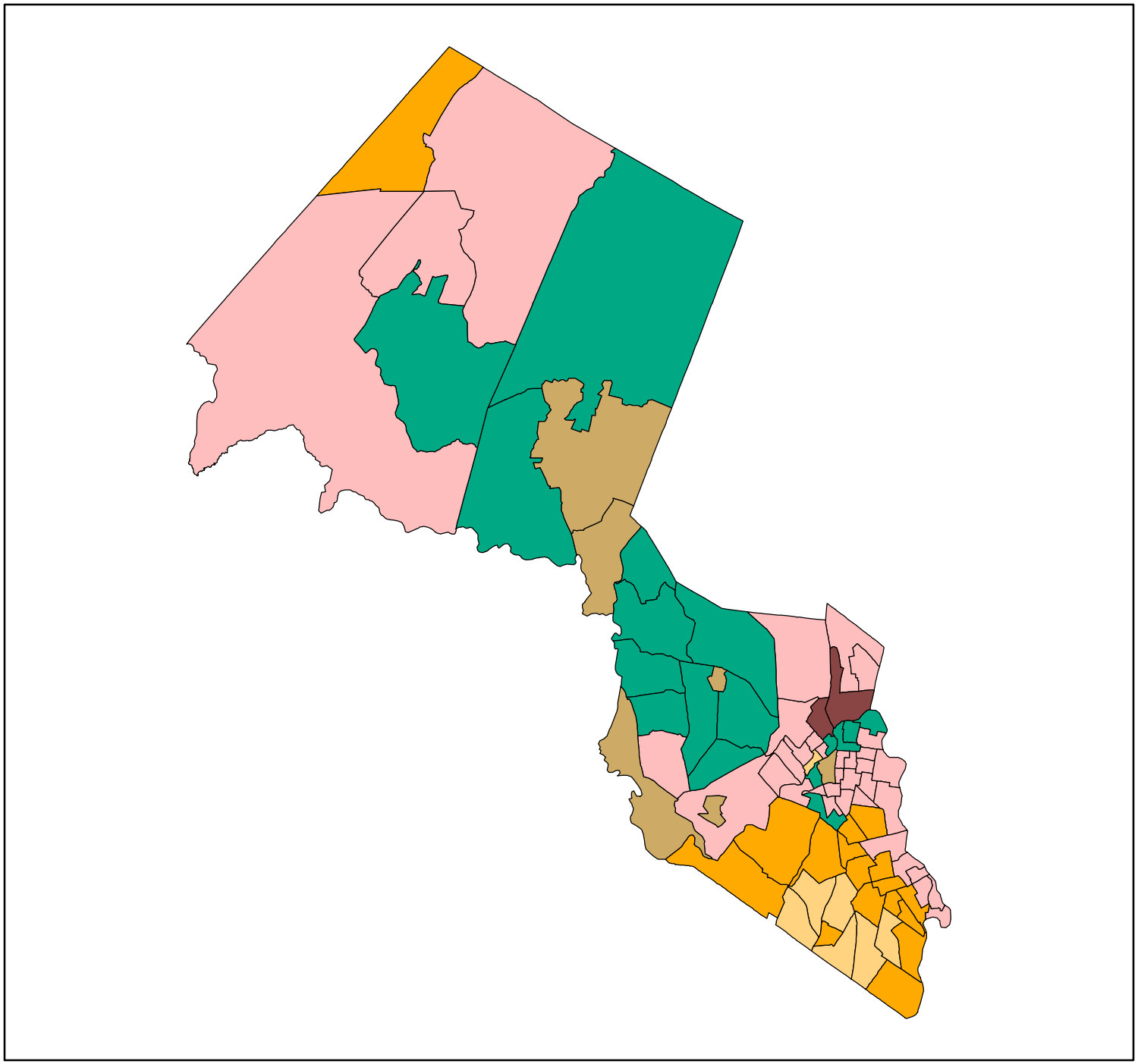
Building Damage by Count by General Occupancy

August 02, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*0*	*1*	*1*	*1*	*1*	*3*
Commercial	*272*	*266*	*463*	*315*	*255*	*1,571*
Education	*0*	*1*	*1*	*1*	*1*	*4*
Government	*16*	*13*	*25*	*18*	*15*	*87*
Industrial	*73*	*64*	*121*	*87*	*75*	*419*
Religion	*14*	*16*	*22*	*14*	*11*	*77*
Other Residential	*6,386*	*6,665*	*6,399*	*2,868*	*2,293*	*24,611*
Single Family	*16,967*	*23,054*	*21,337*	*7,351*	*4,631*	*73,339*
Total State	**23,728**	**30,079**	**28,369**	**10,654**	**7,280**	**100,111**
Study region	**23,728**	**30,079**	**28,369**	**10,654**	**7,280**	**100,111**

APPENDIX J

Magnitude 7 with full upgraded geology



Study Region:
Passaic County

7.0 Upgrade Scenario

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	3.90 - 15.60
	Building Contents	0.30 - 1.10
	Business Interruption	0.60 - 2.40
Infrastructure	Lifelines Damage	
	Total	5.60 - 22.60

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	30 - 120	0 - 1	< 1.0	30 - 120
Major	15 - 60	0 - 1	< 1.0	15 - 60
Total	40 - 180	0 - 3	0 - 1	40 - 180

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	4,000 - 14,000
Level 2	Hospital Care	1,000 - 4,000
Level 3	Life-threatening	160 - 600
Level 4	Fatalities	300 - 1,200

Estimated Shelter Needs

Type	Households	People
Displaced Households	19,000 - 76,000	
Public Shelter		5,000 - 20,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 7.00

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 2.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 02, 2004 1:35 pm

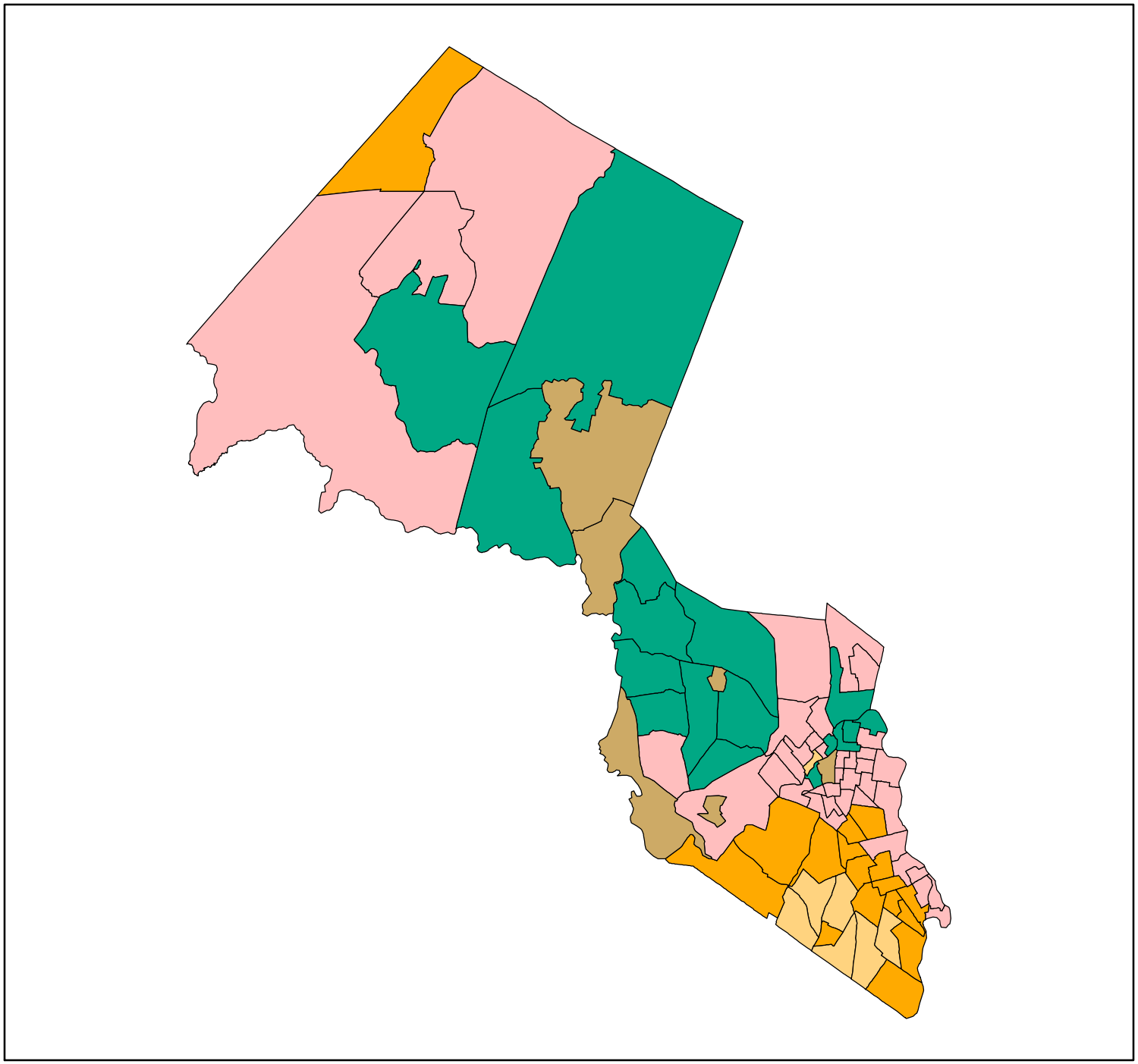
Building Damage by Count by General Occupancy

August 02, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*0*	*0*	*1*	*1*	*1*	*3*
Commercial	*92*	*149*	*401*	*431*	*497*	*1,571*
Education	*0*	*0*	*1*	*1*	*2*	*4*
Government	*5*	*7*	*21*	*25*	*29*	*87*
Industrial	*24*	*34*	*99*	*120*	*142*	*419*
Religion	*5*	*11*	*21*	*19*	*20*	*77*
Other Residential	*2,712*	*5,284*	*7,723*	*4,892*	*4,000*	*24,611*
Single Family	*7,275*	*18,253*	*26,717*	*13,103*	*7,991*	*73,339*
Total State	**10,115**	**23,739**	**34,984**	**18,591**	**12,682**	**100,111**
Study region	**10,115**	**23,739**	**34,984**	**18,591**	**12,682**	**100,111**

APPENDIX K

Magnitude 7 with no landslide hazard



Study Region:
Passaic County

7.0 Upgrade Scenario With Default Landslide Data

Percentage Of Buildings With Moderate and Greater Damage

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 90
- 90 to 100

5 2.5 0 5 10 15 Miles

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH GIS software.
August 3, 2004

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	3.90 - 15.50
	Building Contents	0.30 - 1.10
	Business Interruption	0.60 - 2.40
Infrastructure	Lifelines Damage	
	Total	5.60 - 22.30

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	30 - 120	0 - 1	< 1.0	30 - 120
Major	14 - 60	0 - 1	< 1.0	15 - 60
Total	40 - 180	0 - 3	0 - 1	40 - 180

Estimated Casualties : Day Time

Severity Level	Description	# Persons
Level 1	Medical Aid	4,000 - 14,000
Level 2	Hospital Care	1,000 - 4,000
Level 3	Life-threatening	160 - 600
Level 4	Fatalities	300 - 1,200

Estimated Shelter Needs

Type	Households	People
Displaced Households	19,000 - 74,000	
Public Shelter		5,000 - 20,000

Comments :

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

Earthquake Information

Location :

Origin Time:

Magnitude : 7.00

Epicenter Latitude/Longitude :
41.04 / -74.29

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 2.00

Ground Motion /Attenuation : Project 2000 East

Information Sources:

Comments :

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

Population: 489,049

Building Exposure : ($ Millions)

Residential	19,218
Commerical	3,669
Other	1,683
Total	24,570

State:

Counties :
- Passaic,NJ

Major Metro Area :

Time of report: August 04, 2004 8:10 am

Building Damage by Count by General Occupancy

August 04, 2004

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Passaic						
Agriculture	*0*	*0*	*1*	*1*	*1*	*3*
Commercial	*94*	*151*	*403*	*428*	*496*	*1,571*
Education	*0*	*0*	*1*	*1*	*2*	*4*
Government	*5*	*7*	*21*	*25*	*29*	*87*
Industrial	*25*	*34*	*100*	*119*	*141*	*419*
Religion	*5*	*11*	*21*	*19*	*20*	*77*
Other Residential	*2,822*	*5,509*	*7,735*	*4,632*	*3,913*	*24,611*
Single Family	*7,402*	*18,531*	*26,765*	*12,756*	*7,887*	*73,339*
Total State	**10,353**	**24,243**	**35,047**	**17,979**	**12,488**	**100,111**
Study region	**10,353**	**24,243**	**35,047**	**17,979**	**12,488**	**100,111**

APPENDIX L

Seismic velocity data

Abbreviations are:

P-Wave=compressional wave
S-Wave=shear wave
gp spc = distance of geophone from source (feet)
pick = arrival time of wave at geophone (milliseconds)
int time = interval travel time between geophones (milliseconds)
int vel = interval velocity--wave velocity between geophones (feet/second)
avg vel = wave velocity calculated by averaging the interval velocities
regression velocity = wave velocity calculated from best-fit line to first arrivals

Back Beach

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	8.6			ft/sec		ft/sec
6	13	4.4	1363.636364	**1368.083004**	0.71667	**1395.348837**
12	17	4	1500			
18	21.6	4.6	1304.347826			
24	26.2	4.6	1304.347826			
30	28.6	2.4	2500	**4339.285714**	0.24762	**4038.461538**
36	30.2	1.6	3750			
42	31.6	1.4	4285.714286			
48	34.6	3	2000			
54	35.6	1	6000			
60	36.4	0.8	7500			
66	37	0.6				

S-WAVE

0	14.4					
6	36.8	22.4	267.8571429	**267.8571429**	3.73333	**267.8571429**
12	42.2	5.4	1111.111111	**1544.720134**	0.70242	**1423.64107**
18	47.2	5	1200			
24	54.2	7	857.1428571			
30	58	3.8	1578.947368			
36	61.2	3.2	1875			
42	66	4.8	1250			
48	70	4	1500			
54	75	5	1200			
60	77	2	3000			
66	80.2	3.2	1875			

Buttonwood

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	11.2			ft/sec		ft/sec
6	19	7.8	769.2307692	769.2307692	1.3	**769.2307692**
12	22.6	3.6	1666.666667	**2067.599068**	0.50667	**1973.684211**
18	25.2	2.6	2307.692308			
24	29.6	4.4	1363.636364			
30	32	2.4	2500			
36	34.4	2.4	2500			
42	35.4	1	6000	**6500**	0.15333	**6521.73913**
48	36.6	1.2	5000			
54	37.4	0.8	7500			
60	38.2	0.8	7500			
66	38.8					

S-WAVE

0	17.6					
6	34.2	16.6	361.4457831	**561.74191**	1.86788	**535.366645**
12	42	7.8	769.2307692			
18	58	16	375			
24	70.4	12.4	483.8709677			
30	82.6	12.2	491.8032787			
36	90.6	8	750			
42	101.6	11	545.4545455			
48	112	10.4	576.9230769			
54	126.6	14.6	410.9589041			
60	136.2	9.6	625			
66	143.8	7.6	789.4736842			

Echo Lake

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	5.8			ft/sec		ft/sec
6	12.2	6.4	937.5	**1347.791988**	0.87667	**1140.684411**
12	19.6	7.4	810.8108108			
18	23.6	4	1500			
24	26.4	2.8	2142.857143			
30	27.8	1.4	4285.714286	**5186.507937**	0.20238	**4941.176471**
36	29	1.2	5000			
42	30.2	1.2	5000			
48	32	1.8	3333.333333			
54	33	1	6000			
60	33.8	0.8	7500			
66	35					

S-WAVE

0	12					
6	29	17	352.9411765	**566.1255816**	1.74424	**573.3148019**
12	39.8	10.8	555.5555556			
18	47.4	7.6	789.4736842			
24	60.6	13.2	454.5454545			
30	71.8	11.2	535.7142857			
36	79.8	8	750			
42	89.8	10	600			
48	101.6	11.8	508.4745763			
54	113	11.4	526.3157895			
60	123.2	10.2	588.2352941			
66	129.4					

Farmingdale Road

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	15.4			ft/sec		ft/sec
6	17.6	2.2	2727.272727	**3293.706294**	0.50667	**1973.684211**
12	22.8	5.2	1153.846154			
18	23.8	1	6000			
24	24.8	1	6000	**13500**	0.09563	**10456.43154**
30	24.8					
36	25.6	0.8	7500			
42	26.4	0.8	7500			
48	26.8	0.4	15000			
54	27.8					
60	28	0.2	30000			
66	28.4	0.4	15000			

S-WAVE

0	47.6					
6	64.2	16.6	361.4457831	**468.3343173**	2.17	**460.8294931**
12	75.6	11.4	526.3157895			
18	87.2	11.6	517.2413793			
24	92.4	5.2	1153.846154	**2383.484163**	0.56548	**1768.421053**
30	93.4	1	6000			
36	96.8	3.4	1764.705882			
42	103.6	6.8	882.3529412			
48	106.6	3	2000			
54	109	2.4	2500			
60	110.4	1.4				
66	109.6	-0.8				

Hewitt School

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	9.2			ft/sec		ft/sec
6	13.2	4	1500	**2128.246753**	0.49667	**2013.422819**
12	16	2.8	2142.857143			
18	18.2	2.2	2727.272727			
24	21	2.8	2142.857143			
30	23.4	2.4	2500			
36	24.8	1.4	4285.714286	**4742.857143**	0.27333	**3658.536585**
42	29	4.2	1428.571429			
48	29.6	0.6	10000			
54	31.6	2	3000			
60	32.8	1.2	5000			
66	33.6	0.8				

S-WAVE

0	15.4					
6	21.4	6	1000	**1125**	0.9	**1111.111111**
12	26.2	4.8	1250			
18	29.4	3.2	1875	**2134.259655**	0.38889	**2571.428571**
24	32.6	3.2	1875			
30	36.4	3.8	1578.947368			
36	39.6	3.2	1875			
42	42.4	2.8	2142.857143			
48	42.2	-0.2				
54	44.4	2.2	2727.272727			
60	46.4	2	3000			
66	49.4	3	2000			

Kanouse Road

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	7.8			ft/sec		ft/sec
6	13.4	5.6	1071.428571	**2037.593985**	0.65333	**1530.612245**
12	17.2	3.8	1578.947368			
18	19.6	2.4	2500			
24	21.6	2	3000			
30	22.6	1	6000	**5112.121212**	0.19286	**5185.185185**
36	23.4	0.8	7500			
42	24.2	0.8				
48	26.4	2.2	2727.272727			
54	28.2	1.8	3333.333333			
60	29.2	1	6000			
66	28.2	-1				

S-WAVE

0	18.4					
6	27	8.6	697.6744186	**697.6744186**	1.43333	**697.6744186**
12	32.2	5.2	1153.846154	**2179.806159**	0.53515	**1868.629672**
18	35	2.8	2142.857143			
24	39.4	4.4	1363.636364			
30	43	3.6	1666.666667			
36	47.2	4.2	1428.571429			
42	48.2	1	6000			
48	52	3.8	1578.947368			
54	54.6	2.6	2307.692308			
60	58.8	4.2	1428.571429			
66	61	2.2	2727.272727			

LaRue Road

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	9			ft/sec		ft/sec
6	14.8	5.8	1034.482759	**1034.482759**	0.96667	**1034.482759**
12	15.8	1	6000	**5385.227273**	0.28566	**3500.707214**
18	17.8	2	3000			
24	19.4	1.6	3750			
30	21.4	2	3000			
36	23.8	2.4	2500			
42	24.8	1	6000			
48	28	3.2	1875			
54	28.4	0.4	15000			
60	29	0.6	10000			
66	31.2	2.2	2727.272727			

S-WAVE

0	12.6					
6	26.2	13.6	441.1764706	**441.1764706**	2.26667	**441.1764706**
12	28.2	2				
18	32.2	4	1500	**1943.998323**	0.50808	**1968.190855**
24	35.8	3.6	1666.666667			
30	37.8	2	3000			
36	41.4	3.6	1666.666667			
42	44.8	3.4	1764.705882			
48	48.6	3.8	1578.947368			
54	51.8	3.2	1875			
60	52.8	1				
66	55.2	2.4	2500			

Long Pond

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	8.8			ft/sec		ft/sec
6	11.4	2.6	2307.692308	**2078.754579**	0.5	**2000**
12	13.8	2.4	2500			
18	18	4.2	1428.571429			
24	19.2	1.2	5000	**5002.164502**	0.18571	**5384.615385**
30	20.6	1.4	4285.714286			
36	21.2	0.6	10000			
42	23.2	2	3000			
48	25.4	2.2	2727.272727			
54	25.6	0.2				
60	25.6	0				
66	26.8	1.2	5000			

S-WAVE

0	18.4					
6	31	12.6	476.1904762	**476.1904762**	2.1	**476.1904762**
12	37.4	6.4	937.5	**1289.060578**	0.81838	**1221.920513**
18	42.2	4.8	1250			
24	45.2	3	2000			
30	48.6	3.4	1764.705882			
36	52.8	4.2	1428.571429			
42	58.8	6	1000			
48	67	8.2	731.7073171			
54	72	5	1200			
60	77.6	5.6				
66	78.2	0.6				

McDonald

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	5.85			ft/sec		ft/sec
6	14.9	9.05	662.9834254	**662.9834254**	1.50833	**662.9834254**
12	16.8	1.9	3157.894737	**3600.63822**	0.26738	**3739.982191**
18	18.85	2.05	2926.829268			
24	20.35	1.5	4000			
30	21.8	1.45	4137.931034			
36	23.25	1.45	4137.931034			
42	25.1	1.85	3243.243243			
48	26.2	1.1	5454.545455	**5121.485121**	0.22917	**4363.636364**
54	28.05	1.85	3243.243243			
60	28.95	0.9	6666.666667			
66	29.55					

S-WAVE

0	13.65					
6	17.75	4.1	1463.414634	**3694.40017**	0.265	**3773.584906**
12	19.6	1.85	3243.243243			
18	21.45	1.85	3243.243243			
24	22.55	1.1	5454.545455			
30	23.8	1.25	4800			
36	25.4	1.6	3750			
42	26.9	1.5	4000			
48	29.25	2.35	2553.191489			
54	30.9	1.65	3636.363636			
60	32.15	1.25	4800			
66	32.85					

N. Cove Park

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	9.95			ft/sec		ft/sec
6	13.1	3.15	1904.761905	**2415.795587**	0.34167	**2926.829268**
12	15.15	2.05	2926.829268			
18	16.65	1.5	4000	**4307.692308**	0.21667	**4615.384615**
24	17.95	1.3	4615.384615			
30	18.2	0.25		**7262.040134**	0.14667	**6818.181818**
36	19.25	1.3	9230.769231			
42	20.45	1.2	5000			
48	20.65	0.2				
54	21.7	1.25	9600			
60	22.85	1.15	5217.391304			
66	23.55					

S-WAVE

0	24					
6	32.6	8.6	697.6744186	**805.6613785**	1.20889	**827.2058824**
12	40.8	8.2	731.7073171			
18	48.8	8	750			
24	55.8	7	857.1428571			
30	61.4	5.6	1071.428571			
36	69.2	7.8	769.2307692			
42	75	5.8	1034.482759			
48	83.4	8.4	714.2857143			
54	93	9.6	625			
60	95.8	2.8	2142.857143	**2225.274725**	0.43333	**2307.692308**
66	98.4	2.6	2307.692308			

Oak Ridge

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	3.4			ft/sec		ft/sec
6	13.2	9.8	612.244898	**844.7222733**	1.25333	**797.8723404**
12	20.6	7.4	810.8108108			
18	26	5.4	1111.111111			
24	27.4	1.4	4285.714286	**3576.423576**	0.26984	**3705.882353**
30	29.6	2.2	2727.272727			
36	32.2	2.6	2307.692308			
42	32.2	0				
48	35	2.8	2142.857143			
54	36.2	1.2	5000			
60	37.6	1.4	4285.714286			
66	39	1.4	4285.714286			

S-WAVE

0	19.4					
6	33.4	14	428.5714286	**428.5714286**	2.33333	**428.5714286**
12	36.6	3.2	1875	**1945.153061**	0.41737	**2395.934172**
18	43	6.4	937.5			
24	46.2	3.2	1875			
30	49	2.8	2142.857143			
36	50	1				
42	52	2				
48	54.8	2.8	2142.857143			
54	57.6	2.8	2142.857143			
60	60	2.4	2500			
66	60.8	0.8				

Ryerson

P-WAVE

gp spc	pick	int time	int vel.	**AVG VEL**	SLOPE	**REGRESSION VELOCITY**
0	12			ft/sec		ft/sec
6	15.2	3.2	1875	**2663.003663**	0.37262	**2683.70607**
12	18.4	3.2	1875			
18	21	2.6	2307.692308			
24	23.4	2.4	2500			
30	25.2	1.8	3333.333333			
36	27.2	2	3000			
42	28.8	1.6	3750			
48	29.8	1	6000	**6166.666667**	0.16667	**6000**
54	30.6	0.8	7500			
60	31.8	1.2	5000			
66	32.4					

S-WAVE

0	20					
6	33	13	461.5384615	**562.8412705**	2.10222	**475.6871036**
12	43.4	10.4	576.9230769			
18	49.8	6.4	937.5			
24	64.4	14.6	410.9589041			
30	76.4	12	500			
36	93.6	17.2	348.8372093			
42	111.8	18.2	329.6703297			
48	121.8	10	600			
54	131	9.2	652.173913			
60	138.4	7.4	810.8108108			
66	140.4					

SEISMIC SOIL CLASS MAP
FOR
PASSAIC COUNTY, NEW JERSEY

Prepared by Scott D. Stanford, New Jersey Geological Survey

for the

New Jersey State Police, Office of Emergency Management

2004

Soil Class A--hard rock with less than 10 feet of soil cover. Shear wave velocity greater than 1500 m/s (HAZUS number 1).

Soil Class B--rock with less than 10 feet of soil cover. Shear wave velocity between 760 and 1500 m/s (HAZUS number 2).

Soil Class C--very dense soil and soft rock. Shear wave velocity between 360 and 760 m/s (HAZUS number 3).

Soil Class D--stiff soil. Shear wave velocity between 180 and 360 m/s (HAZUS number 4).

Soil Class E--soft soil. Shear wave velocity less than 180 m/s (HAZUS number 5).

The soil class designations are defined in the 1997 National Earthquake Hazards Reduction Program (NEHRP) Provisions. Soil classes were assigned using Standard Penetration Test data and geologic map data from Stanford (1991, 1992a, 1992b, 1993a, 1993b, 1993c, 2001, 2003) and Stone and others (2002) according to the procedures described in sections 4.1.2.1, 4.1.2.2., and 4.1.2.3 of the NEHRP Provisions (Federal Emergency Management Agency, 1998). Equation 4.1.2.3-2 was used to assign soil class in layered cases.

This map shows the extent of natural soils. Man-made fill overlies these soils (particularly soil class E) over parts of the county. This fill includes a wide range of materials. The behavior of fill during seismic shaking should be assessed on a site-specific basis.

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SCALE 1:48000

2 1 0 2 MILES

2000 0 2000 4000 6000 8000 10,000 12,000 14,000 FEET

2 1 0 2 KILOMETERS

SOIL LIQUEFACTION SUSCEPTIBILITY FOR PASSAIC COUNTY, NEW JERSEY

Prepared by Scott D. Stanford, New Jersey Geological Survey

for the

New Jersey State Police, Office of Emergency Management

- Category 0--none
- Category 1--very low
- Category 2--low
- Category 3--moderate
- Category 4--high

Categories are from the HAZUS User's Manual, Table 9.1 (National Institute of Building Sciences, 1997). Geologic data are from Stanford (1991, 1992a, 1992b, 1993a, 1993b, 1993c, 2001, 2003) and Stone and others (2002).

This map shows the liquefaction susceptiblity of natural soils. Man-made fill overlies these soils (particularly those in Category 4) over parts of the county. While most fill has a low liquefaction susceptiblity, uncompacted sand and silt fill may liquefy. The behavior of fill during seismic shaking should be assessed on a site-specific basis.

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SCALE 1:48000

2 1 0 2 MILES

2000 0 2000 4000 6000 8000 10,000 12,000 14,000 FEET

2 1 0 2 KILOMETERS

LANDSLIDE SUSCEPTIBILITY OF PASSAIC COUNTY, NEW JERSEY

Prepared by Scott D. Stanford, New Jersey Geological Survey
for the
New Jersey State Police, Office of Emergency Management

2004

- None--HAZUS number 0
- Landslide Class A I--strongly cemented rock, slope angle 15-20 degrees (HAZUS number 1)
- Landslide Class A II--strongly cemented rock, slope angle 20-30 degrees (HAZUS number 2)
- Landslide Class A IV--strongly cemented rock, slope angle 30-40 degrees (HAZUS number 5)
- Landslide Class B III--weakly cemented rock and soil, slope angle 10-15 degrees (HAZUS number 3)
- Landslide Class B IV--weakly cemented rock and soil, slope angle 15-20 degrees (HAZUS number 4)
- Landslide Class B V--weakly cemented rock and soil, slope angle 20-30 degrees (HAZUS number 7)

Landslide classes are from the HAZUS User's Manual, Table 9.2 (National Institute of Building Sciences, 1997). Slope angles were measured from the following U. S. Geological Survey 7.5 minute quadrangles: Ramsey, Hackensack, Paterson, Weehawken (all with 10 foot contour interval), and Orange, Wanaque, Newfoundland, Wawayanda, Greenwood Lake, Pompton Plain and Sloatsburg (20 foot contour interval). Slope materials were determined from field mapping (Stanford, 1991, 1992a, 1992b, 1993a, 1993b, 1993c, 2001, 2003; Stone and others, 2002).

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SCALE 1:48000

2 1 0 2 MILES

2000 0 2000 4000 6000 8000 10,000 12,000 14,000 FEET

2 1 0 2 KILOMETERS