EARTHQUAKE LOSS ESTIMATION STUDY
FOR
MORRIS COUNTY, NEW JERSEY:

GEOLOGIC COMPONENT

Prepared for the
New Jersey State Police
Office of Emergency Management

by the
New Jersey Geological Survey

November 2005

CONTENTS

FINAL REPORT

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

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

by
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New Jersey Geological Survey

November 2005

Summary: Geologic, topographic, and test-boring data were acquired and analyzed in order to map seismic soil class, liquefaction susceptibility, and landslide susceptibility for Morris County (maps folded in pocket). The soil class, liquefaction susceptibility, and landslide susceptibility data were entered into the HAZUS earthquake-simulation model for each census tract in the county (Appendix A). The HAZUS model was run with these upgraded geologic data for earthquake magnitudes of 5.5 and 6. As a comparison, the HAZUS model was run with its prepackaged geologic data (referred to henceforth as *default* data) at the same magnitudes. 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 eastern part of the county, where glacial-lake and alluvial soils are more liquefiable, and, in places, more prone to shaking, than the default, and less building damage in most other areas, where till, bedrock, weathered bedrock, and hillslope deposits are stronger than the default and have low liquefaction susceptibility. Landslide susceptibility has no effect on damage at any magnitude at the census-tract level of analysis, but is a potential hazard on certain hillslopes.

In addition to the HAZUS data upgrades and runs, shear-wave velocity was measured on four soil types (weathered gneiss, gneiss colluvium, till of Illinoian age, and till of pre-Illinoian age) 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 Morris County include postglacial, glacial, and hillslope deposits, weathered bedrock, and exposed bedrock with thin or no soil cover (fig. 1). Postglacial deposits are sediments laid down within the past 15,000 years after retreat of the most-recent glacier. They include floodplain alluvium, stream-terrace sand, and peat and organic silt and clay deposited in swamps and marshes. Glacial deposits include till, sand and gravel

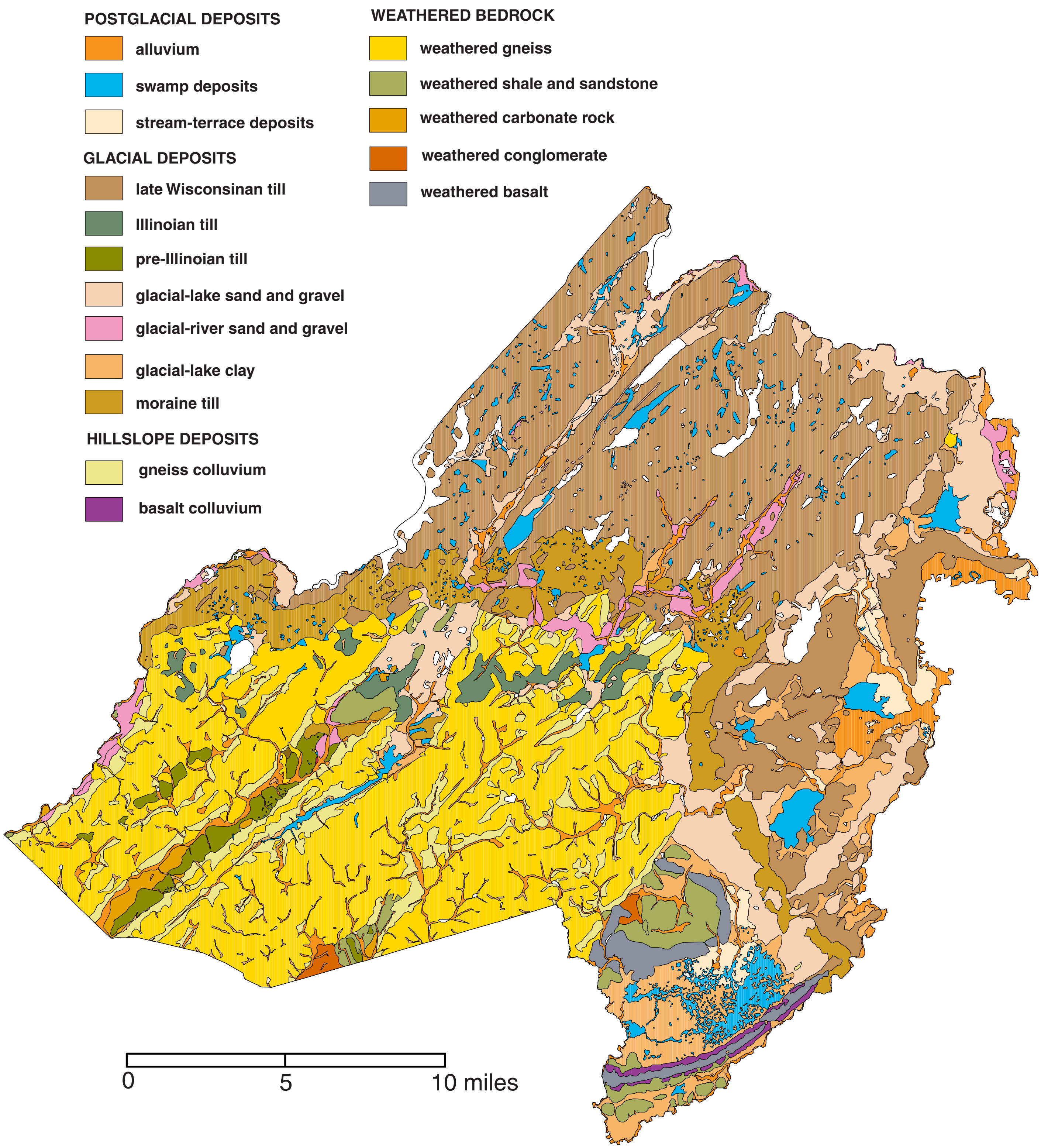

Figure 1. Surficial materials of Morris County. From N. J. Geological Survey digital data.

deposited in glacial lakes and river plains, and silt and clay deposited in glacial lakes. Till is a compact ice-laid sediment consisting of a mix of silt, sand, clay, gravel, and boulders. In Morris County till was deposited during three glaciations: the late Wisconsinan (about 20,000 years ago), Illinoian (about 150,000 years ago) and pre-Illinoian (sometime between 2,000,000 and 800,000 years ago). The distribution and thickness of these materials were mapped between 1983 and 2005 at 1:24,000 scale using stereo-airphoto interpretation, field observations, archival geologic map data on file at the NJGS, and logs of wells and test borings . Geologic-map references are listed on the map sheets (folded in pocket).

Late Wisconsinan till discontinuously veneers the bedrock surface in the northern and eastern parts of the county, and forms a terminal moraine that bisects the county on an east-west line (fig. 1). In the Musconetcong, Rockaway, and Passaic valleys, till overlies glacial-lake sand and gravel that was deposited in front of the advancing glacier, and then overridden by the glacier. These deposits are hereafter referred to as *overrun sand and gravel*. Late Wisconsinan till is as much as 200 feet thick. Illinoian till and pre-Illinoian till occur in patches south of the terminal moraine and are generally less than 25 feet thick. Glacial-lake deposits fill the bottoms of parts of the Passaic, Rockaway, Lamington, Pequannock, and Musconetcong valleys. The lake deposits include sand and gravel as much as 100 feet thick and silt, clay and fine sand as much as 200 feet thick. Glacial-river sand and gravel forms terraces and small plains in the Musconetcong, Rockaway, and Pequannock valleys. The glacial-river deposits are as much as 50 feet thick, and overlie glacial-lake deposits in places. Ridgetops and uplands in the northern half of the county, north of the terminal moraine, were scoured by glacial erosion and have widespread areas of exposed bedrock with little or no soil or glacial-sediment cover.

Hillslope deposits (known as *colluvium*) collect at the foot of steep slopes and are formed by downslope movement of weathered rock (chiefly gneiss and basalt in Morris County) exposed on the slope. They are generally less than 50 feet thick. Weathered bedrock is formed by mechanical and chemical decomposition of bedrock. It ranges from blocky rubble to clayey sand to silty clay, and may be as much as 150 feet thick. Hillslope deposits and weathered bedrock materials cover most of the southwestern part of the county, south of the terminal moraine.

Bedrock includes basalt, sandstone, shale, and conglomerate in the eastern part of the county, and gneiss in most of the rest of the county (fig. 2). Several downfaulted belts of shale, carbonate rock, and quartzite are inset in the gneiss in the western part of the county. Basalt, gneiss, and quartzite are crystalline rocks that are resistant to erosion and are extensively exposed on ridges and uplands, especially north of the terminal moraine. Sandstone, shale, conglomerate, and carbonate rock are more easily eroded. They underlie valleys and are mostly covered by glacial sediment, colluvium, and weathered-rock material.

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 3,521 SPT tests from 496 borings in Morris County were obtained from test-

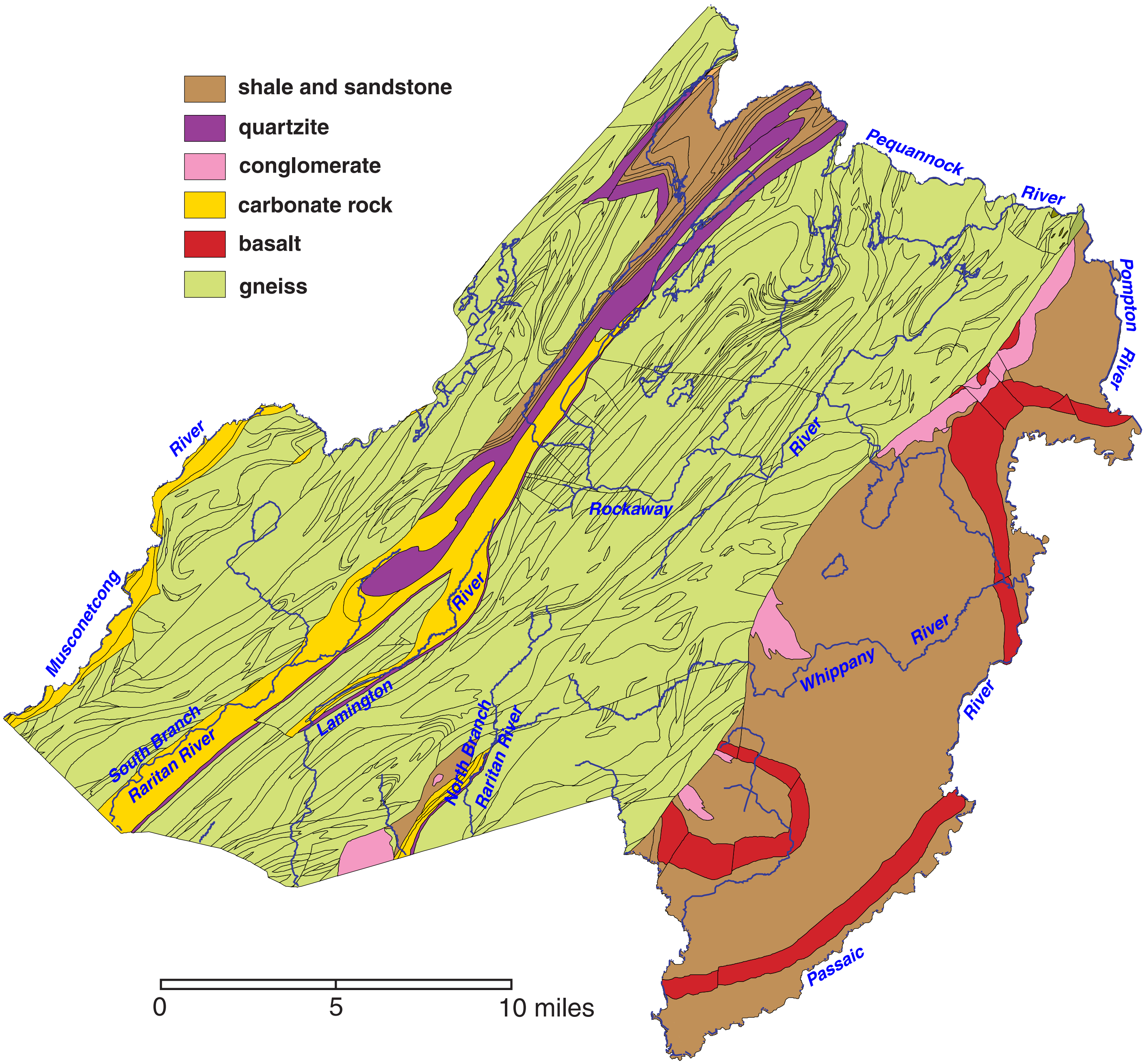

Figure 2. Bedrock and drainage of Morris County. From N. J. Geological Survey digital data.

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 tests; 60 borings, with a total of 688 tests, collected for western Essex County; 193 borings, with a total of 944 tests, collected for Union County; 50 borings, with a total of 234 tests, collected for Bergen County; and 442 borings, with a total of 1,731 tests, collected for Passaic County.

SPT data from the Morris County borings yield means, ranges, and standard deviations that are similar to those from other counties for the same soil types. The only significant discrepancy is weathered shale in Middlesex and Union counties, which yields a mean SPT of 70 and 110, respectively, compared to a mean of 39 for weathered shale in Morris County. The Morris County value is based on only 11 tests; the Middlesex and Union values are based on 179 and 45 tests, respectively. The low number of tests in Morris County likely does not provide a true representation of the soil, and the higher values from Union and Middlesex were used to assign soil class for weathered shale in Morris County.

Penetration tests for late Wisconsinan till in Morris County can be subdivided into three groups: Rahway Till, which is a reddish brown silty till that covers the eastern part of the county; Netcong Till, which is a yellowish brown sandy till covering the northern part of the county; and moraine till, which occurs in the terminal moraine. Netcong Till has a higher mean SPT value than the other groups because it contains more gravel and boulders, which resist the sampling tubes during penetration testing. Moraine till has the lowest mean SPT value because it was deposited along the front of, rather than beneath, the glacier, and so was not compacted by the weight of the overlying glacial ice. Illinoian till has a much lower mean SPT value than the late Wisconsinan tills because it has been exposed to erosion and weathering for much longer. Weathering loosens the original compaction of the till and reduces penetration resistance.

Another example of the compacting effect of the weight of glacial ice is the mean SPT value for overrun sand and gravel. These deposits, which were compacted when the late Wisconsinan glacier overrode them as it advanced to the terminal moraine, have a mean SPT value about 50% greater than the mean SPT value for non-overrun glacial-lake sand and gravel.

Different types of glacial sand and gravel do not show significant differences in penetration resistance. Glacial-lake sand and gravel deposits can be divided into delta deposits, which are predominantly sand, and lacustrine-fan deposits, which are mixed sand and gravel. The additional gravel in the fan deposits yields a slightly higher mean SPT than that for delta deposits (50 vs. 41), but the difference is minor. Glacial-river deposits, which are also mixed sand and gravel, have an SPT distribution nearly identical to delta deposits. Gravel-rich parts of the glacial-lake and glacial-river deposits account for the high end in the SPT distribution, an effect previously documented in the SPT data for Passaic County and shear-wave measurements in Bergen County. Likewise, glacial lake-bottom deposits containing more fine sand and less clay have a slightly higher mean SPT than those that are predominantly silt and clay (21 vs. 17), because sand resists penetration more than does clay.

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

Material	Number of Borings	Number of Tests	Range of SPT Values	Mean ± Standard Deviation	Percentage of tests with blows=0[1]	Percentage of tests refused[2]
fill	102	266	1-115	17±17	0	0
alluvium	20	59	1-76	21±17	0	0
stream-terrace sand	25	111	2-92	20±15	0	0
swamp deposits	22	53	0-31	4±5	11	0
glacial-lake silt and clay	63	383	0-190	17±18	6	0
glacial-lake silt and fine sand	28	121	7-57	21±8	0	0
glacial-lake sand and gravel--deltaic deposits	60	525	3-168	41±29	0	6
glacial-lake sand and gravel--lacustrine-fan deposits	10	95	8-156	50±26	0	2
overrun glacial sand and gravel	27	127	14-165	66±33	0	2
glacial-river sand and gravel	45	129	3-210	40±34	0	6
late Wisconsinan till, combined Rahway+Netcong	181	1078	1-640	97±75	0	12
late Wisconsinan till--Rahway Till	81	439	10-305	76±53	0	25
late Wisconsinan till--Netcong Till	100	639	1-640	108±81	0	3
late Wisconsinan till--moraine till	69	178	2-300	56±51	0	0.6
Illinoian till	15	62	3-175	28±40	0	8
weathered gneiss	29	116	4-161	35±34	0	5

weathered carbonate rock	48	382	0-180	37±34	0.3	4
weathered shale	7	11	20-59	39±14	0	0
gneiss colluvium	32	170	1-135	33±23	0	2

[1] For these tests, the sampling tube was advanced 12 inches by the weight of the hammer or the weight of the drill rods alone, with no blows on the hammer.

[2] For these tests, the sampling tube failed to advance 6 inches after 100 blows of the hammer. In some tests, hammering continued past 100 blows until the tube was advanced 6 inches. In these cases, the full blow count was included in the data set even if it exceeded 100 blows per 6 inches.

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, as determined by geologic mapping and records of test borings and water wells, 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 SPT and shear-wave properties of the soil and rock layers to a depth of 100 feet.

In most of the county, the upper 100 feet includes some thickness of unweathered bedrock. To calculate soil class in these cases, an average shear-wave velocity of 5500 feet per second for basalt, gneiss, quartzite, and carbonate rock, and of 2300 feet per second for shale, sandstone, and conglomerate, was applied to the thickness of the bedrock column. These velocities are low-end estimates for shallow bedrock based on P-wave velocities measured by seismic refraction surveys in the Morris County area conducted in the course of groundwater-resource studies in the 1980s (Canace and others, 1983, 1993), and on direct measurements of shear-wave velocity on similar rock types in the Los Angeles area (Fumal and Tinsley, 1985).

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 stream-terrace 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 Morris County were calculated from 1:24,000 topographic maps with 20-foot contour interval and slope materials were determined in the field (data sources are listed on the landslide map, folded in pocket). 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 quartzite, gneiss, and basalt bedrock and till north of the terminal moraine, steep slopes on weathered gneiss and basalt south of the terminal moraine, and a few steep slopes cut into glacial deposits by postglacial river erosion in the Pequannock, Passaic, Rockaway, and Whippany valleys, and by cuts for roads and railroads.

Shear-wave Velocity Measurements: To test the accuracy of using SPT tests as a proxy for shear-wave velocity, and to obtain data for deposits lacking SPT tests, seismic velocities were collected at twelve sites in Morris County. The tested soil types include weathered gneiss (3 sites), gneiss colluvium (3 sites), Illinoian till (3 sites), and pre-Illinoian 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, holes were hand-augered or dug to test for soil disturbance and fill. The seismic data were collected using a Bison 9000 digital engineering seismograph. Both shear (S) 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 at five of the twelve sites 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. At one site (Thomasville Road) the P wave data also record a high-velocity lowermost layer that most likely is unweathered bedrock.

To measure the P and S velocities, twelve P-wave geophones and twelve S-wave geophones were planted along the survey line with a 6-foot spacing. The source was located 6 feet from the first geophone. For the S-wave measurement, each geophone was oriented with its axis of movement parallel to the generating source. The S-wave 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.

For the P-wave measurement, 8-hertz geophones were used. A 10-pound sledgehammer and a strike plate are used as a source.

The first seismic break on the raw records from both the S and P data is picked for each geophone and marks the arrival of the wave at the geophone. 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 five of the twelve sites the shear-wave measurements record a low-velocity layer overlying a higher-velocity layer (Table 2). Three of these five sites (Black River 1, Black River 2, Tiger Brook) are in weathered gneiss, where the weathered-rock material grades downward from loose surface soil into increasingly compact weathered rock, then into unweathered rock. This transition produces an increasing shear-wave velocity with depth, as reflected in the layer velocities. At the Raritan site, layer 1 is colluvium and layer 2 may be slightly weathered carbonate rock or gneiss underlying the colluvium. Similarly, at the DMV site, layer 1 is Illinoian till and layer 2 may be slightly weathered gneiss underlying the till.

Table 2 shows that eight of the twelve velocity measurements fall within the range predicted from the county-wide SPT data for the layer in question. Two of the four discrepancies (Black River 1 and Reger Road) are slightly higher than the predicted range; the other two (James Andrews and Fairview Avenue) exceed the predicted range by about 200 feet per second. Colluvium and weathered gneiss that contain abundant gravel- and boulder-size fragments of unweathered rock will have a higher shear-wave velocity than soil with few such fragments. This factor accounts for the greater-than-predicted velocities at the Black River 1, James Andrews, and Fairview Avenue sites. The Reger Road site is in Illinoian till. The slightly greater-than-predicted velocity here may be due to an abundance of cobbles in the till, or to the presence of partially weathered carbonate rock at shallow depth at the test site. This latter possibility is suggested by higher interval velocities at the distant geophones (Appendix L).

No SPT data are available for pre-Illinoian till. Pre-Illinoian till is similar in composition and compaction to Illinoian till, based on field observations, and so a similar shear-wave velocity range is expected. The three measured velocities support this expectation.

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
Black River 1	40E48'25"; 74E39'45"	weathered gneiss	1279 (layer 1) 1801 (layer 2)	600-1200 (layer 1)	slightly greater than predicted
Black River 2	40E49'15"; 74E37'58"	weathered gneiss	805 (layer 1) 2135 (layer 2)	600-1200 (layer 1)	agrees
Tiger Brook	40E46'24"; 74E41'13"	weathered gneiss	1034 (layer 1) 2091 (layer 2)	600-1200 (layer 1)	agrees
James Andrews	40E50'01"; 74E33'39"	gneiss colluvium	1485	600-1200	greater than predicted
Raritan	40E48'56"; 74E43'45"	gneiss colluvium	795 (layer 1) 2995 (layer 2)	600-1200 (layer 1)	agrees
Fairview Avenue	40E47'40"; 74E46'15"	gneiss colluvium	1445	600-1200	greater than predicted
Reger Road	40E50'14"; 74E40'40"	Illinoian till	1291	600-1200	slightly greater than predicted
DMV	40E51'52"; 74E36'38"	Illinoian till	930 (layer 1) 1836 (layer 2)	600-1200 (layer 1)	agrees

Thomastown Road	41E51'56"; 74E42'43"	Illinoian till	970	600-1200	agrees
Toys R Us	40E49'23"; 74E42'43"	pre-Illinoian till	1009	no SPT data, similar to Illinoian till	agrees
Flocktown Road	40E49'27"; 74E46'24"	pre-Illinoian till	1063	do.	agrees
Rock Road	40E48'23"; 74E47'51"	pre-Illinoian till	1119	do.	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 provided with the HAZUS model. 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 data fields for soil type, liquefaction susceptibility, and landslide susceptibility in the HAZUS model 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.

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	-	-	-	0.5-2.1	0-2	600-2000	-	-	-
5.5	1.1-4.4	1-3	900-4000	1.6-6.4	2-10	3000-11,000	1.6-6.4	2-10	3000-11,000
6.0	3.0-11.9	6-30	4000-17,000	3.5-14.0	7-30	6000-25,000	3.5-14.0	7-30	6000-25,000
6.5	-	-	-	6.1-24.4	14-60	11,000-44,000	-	-	-
7.0	-	-	-	9.0-36.2	20-90	17,000-68,000	9.0-36.2	20-90	17,000-68,000

Evaluation of Simulations: The upgraded geologic data produced increased damage estimates for census tracts on vulnerable soils in the Passaic, Whippany, and Pompton River valleys in the eastern part of the county, and in a few places in the Rockaway 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, in places, of weaker soil class than the default, and the compact till, weathered rock, and colluvial soils 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, weathered rock, and colluvium (soil class C) rather than the default class of D show up to 20% fewer buildings experiencing moderate-or-greater damage.

Landslide hazard has no discernable impact on building damage or economic loss. None of the census tracts in Morris County were judged to have a landslide susceptibility of HAZUS class 4 or greater, although there are a few hillslopes in the county of susceptibility classes 4, 5, and 7 (see map folded in pocket). In Passaic County, tracts of landslide susceptibility class 4 showed, at magnitude 7.0, 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 a potential but 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.

References Cited (additional references listed on map plates)

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Canace, R., Stanford, S. D., and Hall, D. W., 1993, Hydrogeologic framework of the middle and lower Rockaway River basin, Morris County, New Jersey: N. J. Geological Survey Report 33, 68 p.

Fumal, T. E., and Tinsley, J. C., 1985, Mapping shear-wave velocities of near-surface geologic materials, *in* Ziony, J. I., ed., Evaluating earthquake hazards in the Los Angeles region--an earth-science perspective: U. S. Geological Survey Professional Paper 1360, p. 127-149.

APPENDIX A

Maps of Morris 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

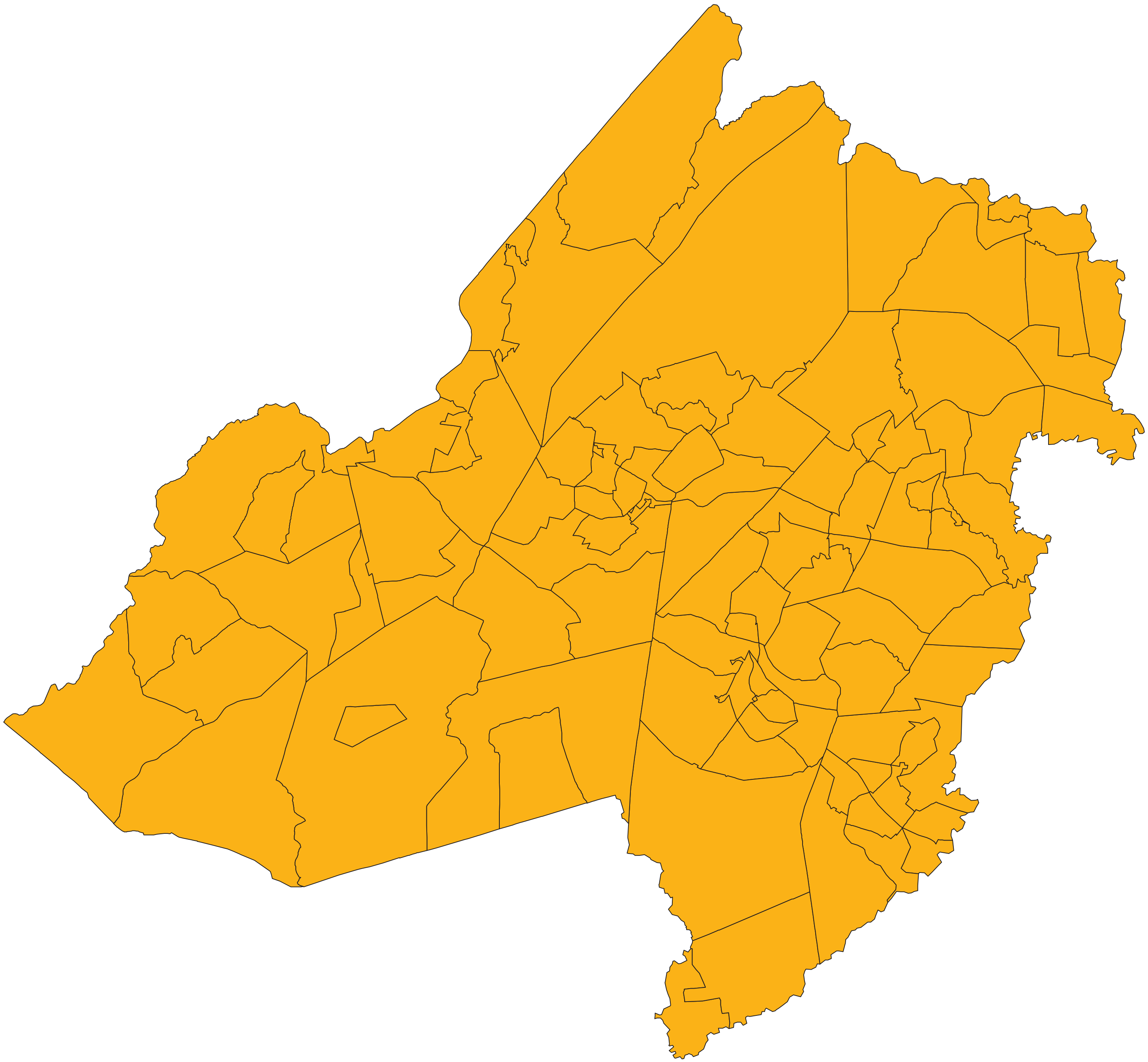
Study Region:
Morris County

Study Region Epicenter

^ **Epicenter (Arbitrary)**
74.59 degrees longitude
40.87 degrees latitude

NEW JERSEY GEOLOGICAL SURVEY
1835

Data from the HAZUS-MH MR1 GIS software.
August 1, 2005

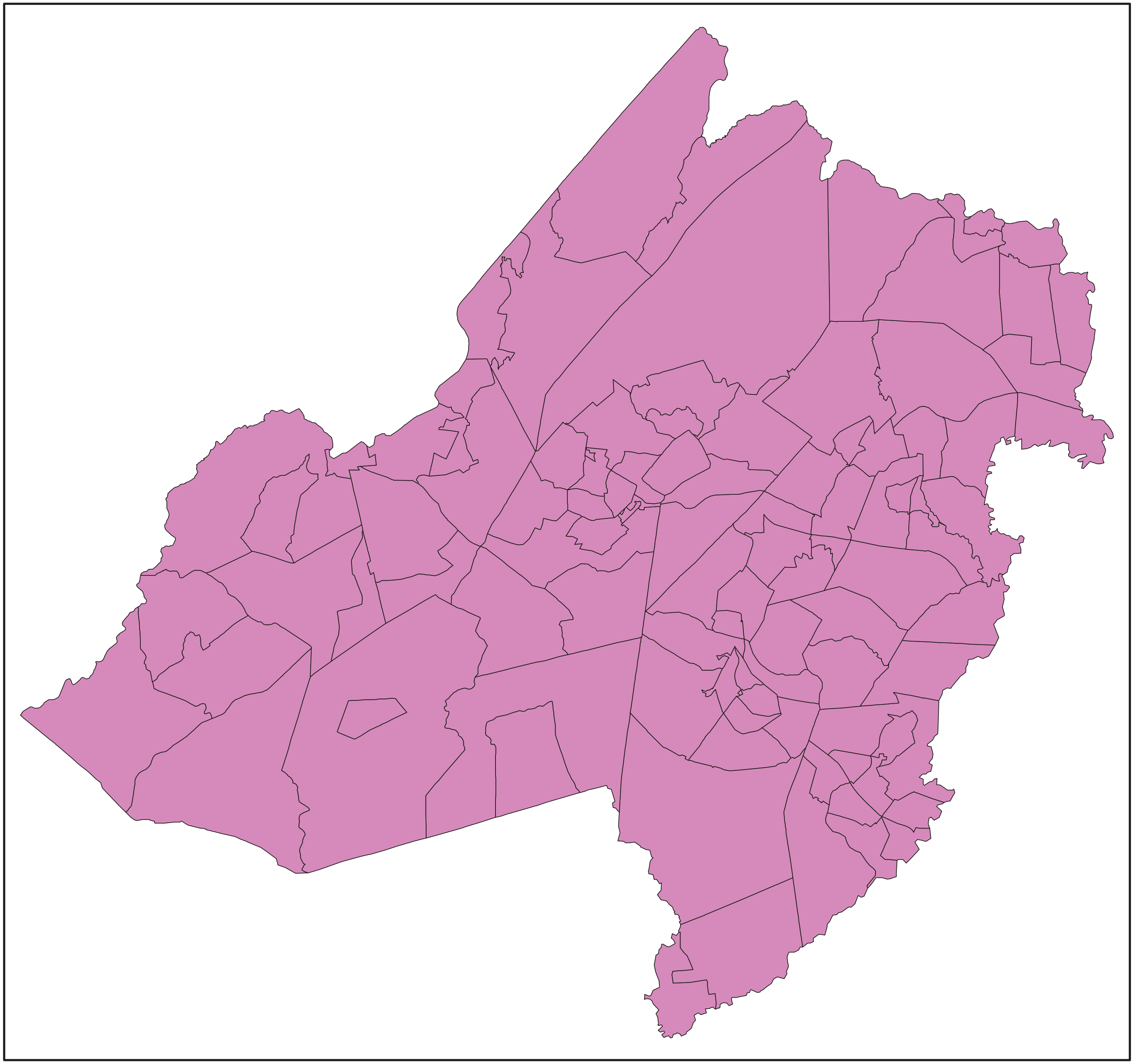


Study Region:
Morris County
Default Soils Map

Soil Type

Class D

Data from the HAZUS-MH MR1 GIS software.
August 1, 2005



Study Region:

Morris County

Default Liquefaction Map

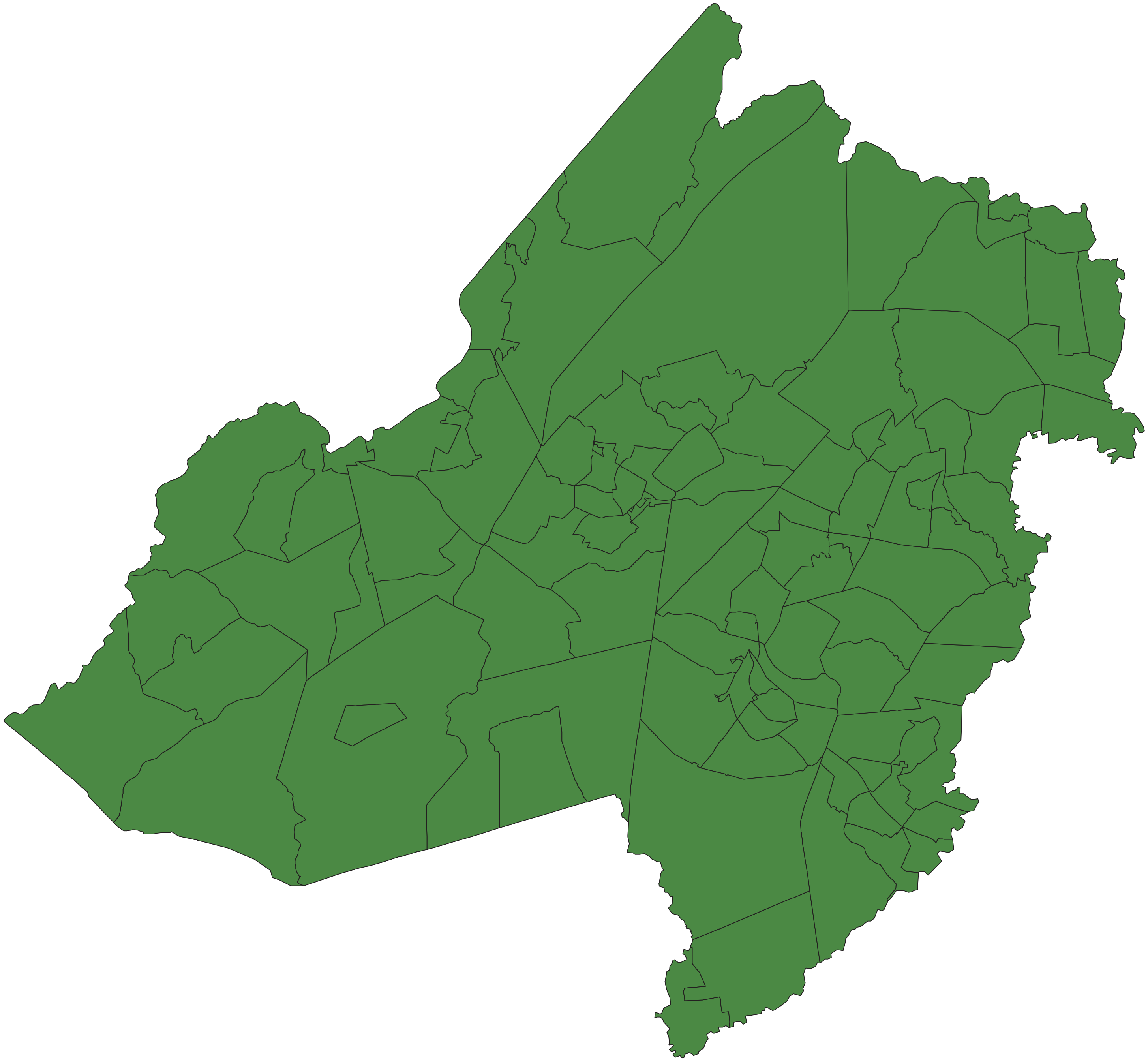
Liquefaction Susceptibility

None

Data from the HAZUS-MH MR1 GIS software
August 1, 2005

Study Region:
Morris County

Default Landslide Map

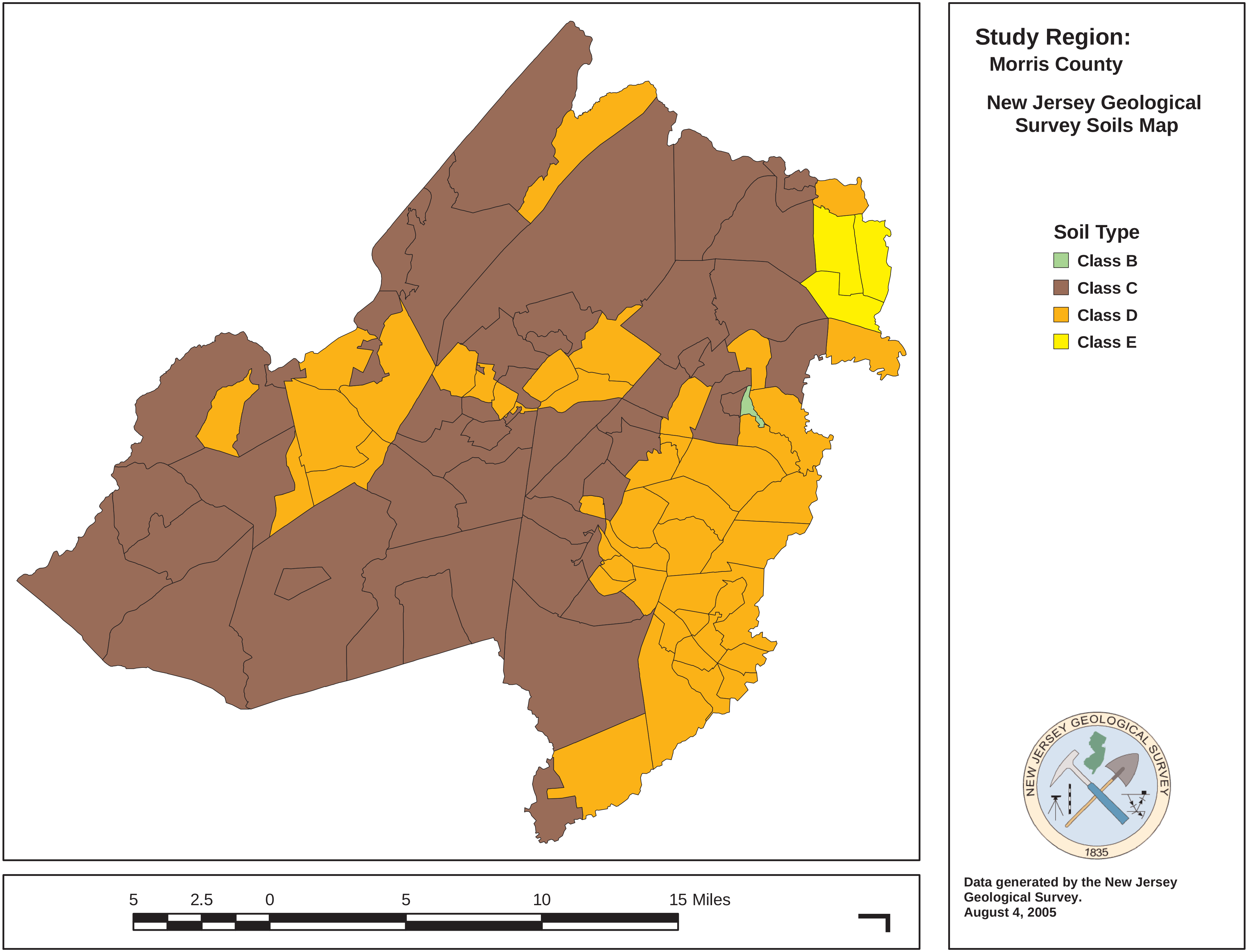


Landslide Susceptibility

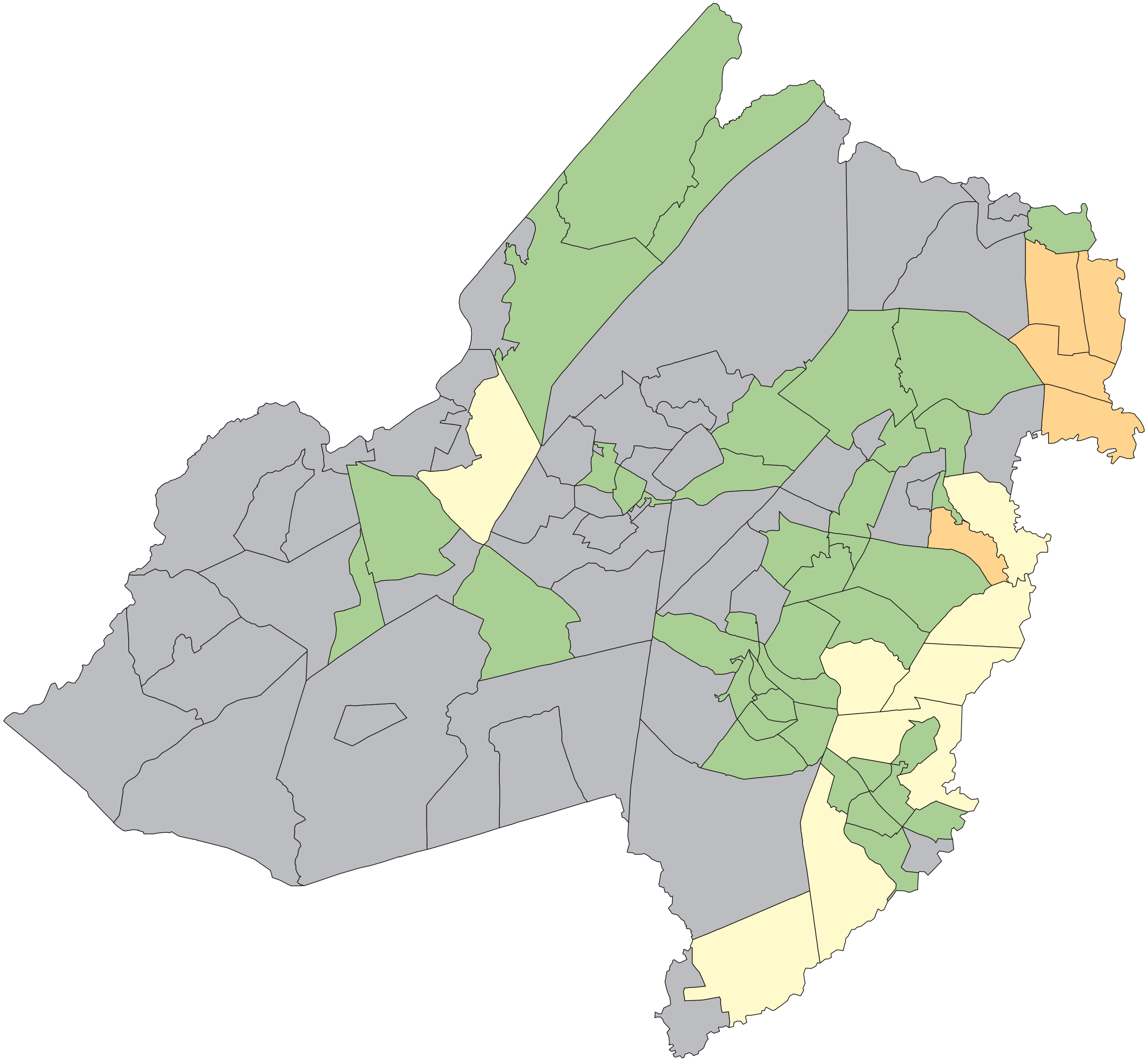
None

5 2.5 0 5 10 15 Miles

Data from the HAZUS-MH MR1 GIS software.
August 1, 2005



Data generated by the New Jersey Geological Survey.
August 4, 2005



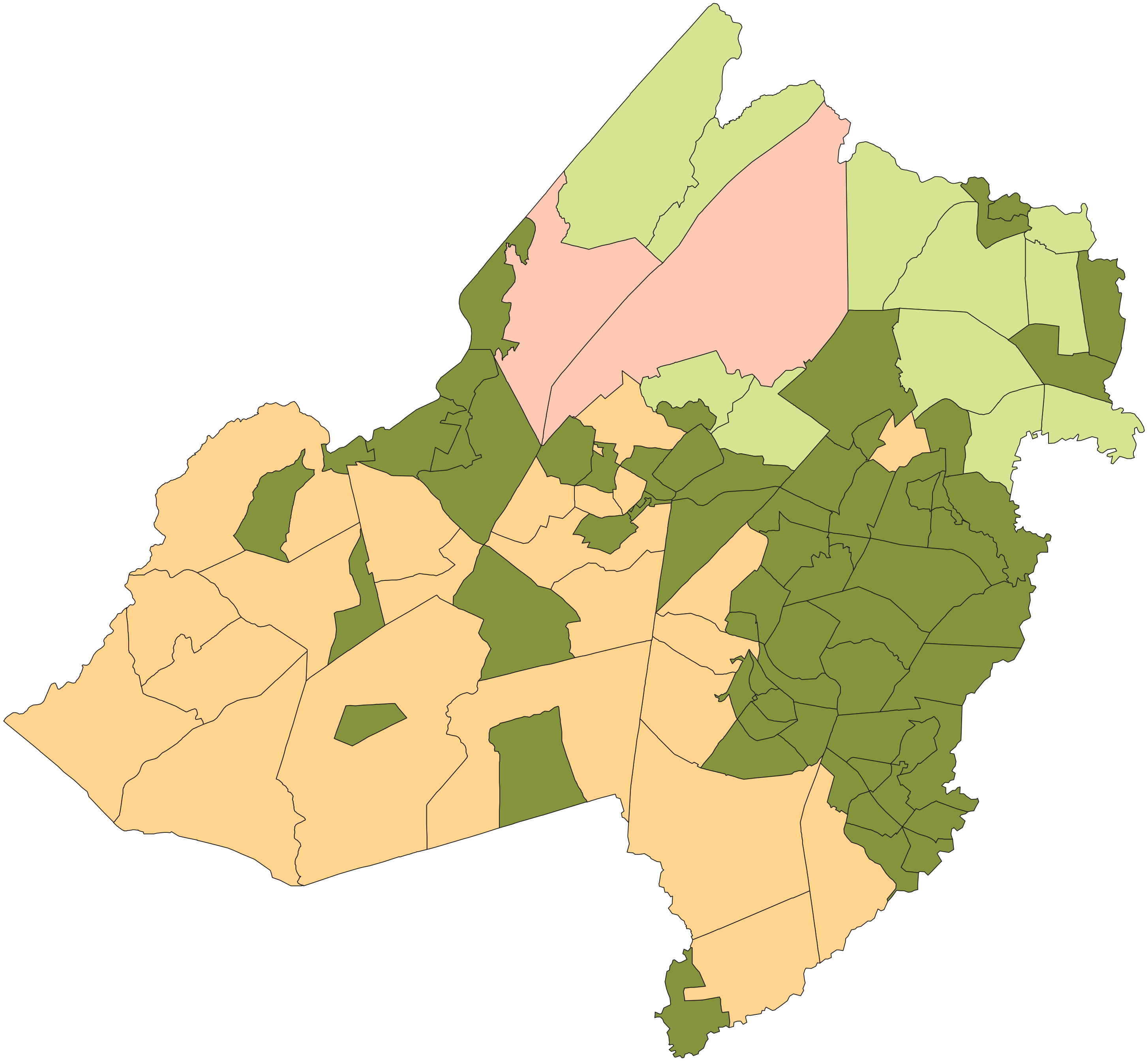
Study Region:
Morris County

New Jersey Geological Survey Liquefaction Map

Liquefaction Susceptibility

- Very Low (Class 1)
- Low (Class 2)
- Moderate (Class 3)
- High (Class 4)

Data generated by the New Jersey Geological Survey.
August 4, 2005



5 2.5 0 5 10 15 Miles

Study Region:

Morris County

New Jersey Geological Survey Landslide Map

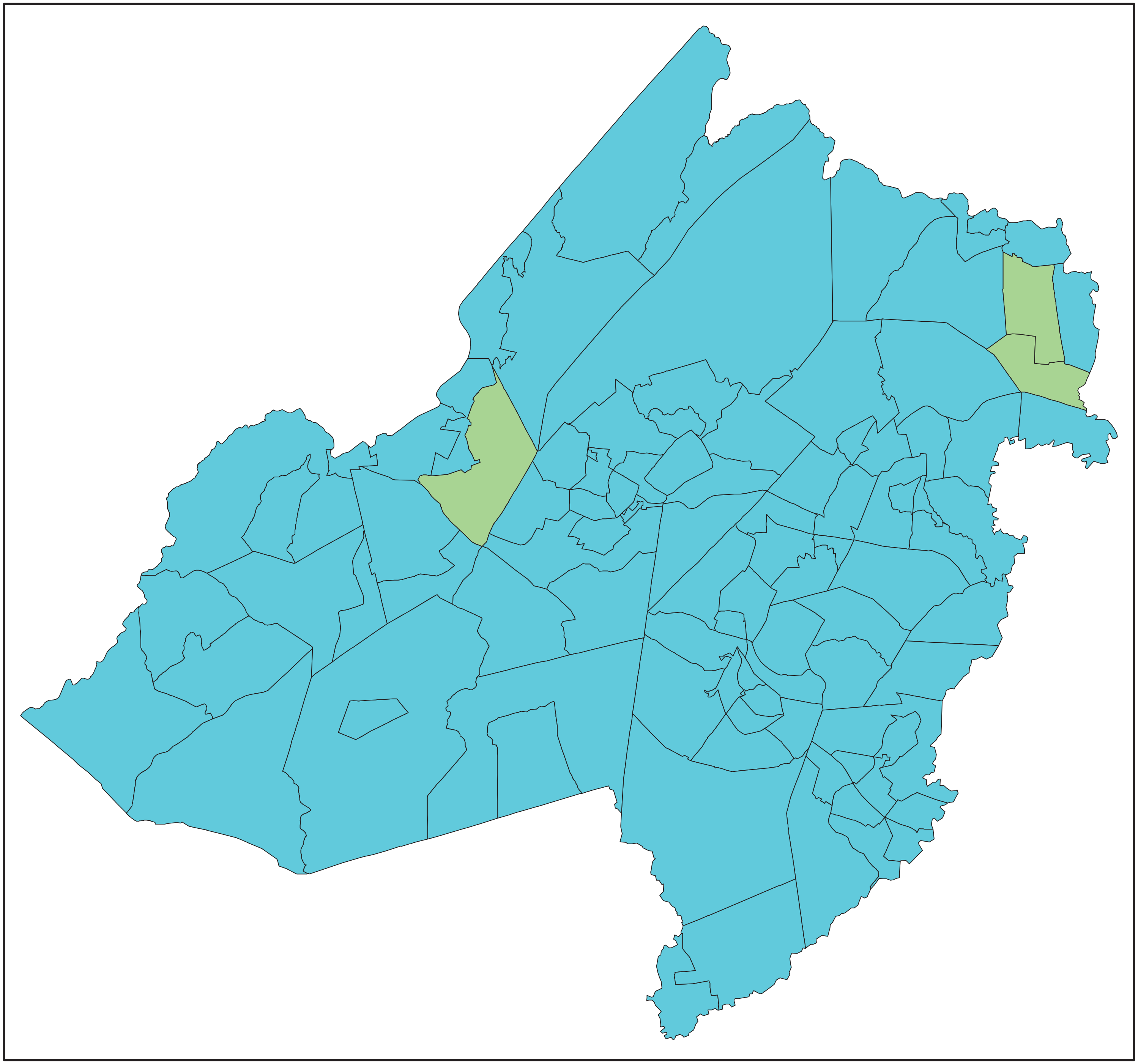
Landslide Susceptibility

- None (Class 0)
- Very Low (Class 1)
- Low (Class 2)
- Moderate (Class 3)

Data generated by the New Jersey Geological Survey.
August 4, 2005

APPENDIX B

Magnitude 5 with full upgraded geology



Study Region:
Morris 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

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey August 8, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.30 - 1.30
	Building Contents	0.00 - 0.10
	Business Interruption	0.00 - 0.10
Infrastructure	Lifelines Damage	
	Total	0.50 - 2.10

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	3 - 15	< 1.0	< 1.0	3 - 15
Major	0 - 2	< 1.0	< 1.0	0 - 2
Total	4 - 17	< 1.0	< 1.0	4 - 18

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	130 - 500
Level 2	Hospital Care	30 - 120
Level 3	Life-threatening	< 20
Level 4	Fatalities	< 20

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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 0.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Time of report: August 08, 2005 10:01 am

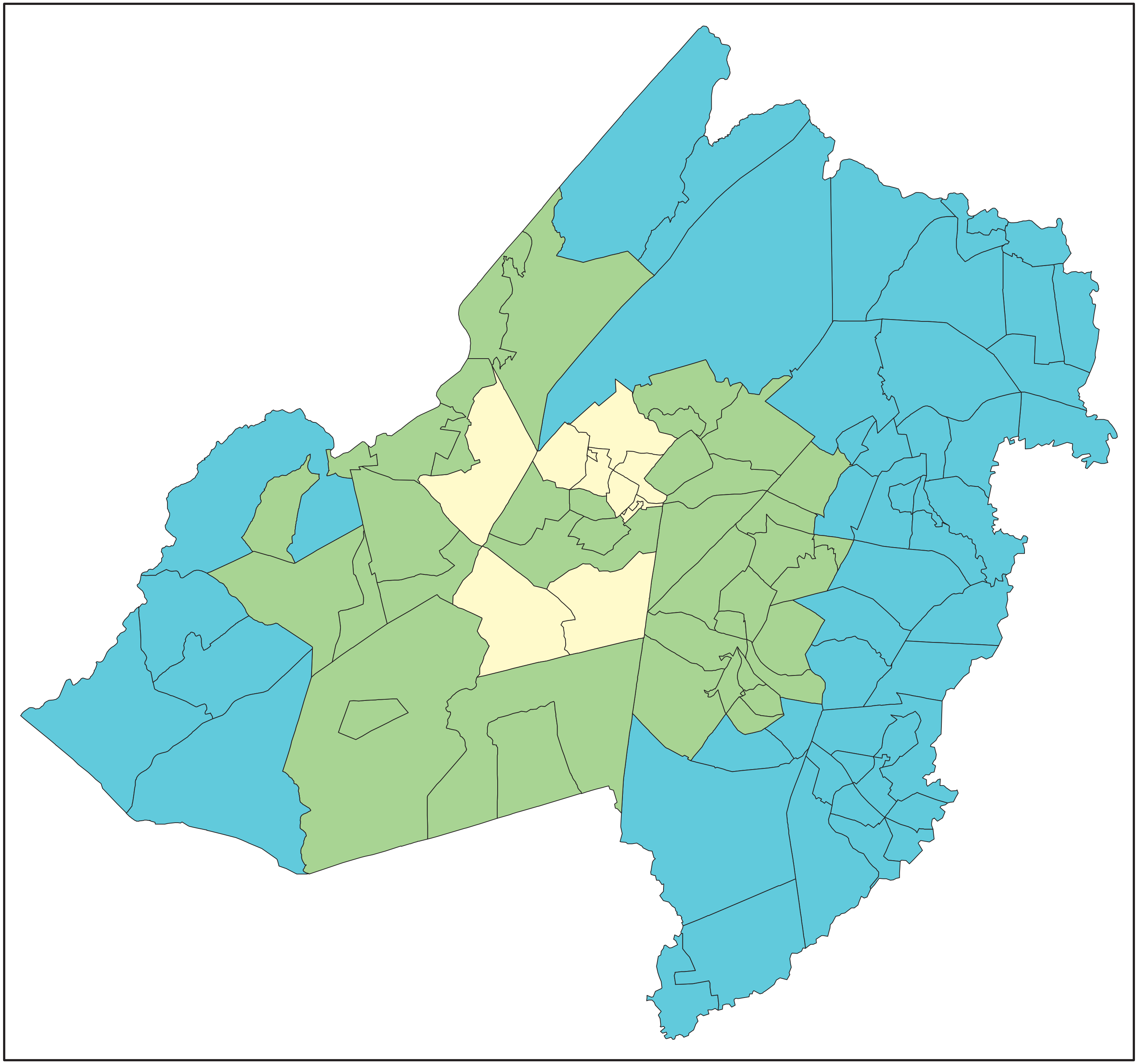
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*12*	*1*	*0*	*0*	*0*	*13*
Commercial	*1,986*	*150*	*70*	*18*	*20*	*2,243*
Education	*7*	*1*	*0*	*0*	*0*	*8*
Government	*52*	*3*	*1*	*0*	*0*	*57*
Industrial	*404*	*28*	*13*	*3*	*3*	*451*
Religion	*89*	*6*	*3*	*1*	*1*	*99*
Other Residential	*5,604*	*403*	*161*	*37*	*34*	*6,239*
Single Family	*122,631*	*5,603*	*1,429*	*476*	*726*	*130,866*
Total State	**130,785**	**6,195**	**1,677**	**535**	**784**	**139,976**
Study region	**130,785**	**6,195**	**1,677**	**535**	**784**	**139,976**

APPENDIX C

Magnitude 5.5 with default geology



Study Region:
Morris 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

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH MR1 GIS software.
August 3, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	0.70 - 2.90
	Building Contents	0.10 - 0.20
	Business Interruption	0.10 - 0.30
Infrastructure	Lifelines Damage	
	Total	1.10 - 4.40

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	20 - 90	0 - 1	< 1.0	20 - 90
Major	1 - 5	< 1.0	< 1.0	1 - 5
Total	20 - 90	0 - 1	< 1.0	20 - 100

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	200 - 900
Level 2	Hospital Care	40 - 160
Level 3	Life-threatening	< 20
Level 4	Fatalities	10 - 30

Estimated Shelter Needs

Type	Households	People
Displaced Households	900 - 4,000	
Public Shelter		180 - 700

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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

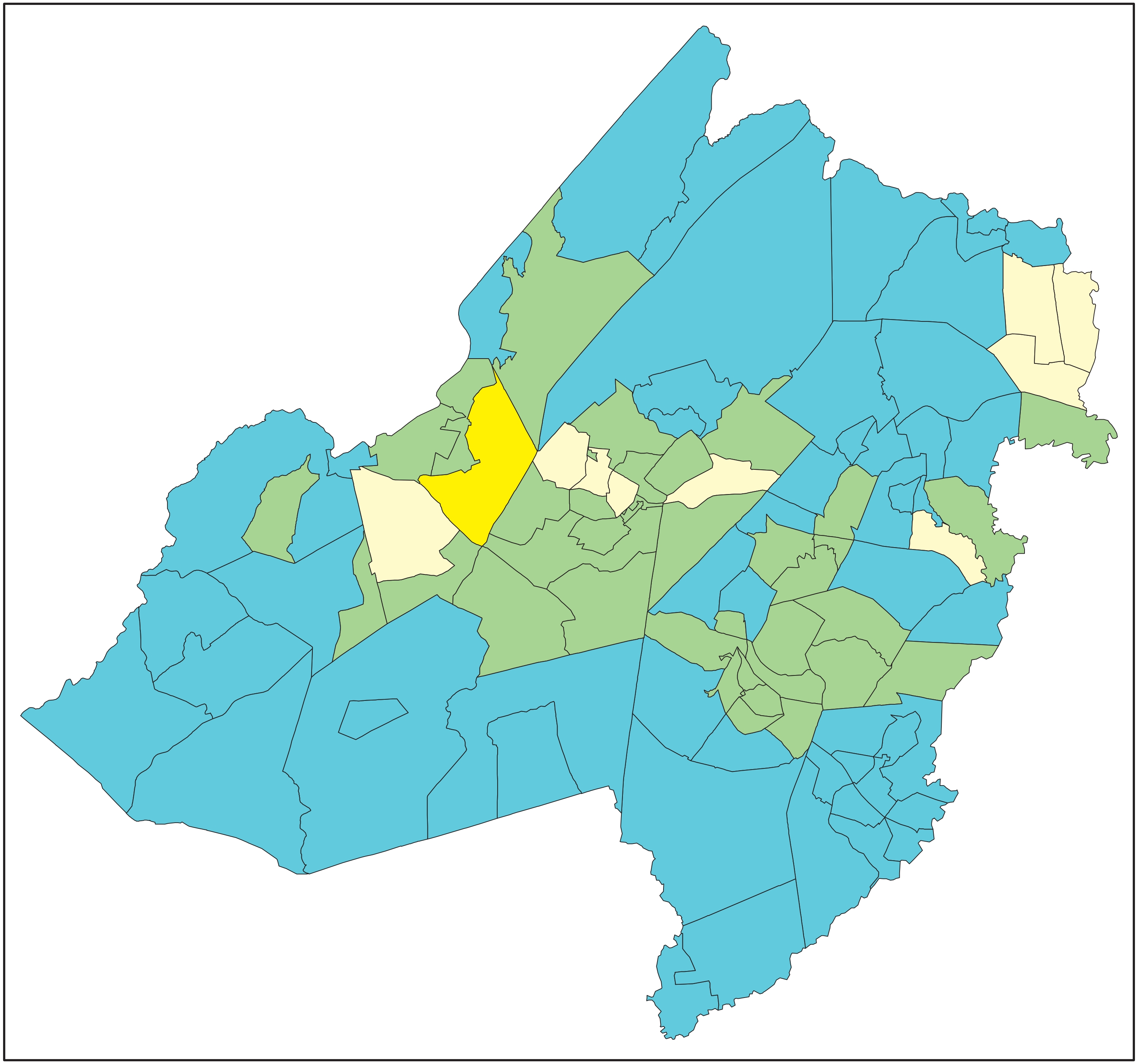
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*9*	*2*	*1*	*0*	*0*	*13*
Commercial	*1,439*	*402*	*300*	*87*	*15*	*2,243*
Education	*5*	*1*	*1*	*0*	*0*	*8*
Government	*37*	*10*	*8*	*2*	*0*	*57*
Industrial	*302*	*73*	*58*	*16*	*2*	*451*
Religion	*60*	*20*	*14*	*4*	*1*	*99*
Other Residential	*3,830*	*1,366*	*808*	*200*	*35*	*6,239*
Single Family	*86,513*	*29,857*	*11,917*	*2,190*	*389*	*130,866*
Total State	**92,196**	**31,732**	**13,106**	**2,500**	**442**	**139,976**
Study region	**92,196**	**31,732**	**13,106**	**2,500**	**442**	**139,976**

APPENDIX D

Magnitude 5.5 with full upgraded geology



5 2.5 0 5 10 15 Miles

Study Region:
Morris 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

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey
August 8, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	1.10 - 4.20
	Building Contents	0.10 - 0.30
	Business Interruption	0.10 - 0.50
Infrastructure	Lifelines Damage	
	Total	1.60 - 6.40

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	17 - 70	0 - 1	< 1.0	17 - 70
Major	2 - 10	< 1.0	< 1.0	2 - 10
Total	20 - 80	0 - 1	< 1.0	20 - 80

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	600 - 2,000
Level 2	Hospital Care	140 - 600
Level 3	Life-threatening	10 - 60
Level 4	Fatalities	30 - 110

Estimated Shelter Needs

Type	Households	People
Displaced Households	3,000 - 11,000	
Public Shelter		500 - 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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Building Damage by Count by General Occupancy

August 08, 2005

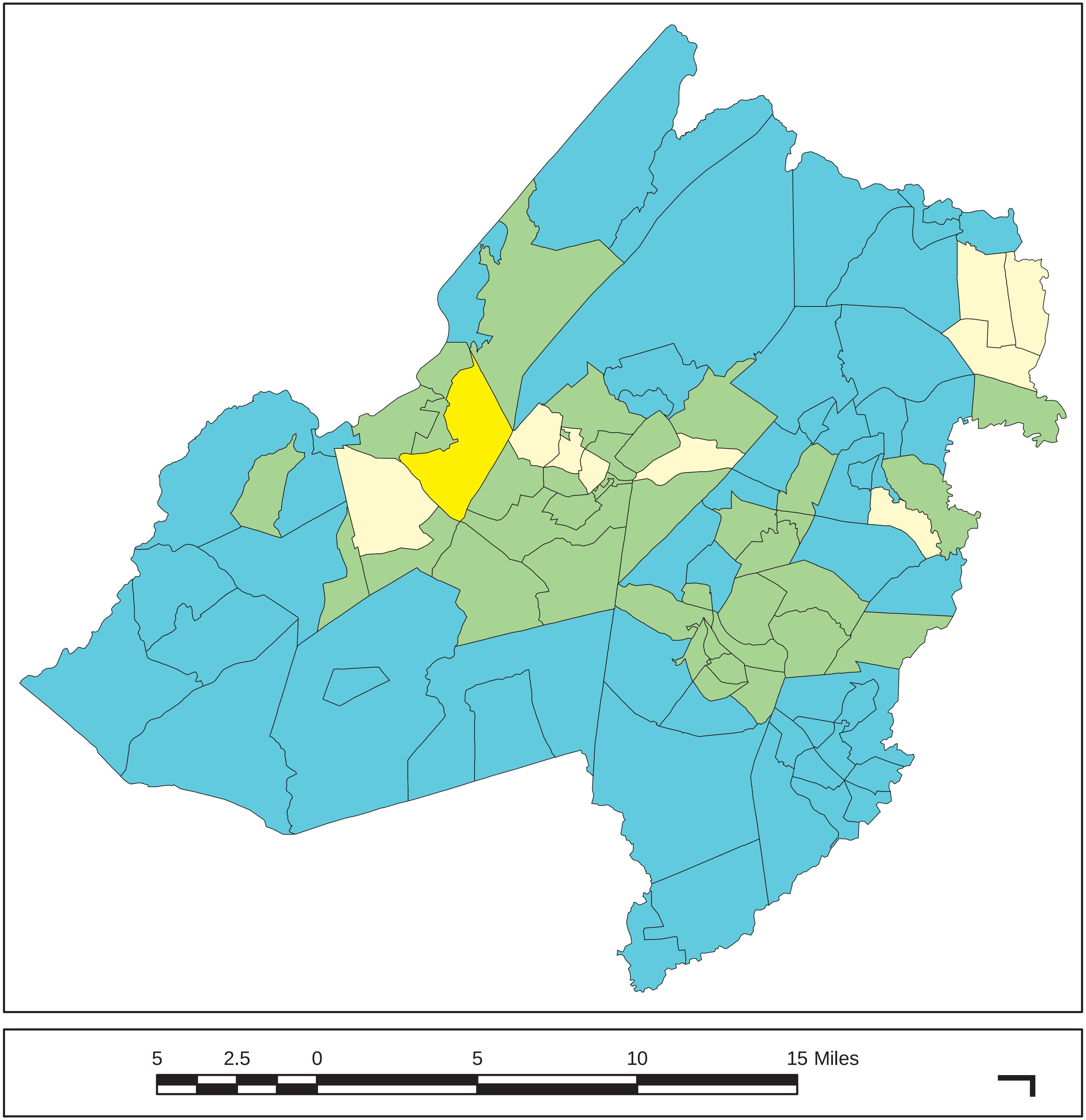
	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*10*	*2*	*1*	*0*	*0*	*13*
Commercial	*1,468*	*362*	*256*	*75*	*82*	*2,243*
Education	*5*	*1*	*1*	*0*	*0*	*8*
Government	*40*	*8*	*6*	*1*	*1*	*57*
Industrial	*304*	*67*	*51*	*15*	*15*	*451*
Religion	*64*	*18*	*11*	*3*	*3*	*99*
Other Residential	*4,053*	*1,197*	*665*	*165*	*159*	*6,239*
Single Family	*92,817*	*24,362*	*8,749*	*1,711*	*3,227*	*130,866*
Total State	**98,760**	**26,018**	**9,740**	**1,972**	**3,486**	**139,976**
Study region	**98,760**	**26,018**	**9,740**	**1,972**	**3,486**	**139,976**

APPENDIX E

Magnitude 5.5 with no landslide hazard

Study Region:
Morris 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

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey
August 9, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	1.10 - 4.20
	Building Contents	0.10 - 0.30
	Business Interruption	0.10 - 0.50
Infrastructure	Lifelines Damage	
	Total	1.60 - 6.40

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	17 - 70	0 - 1	< 1.0	17 - 70
Major	2 - 10	< 1.0	< 1.0	2 - 10
Total	20 - 80	0 - 1	< 1.0	20 - 80

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	600 - 2,000
Level 2	Hospital Care	140 - 600
Level 3	Life-threatening	10 - 60
Level 4	Fatalities	30 - 110

Estimated Shelter Needs

Type	Households	People
Displaced Households	3,000 - 11,000	
Public Shelter		500 - 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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Time of report: August 08, 2005 3:05 pm

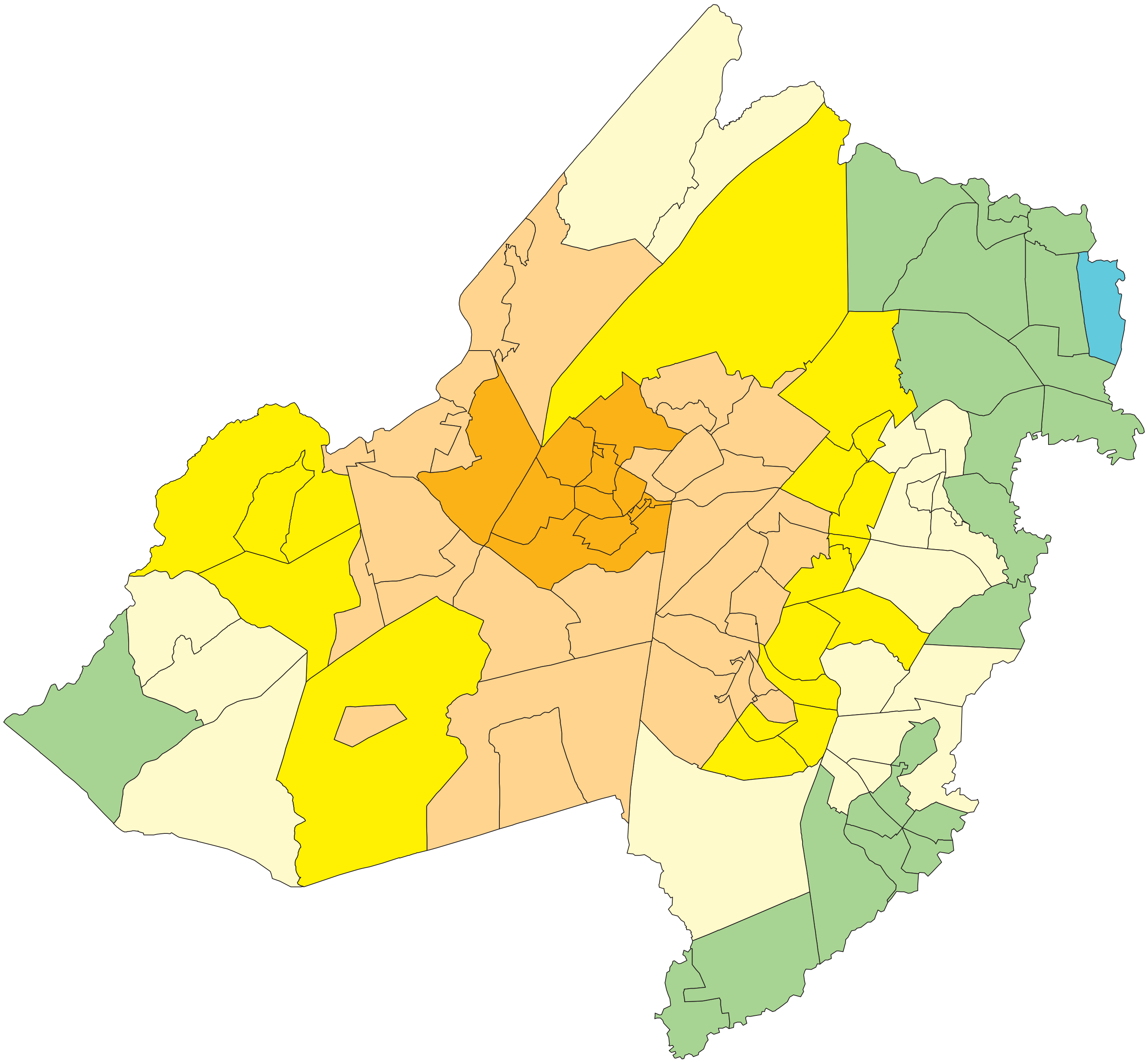
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*10*	*2*	*1*	*0*	*0*	*13*
Commercial	*1,468*	*362*	*256*	*75*	*82*	*2,243*
Education	*5*	*1*	*1*	*0*	*0*	*8*
Government	*40*	*8*	*6*	*1*	*1*	*57*
Industrial	*304*	*67*	*51*	*15*	*15*	*451*
Religion	*64*	*18*	*11*	*3*	*3*	*99*
Other Residential	*4,053*	*1,197*	*665*	*165*	*159*	*6,239*
Single Family	*92,817*	*24,362*	*8,749*	*1,711*	*3,227*	*130,866*
Total State	**98,760**	**26,018**	**9,740**	**1,972**	**3,486**	**139,976**
Study region	**98,760**	**26,018**	**9,740**	**1,972**	**3,486**	**139,976**

APPENDIX F

Magnitude 6 with default geology



5 2.5 0 5 10 15 Miles

Study Region:
Morris 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

Data from the HAZUS-MH MR1 GIS software.
August 4, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	2.00 - 8.10
	Building Contents	0.10 - 0.50
	Business Interruption	0.30 - 1.20
Infrastructure	Lifelines Damage	
	Total	3.00 - 11.90

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	40 - 150	0 - 2	< 1.0	40 - 160
Major	6 - 20	0 - 1	< 1.0	6 - 30
Total	40 - 180	0 - 3	< 1.0	50 - 180

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	1,000 - 4,000
Level 2	Hospital Care	200 - 800
Level 3	Life-threatening	30 - 110
Level 4	Fatalities	50 - 200

Estimated Shelter Needs

Type	Households	People
Displaced Households	4,000 - 17,000	
Public Shelter		900 - 3,000

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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Time of report: August 08, 2005 9:21 am

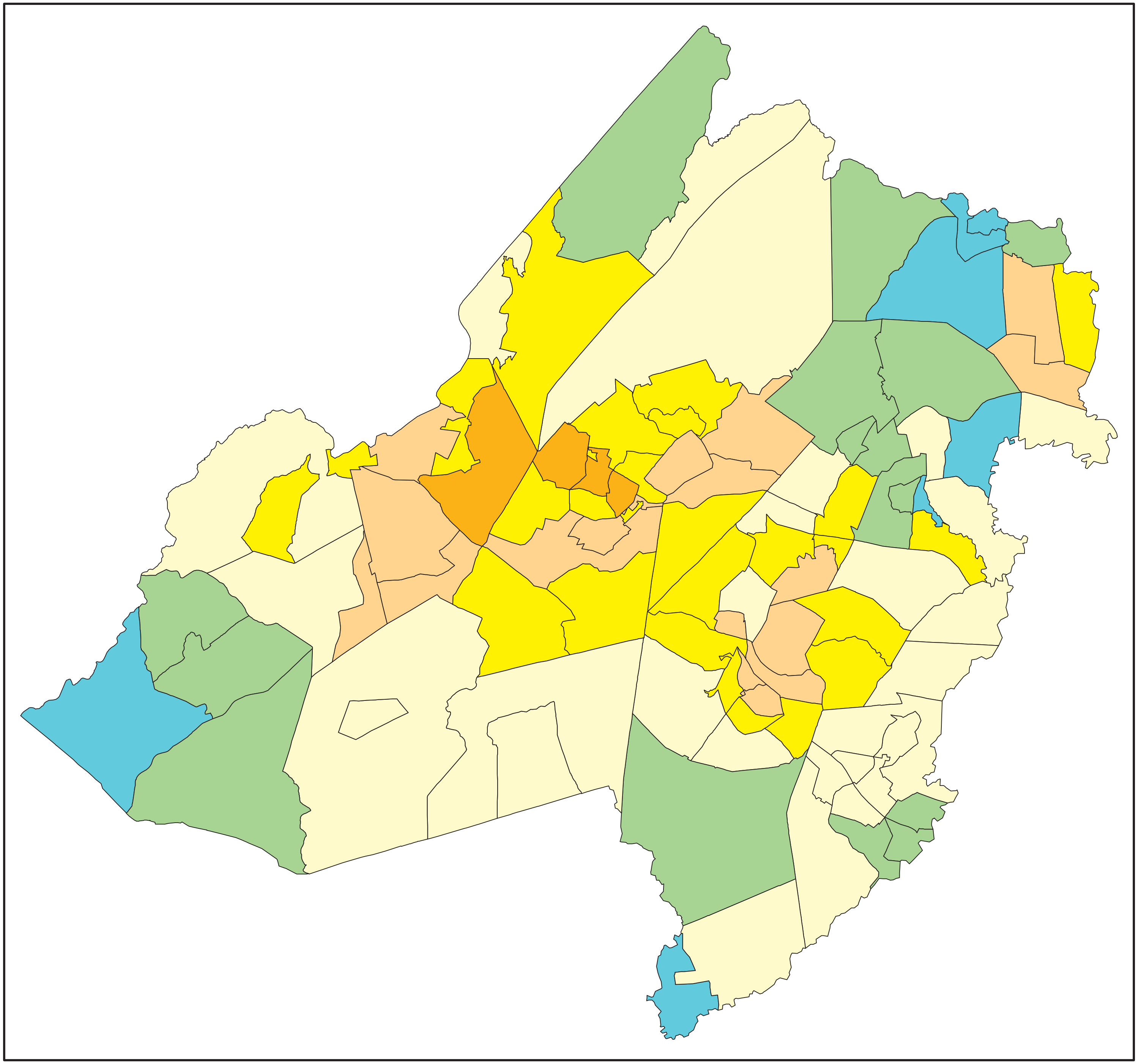
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*5*	*3*	*3*	*1*	*0*	*13*
Commercial	*602*	*457*	*664*	*373*	*147*	*2,243*
Education	*2*	*2*	*3*	*1*	*0*	*8*
Government	*15*	*11*	*18*	*10*	*4*	*57*
Industrial	*130*	*86*	*132*	*76*	*28*	*451*
Religion	*27*	*24*	*27*	*15*	*6*	*99*
Other Residential	*1,818*	*1,670*	*1,693*	*785*	*272*	*6,239*
Single Family	*46,469*	*42,369*	*30,736*	*8,834*	*2,458*	*130,866*
Total State	**49,068**	**44,622**	**33,275**	**10,096**	**2,915**	**139,976**
Study region	**49,068**	**44,622**	**33,275**	**10,096**	**2,915**	**139,976**

APPENDIX G

Magnitude 6 with full upgraded geology



Study Region:
Morris 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

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey
August 9, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	2.40 - 9.50
	Building Contents	0.20 - 0.60
	Business Interruption	0.30 - 1.30
Infrastructure	Lifelines Damage	
	Total	3.50 - 14.00

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	30 - 130	0 - 2	< 1.0	30 - 140
Major	6 - 30	0 - 1	< 1.0	7 - 30
Total	40 - 160	0 - 3	< 1.0	40 - 170

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	1,300 - 5,000
Level 2	Hospital Care	300 - 1,300
Level 3	Life-threatening	40 - 150
Level 4	Fatalities	70 - 300

Estimated Shelter Needs

Type	Households	People
Displaced Households	6,000 - 25,000	
Public Shelter		1,300 - 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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Time of report: August 08, 2005 4:08 pm

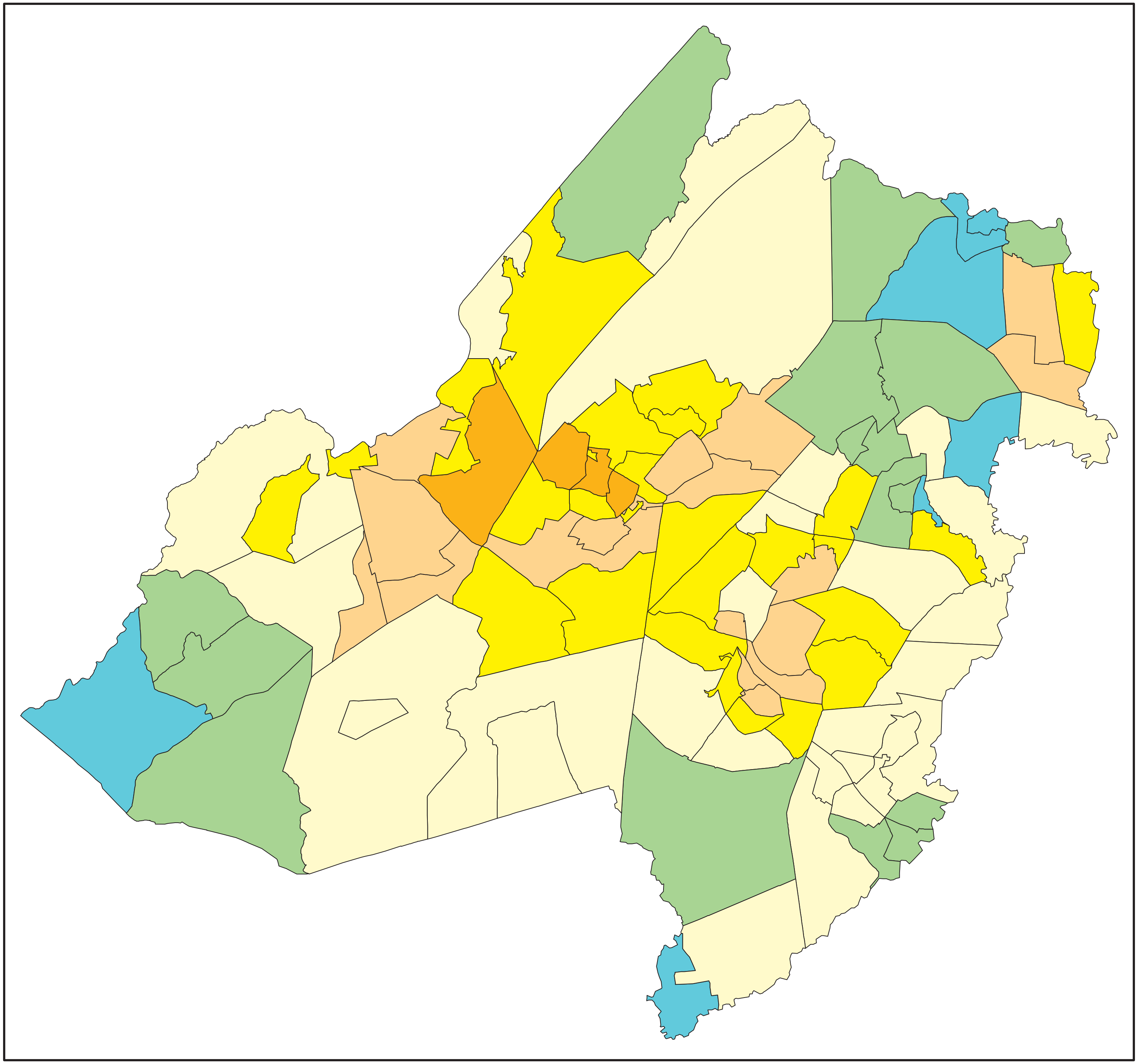
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*5*	*3*	*3*	*1*	*0*	*13*
Commercial	*657*	*451*	*603*	*312*	*219*	*2,243*
Education	*2*	*2*	*2*	*1*	*1*	*8*
Government	*18*	*11*	*16*	*8*	*4*	*57*
Industrial	*137*	*83*	*121*	*65*	*45*	*451*
Religion	*31*	*23*	*24*	*12*	*8*	*99*
Other Residential	*2,108*	*1,610*	*1,490*	*622*	*409*	*6,239*
Single Family	*53,883*	*39,568*	*24,760*	*6,442*	*6,212*	*130,866*
Total State	**56,842**	**41,753**	**27,020**	**7,462**	**6,898**	**139,976**
Study region	**56,842**	**41,753**	**27,020**	**7,462**	**6,898**	**139,976**

APPENDIX H

Magnitude 6 with no landslide hazard



Study Region:
Morris 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

NEW JERSEY GEOLOGICAL SURVEY 1835

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey
August 9, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	2.40 - 9.50
	Building Contents	0.20 - 0.60
	Business Interruption	0.30 - 1.30
Infrastructure	Lifelines Damage	
	Total	3.50 - 14.00

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	30 - 130	0 - 2	< 1.0	30 - 140
Major	6 - 30	0 - 1	< 1.0	7 - 30
Total	40 - 160	0 - 3	< 1.0	40 - 170

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	1,300 - 5,000
Level 2	Hospital Care	300 - 1,300
Level 3	Life-threatening	40 - 150
Level 4	Fatalities	70 - 300

Estimated Shelter Needs

Type	Households	People
Displaced Households	6,000 - 25,000	
Public Shelter		1,300 - 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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Time of report: August 08, 2005 3:25 pm

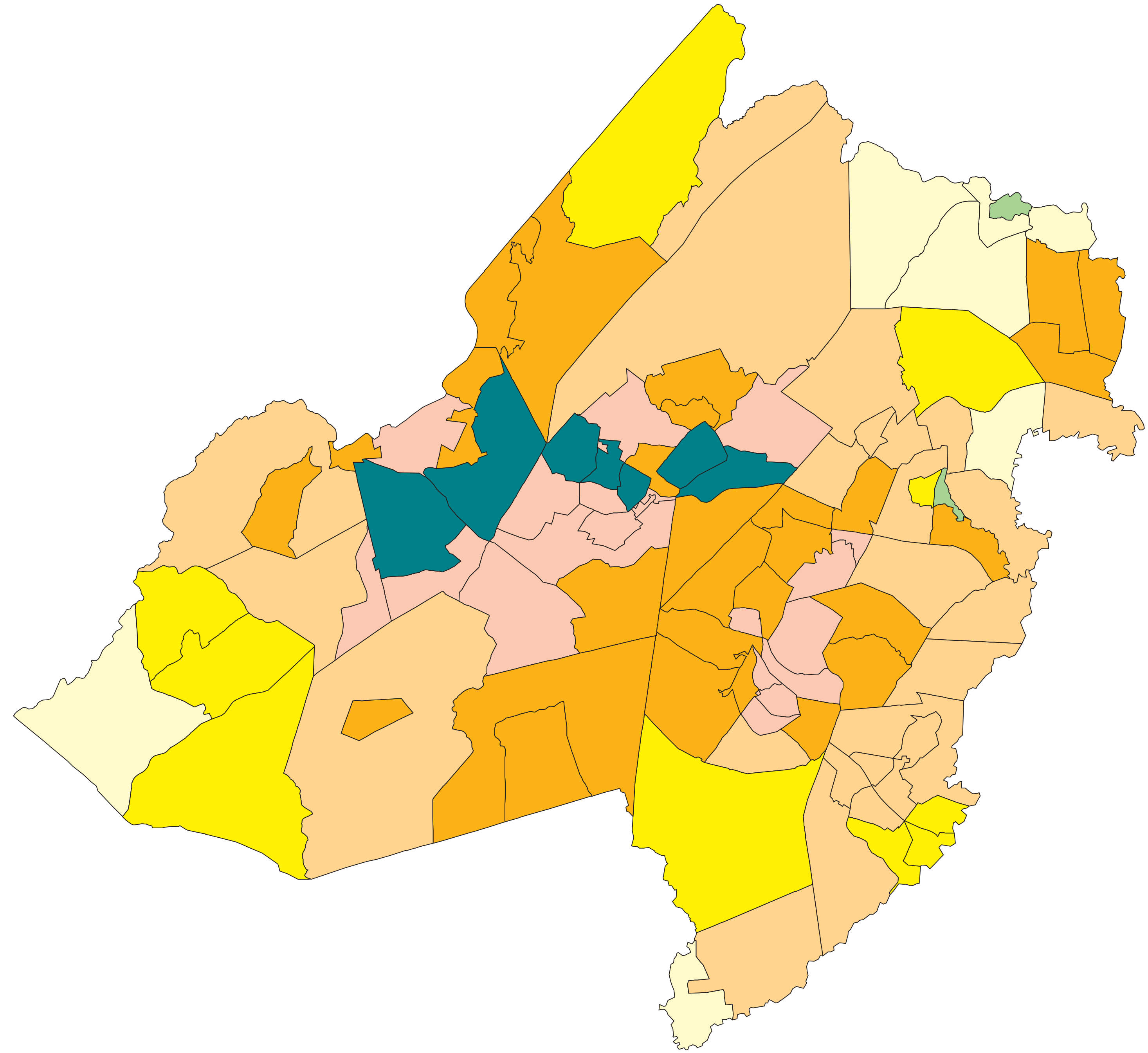
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*5*	*3*	*3*	*1*	*0*	*13*
Commercial	*657*	*451*	*603*	*312*	*219*	*2,243*
Education	*2*	*2*	*2*	*1*	*1*	*8*
Government	*18*	*11*	*16*	*8*	*4*	*57*
Industrial	*137*	*83*	*121*	*65*	*45*	*451*
Religion	*31*	*23*	*24*	*12*	*8*	*99*
Other Residential	*2,108*	*1,610*	*1,490*	*622*	*409*	*6,239*
Single Family	*53,883*	*39,568*	*24,760*	*6,442*	*6,212*	*130,866*
Total State	**56,842**	**41,753**	**27,020**	**7,462**	**6,898**	**139,976**
Study region	**56,842**	**41,753**	**27,020**	**7,462**	**6,898**	**139,976**

APPENDIX I

Magnitude 6.5 with full upgraded geology



Study Region:
Morris 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

NEW JERSEY GEOLOGICAL SURVEY
1835

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey August 9, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	4.20 - 16.90
	Building Contents	0.30 - 1.10
	Business Interruption	0.60 - 2.30
Infrastructure	Lifelines Damage	
	Total	6.10 - 24.40

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	40 - 170	0 - 1	< 1.0	40 - 170
Major	13 - 50	0 - 2	< 1.0	14 - 60
Total	50 - 200	1 - 4	0 - 1	60 - 200

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	2,000 - 10,000
Level 2	Hospital Care	600 - 2,000
Level 3	Life-threatening	80 - 300
Level 4	Fatalities	140 - 600

Estimated Shelter Needs

Type	Households	People
Displaced Households	11,000 - 44,000	
Public Shelter		2,000 - 9,000

Comments :

Disclaimer:
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Earthquake Information

Location :

Origin Time:

Magnitude : 6.50

Epicenter Latitude/Longitude :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 1.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Time of report: August 08, 2005 2:21 pm

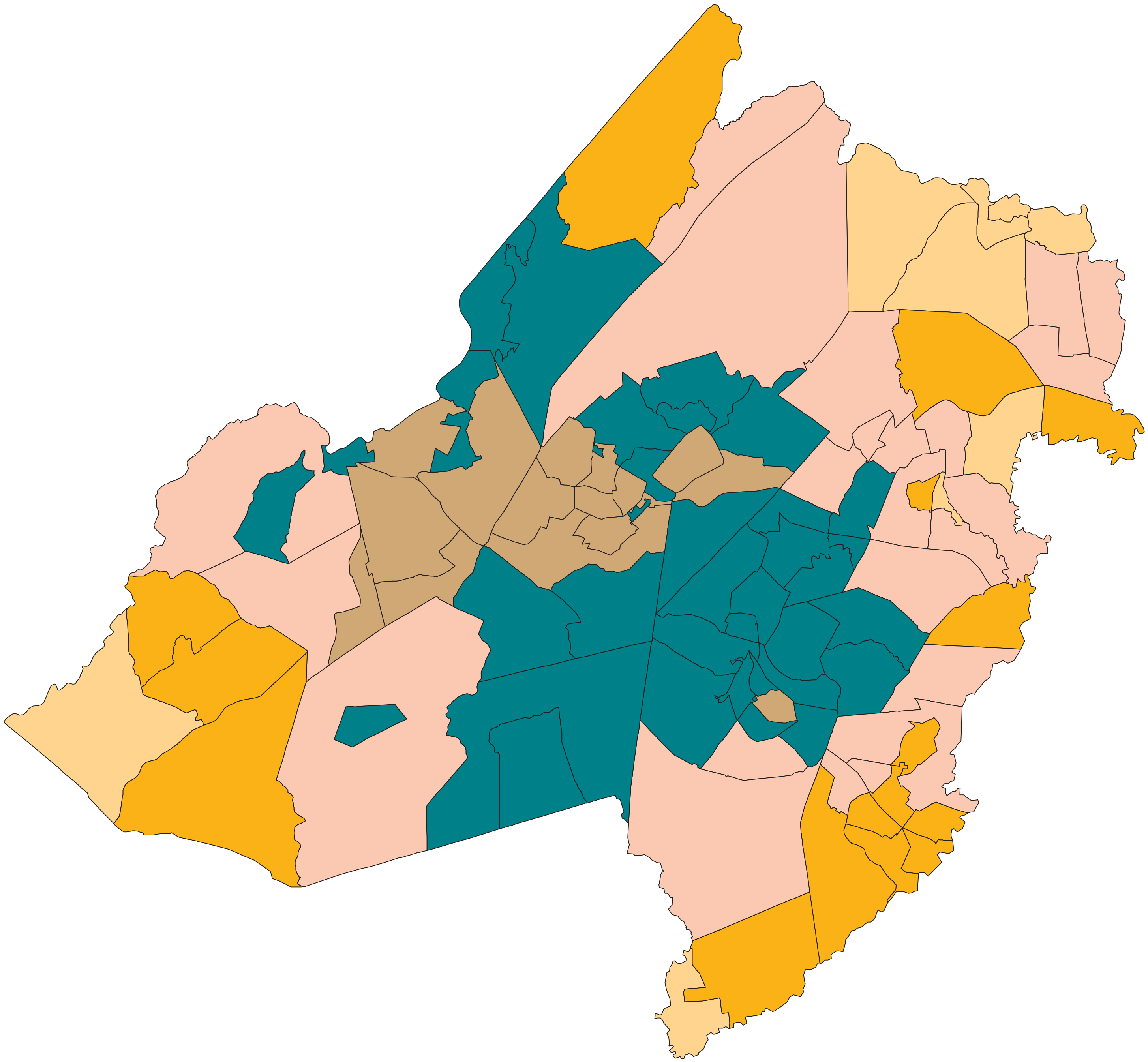
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	2	3	4	2	2	13
Commercial	233	296	648	557	508	2,243
Education	1	1	2	2	2	8
Government	6	7	17	15	11	57
Industrial	48	53	126	118	106	451
Religion	13	19	29	21	17	99
Other Residential	932	1,403	1,895	1,155	854	6,239
Single Family	26,224	39,778	40,012	14,669	10,183	130,866
Total State	**27,459**	**41,560**	**42,734**	**16,541**	**11,682**	**139,976**
Study region	**27,459**	**41,560**	**42,734**	**16,541**	**11,682**	**139,976**

APPENDIX J

Magnitude 7 with full upgraded geology



Study Region:
Morris 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

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey August 9, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	6.30 - 25.40
	Building Contents	0.40 - 1.70
	Business Interruption	0.90 - 3.40
Infrastructure	Lifelines Damage	
	Total	9.00 - 36.20

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	40 - 160	0 - 1	< 1.0	40 - 170
Major	20 - 90	0 - 3	< 1.0	20 - 90
Total	60 - 300	1 - 4	0 - 1	60 - 300

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	4,000 - 16,000
Level 2	Hospital Care	1,000 - 4,000
Level 3	Life-threatening	130 - 500
Level 4	Fatalities	300 - 1,000

Estimated Shelter Needs

Type	Households	People
Displaced Households	17,000 - 68,000	
Public Shelter		3,000 - 14,000

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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 2.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

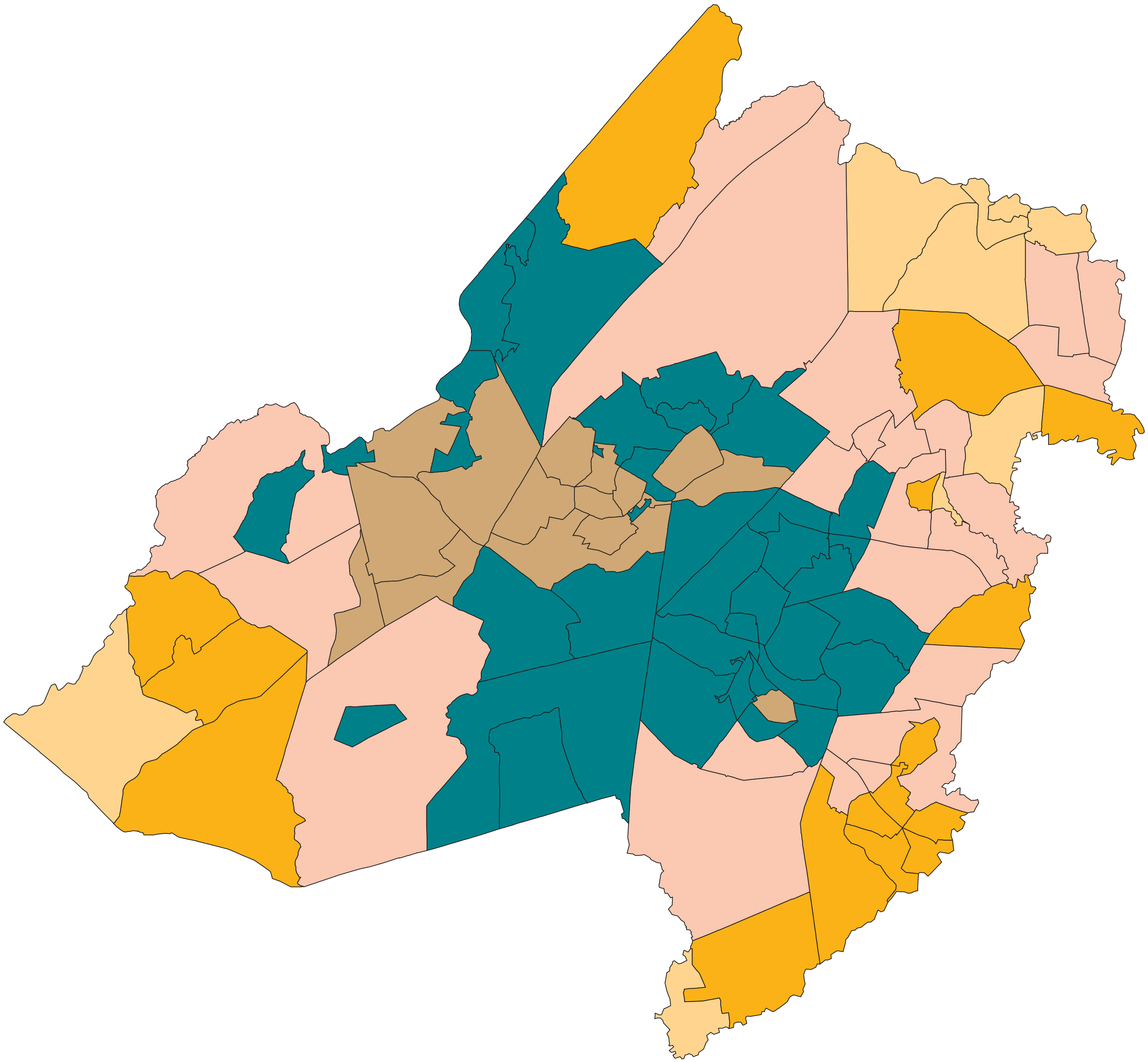
Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*1*	*1*	*4*	*3*	*3*	*13*
Commercial	*69*	*140*	*472*	*632*	*930*	*2,243*
Education	*0*	*0*	*1*	*2*	*4*	*8*
Government	*2*	*3*	*11*	*18*	*24*	*57*
Industrial	*14*	*24*	*86*	*131*	*196*	*451*
Religion	*5*	*12*	*26*	*25*	*31*	*99*
Other Residential	*384*	*995*	*1,875*	*1,474*	*1,511*	*6,239*
Single Family	*11,689*	*31,216*	*47,791*	*23,877*	*16,294*	*130,866*
Total State	**12,163**	**32,392**	**50,266**	**26,162**	**18,992**	**139,976**
Study region	**12,163**	**32,392**	**50,266**	**26,162**	**18,992**	**139,976**

APPENDIX K

Magnitude 7 with no landslide hazard



Study Region:
Morris 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

Data from the HAZUS-MH MR1 GIS software and the New Jersey Geological Survey August 9, 2005

HAZUS-MH Loss Estimation

Estimated Economic Loss ($ Billions)

Category	Description	Range
General Building Stock	Building Damage	6.30 - 25.40
	Building Contents	0.40 - 1.70
	Business Interruption	0.90 - 3.40
Infrastructure	Lifelines Damage	
	Total	9.00 - 36.20

Estimated Building Damage(Thousands of Buildings)

Description	Residential	Commercial	Other	Total
Minor	40 - 160	0 - 1	< 1.0	40 - 170
Major	20 - 90	0 - 3	< 1.0	20 - 90
Total	60 - 300	1 - 4	0 - 1	60 - 300

Estimated Casualties : Night Time

Severity Level	Description	# Persons
Level 1	Medical Aid	4,000 - 16,000
Level 2	Hospital Care	1,000 - 4,000
Level 3	Life-threatening	130 - 500
Level 4	Fatalities	300 - 1,000

Estimated Shelter Needs

Type	Households	People
Displaced Households	17,000 - 68,000	
Public Shelter		3,000 - 14,000

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 :
40.87 / -74.59

Depth & Type :10.00/A

Fault Name :
NA

Maximum PGA : 2.00

Ground Motion /Attenuation : CEUS Event

Information Sources:

Comments :

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

Population: 470,212

Building Exposure : ($ Millions)

Residential	27,959
Commerical	5,608
Other	2,351
Total	35,918

State:

Counties :
- Morris,NJ

Major Metro Area :

Time of report: August 08, 2005 3:42 pm

Building Damage by Count by General Occupancy

August 08, 2005

	# of Buildings					
	None	Slight	Moderate	Extensive	Complete	Total
New Jersey						
Morris						
Agriculture	*1*	*1*	*4*	*3*	*3*	*13*
Commercial	*69*	*140*	*472*	*632*	*930*	*2,243*
Education	*0*	*0*	*1*	*2*	*4*	*8*
Government	*2*	*3*	*11*	*18*	*24*	*57*
Industrial	*14*	*24*	*86*	*131*	*196*	*451*
Religion	*5*	*12*	*26*	*25*	*31*	*99*
Other Residential	*384*	*995*	*1,875*	*1,474*	*1,511*	*6,239*
Single Family	*11,689*	*31,216*	*47,791*	*23,877*	*16,294*	*130,866*
Total State	**12,163**	**32,392**	**50,266**	**26,162**	**18,992**	**139,976**
Study region	**12,163**	**32,392**	**50,266**	**26,162**	**18,992**	**139,976**

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

BLACK RIVER 1

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	6.7					
6	9.7	3	2000	2439	2233	
12	12.8	3.1	1935			
18	16.1	3.3	1818			
24	18.6	2.5	2400			
30	21.6	3	2000			
36	25.7	4.1	1463			
42	27.6	1.9	3158			
48	28.9	1.3	4615			
54	31.4	2.5	2400			
60	34	2.6	2308			
66	36.2	2.2	2727			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	14.7					
6	19.1	4.4	1364	1281	1279	layer 1
12	23.7	4.6	1304			
18	28.8	5.1	1176			
24	31.6	2.8	2143	1911	1801	layer 2
30	34.8	3.2	1875			
36	38.3	3.5	1714			
42	41.2	2.9	2069			
48	44.9	3.7	1622			
54	47.9	3	2000			
60	51.3	3.4	1765			
66	55.8	4.5	1333			

BLACK RIVER 2

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	7.5					
6	10.8	3.3	1818	1980	1967	layer 1
12	13.6	2.8	2143			
18	14.8	1.2	5000	4224	3022	layer 2
24	17.3	2.5	2400			
30	21.8	4.5	1333			
36	23.6	1.8	3333			
42	25.5	1.9	3157			
48	26.5	1	6000			
54	28	1.5	4000			
60	28.7	0.7	8571			
66	29.7	1	6000			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	10.5					
6	19.1	8.6	698	825	805	layer 1
12	25.4	6.3	952			
18	28.9	3.5	1714	2278	2135	layer 2
24	33.8	4.9	1224			
30	36.4	2.6	2308			
36	39.3	2.9	2069			
42	43.1	3.8	1579			
48	45.5	2.4	2500			
54	47.9	2.4	2500			
60	50	2.1	2857			
66	51.6	1.6	3750			

TIGER BROOK

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	4.2					
6	6.8	2.6	2308	2205	2174	layer 1
12	9.8	3	2000			
18	12.4	2.6	2308			
24	14.2	1.8	3333	3681	3096	layer 2
30	15.2	1	6000			
36	19.2	4	1500			
42	20.4	1.2	5000			
48	22.4	2	3000			
54	24.2	1.8	3333			
60	25.6	1.4	4286			
66	27.6	2	3000			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	10.2					
6	17.4	7.2	833	1098	1034	layer 1
12	21.8	4.4	1364			
18	23.8	2	3000	2382	2091	layer 2
24	27	3.2	1875			
30	30.2	3.2	1875			
36	33.6	3.4	1765			
42	37	3.4	1765			
48	39.8	2.8	2143			
54	41	1.2	5000			
60	44.2	3.2	1875			
66	47	2.8	2143			

JAMES ANDREWS

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	6.8					
6	10.9	4.1	1463	5423	3588	
12	14.5	3.6	1667			
18	17.2	2.7	2222			
24	18.8	1.6	3750			
30	19.6	0.8	7500			
36	21.1	1.5	4000			
42	22.8	1.7	3529			
48	23.9	1.1	5455			
54	25.2	1.3	4615			
60	26.3	1.1	5455			
66	26.6	0.3	20000			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	11.5					
6	20.8	9.3	645	1527	1485	
12	24.2	3.4	1765			
18	28	3.8	1579			
24	32.1	4.1	1463			
30	36	3.9	1538			
36	39	3	2000			
42	43.4	4.4	1364			
48	47.7	4.3	1395			
54	51.8	4.1	1463			
60	55.2	3.4	1765			
66	58.5	3.3	1818			

RARITAN

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	7.3					
6	14.8	7.5	800	1784	1322	layer 1
12	19.1	4.3	1395			
18	21	1.9	3158			
24	23.1	2.1	2857	5666	5350	layer 2
30	23.8	0.7	8571			
36	25.1	1.3	4615			
42	26.3	1.2	5000			
48	27.7	1.4	4286			
54	28.6	0.9	6667			
60	29.2	0.6	10000			
66	31	1.8	3333			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	14.8					
6	23.1	8.3	723	863	795	layer 1
12	32.8	9.7	619			
18	39.4	6.6	909			
24	44.4	5	1200			
30	46.4	2	3000	3559	2995	layer 2
36	51.1	4.7	1277			
42	53.5	2.4	2500			
48	55.6	2.1	2857			
54	57.1	1.5	4000			
60	58	0.9	6667			
66	59.3	1.3	4615			

FAIRVIEW AVENUE

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	12.5					
6	16.9	4.4	1364	2217	1881	
12	22.1	5.2	1154			
18	23.8	1.7	3529			
24	27.5	3.7	1622			
30	29.8	2.3	2609			
36	33.8	4	1500			
42	38.3	4.5	1333			
48	40.9	2.6	2308			
54	43.6	2.7	2222			
60	45.6	2	3000			
66	47.2	1.6	3750			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	24.8					
6	28.8	4	1500	2149	1445	
12	32.9	4.1	1463			
18	35.4	2.5	2400			
24	41.5	6.1	984			
30	45.9	4.4	1364			
36	50	4.1	1463			
42	57.8	7.8	769			
48	58.5	0.7	8571			
54	61.5	3	2000			
60	65.5	4	1500			
66	69.2	3.7	1622			

REGER ROAD

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	5.7					
6	9.3	3.6	1667	6800	3956	
12	15.1	5.8	1034			
18	15.6	0.5	12000			
24	17.5	1.9	3158			
30	17.8	0.3	20000			
36	19.7	1.9	3158			
42	20.7	1	6000			
48	21.5	0.8	7500			
54	22.9	1.4	4286			
60	23.9	1	6000			
66	24.5	0.6	10000			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	8.7					
6	13.9	5.2	1154	1417	1291	
12	23.5	9.6	625			
18	29	5.5	1091			
24	33.7	4.7	1277			
30	38.5	4.8	1250			
36	41.7	3.2	1875			
42	45.5	3.8	1579			
48	49.2	3.7	1622			
54	54.8	5.6	1071			
60	58.1	3.3	1818			
66	60.8	2.7	2222			

DMV

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	8.1					
6	11.4	3.3	1818	2751	3181	
12	13.8	2.4	2500			
18	15.3	1.5	4000			
24	17.7	2.4	2500			
30	20.8	3.1	1935			
36	22.4	1.6	3750	5030	4784	
42	24.3	1.9	3158			
48	25.7	1.4	4286			
54	26.8	1.1	5455			
60	27.4	0.6	10000			
66	29.1	1.7	3529			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	9					
6	14	5	1200	980	930	layer 1
12	21.9	7.9	759			
18	25.7	3.8	1579	1919	1836	layer 2
24	29.5	3.8	1579			
30	33.4	3.9	1538			
36	37.1	3.7	1622			
42	39.4	2.3	2609			
48	42	2.6	2308			
54	46	4	1500			
60	49.9	3.9	1538			
66	51.9	2	3000			

THOMASTOWN ROAD

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	6.5					
6	11.2	4.7	1277	1472	1446	layer 1
12	14.8	3.6	1667			
18	16.1	1.3	4615	4505	4478	water table?
24	17.5	1.4	4286			
30	18.8	1.3	4615			
36	19.5	0.7	8571	13595	9081	bedrock?
42	20.7	1.2	5000			
48	21.2	0.5	12000			
54	21.5	0.3	20000			
60	22.5	1	6000			
66	22.7	0.2	30000			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	18.5					
6	25.4	6.9	870	969	970	no layering
12	32.9	7.5	800			
18	39.2	6.3	952			
24	45.5	6.3	952			
30	51.3	5.8	1034			
36	57.3	6	1000			
42	63.7	6.4	937			
48	68.8	5.1	1176			
54	74.9	6.1	983			
60	82	7.1	845			
66	87.4	5.4	1111			

TOYS R US

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	9.7					
6	14.8	5.1	1176	1791	1614	
12	23.1	8.3	723			
18	28	4.9	1224			
24	31.5	3.5	1714			
30	34.8	3.3				
36	39	4.2	1429			
42	41.3	2.3				
48	45.6	4.3	1395			
54	47.4	1.8	3333			
60	49.2	1.8	3333			
66	51.7	2.5				

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	21.7					
6	28.2	6.5	923	1062	1009	
12	35.5	7.3	822			
18	43.5	8	750			
24	49.4	5.9	1017			
30	55.3	5.9	1017			
36	61.4	6.1	984			
42	66.6	5.2	1154			
48	72.4	5.8	1034			
54	77.8	5.4	1111			
60	82.8	5	1200			
66	86.4	3.6	1667			

FLOCKTOWN ROAD

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	6.8					
6	16.4	9.6	625	5344	2074	
12	20.4	4	1500			
18	25.1	4.7	1277			
24	29.9	4.8	1250			
30	33.1	3.2	1875			
36	35.7	2.6	2308			
42	37.7	2	3000			
48	39.1	1.4	4286			
54	40.1	1	6000			
60	40.3	0.2	30000			
66	41.2	0.9	6667			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	14.5					
6	22.9	8.4	714	1081	1063	
12	30.5	7.6	789			
18	35.6	5.1	1176			
24	41.2	5.6	1071			
30	47.4	6.2	968			
36	51.9	4.5	1333			
42	57.8	5.9	1017			
48	64.1	6.3	952			
54	68.6	4.5	1333			
60	73.1	4.5	1333			
66	78.1	5	1200			

ROCK ROAD

P WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	8.7					
6	13.2	4.5	1333	8572	4025	
12	15.7	2.5	2400			
18	17.6	1.9	3158			
24	20	2.4	2500			
30	21.3	1.3	4615			
36	22.5	1.2	5000			
42	23.9	1.4	4286			
48	24.1	0.2	30000			
54	25.3	1.2	5000			
60	26.3	1	6000			
66	26.5	0.2	30000			

S WAVE

gp spc	pick	int time	int velocity	avg velocity	regression velocity	comments
0	12.9					
6	21.4	8.5	706	1214	1119	
12	26.2	4.8	1250			
18	30.7	4.5	1333			
24	34.7	4	1500			
30	41.9	7.2	833			
36	46.8	4.9	1224			
42	52.6	5.8	1034			
48	60.1	7.5	800			
54	64.1	4	1500			
60	67.6	3.5	1714			
66	71.7	4.1	1463			

SEISMIC SOIL CLASS MAP
FOR
MORRIS COUNTY, NEW JERSEY

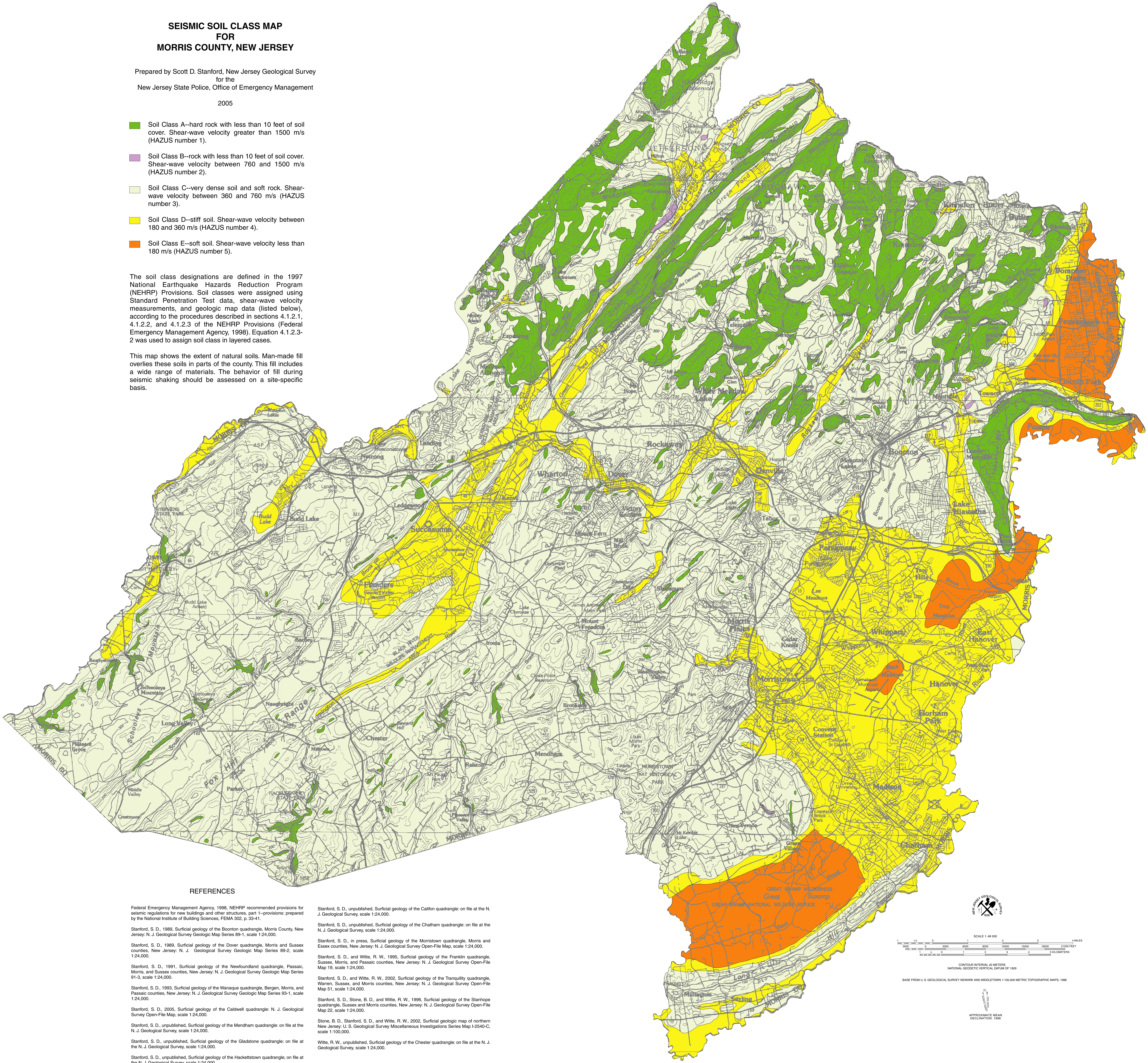
Prepared by Scott D. Stanford, New Jersey Geological Survey
for the
New Jersey State Police, Office of Emergency Management

2005

- 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, shear-wave velocity measurements, and geologic map data (listed below), 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 in 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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SOIL LIQUEFACTION SUSCEPTIBILITY
FOR
MORRIS COUNTY, NEW JERSEY

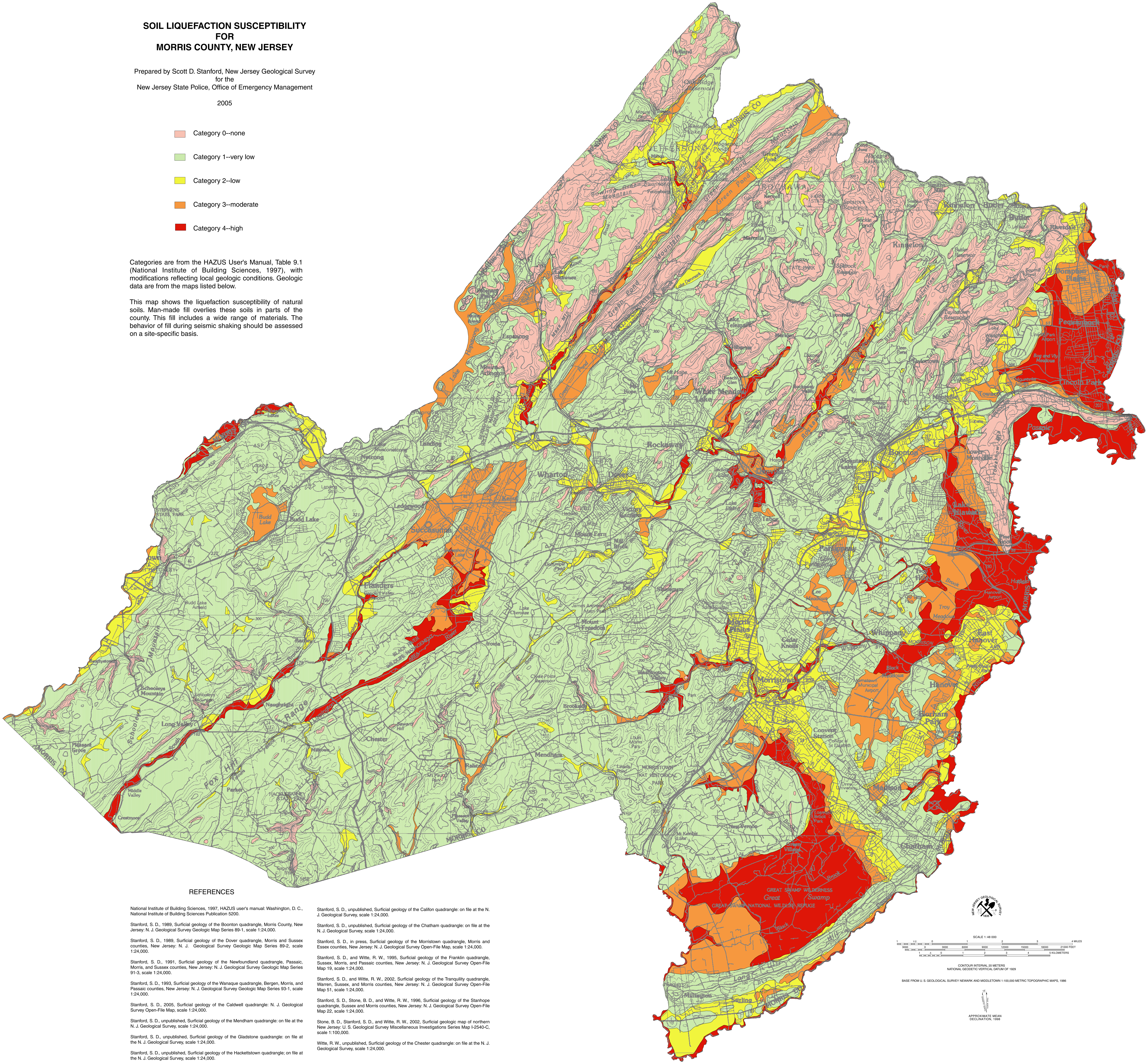
Prepared by Scott D. Stanford, New Jersey Geological Survey
for the
New Jersey State Police, Office of Emergency Management

2005

- 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), with modifications reflecting local geologic conditions. Geologic data are from the maps listed below.

This map shows the liquefaction susceptibility of natural soils. Man-made fill overlies these soils in 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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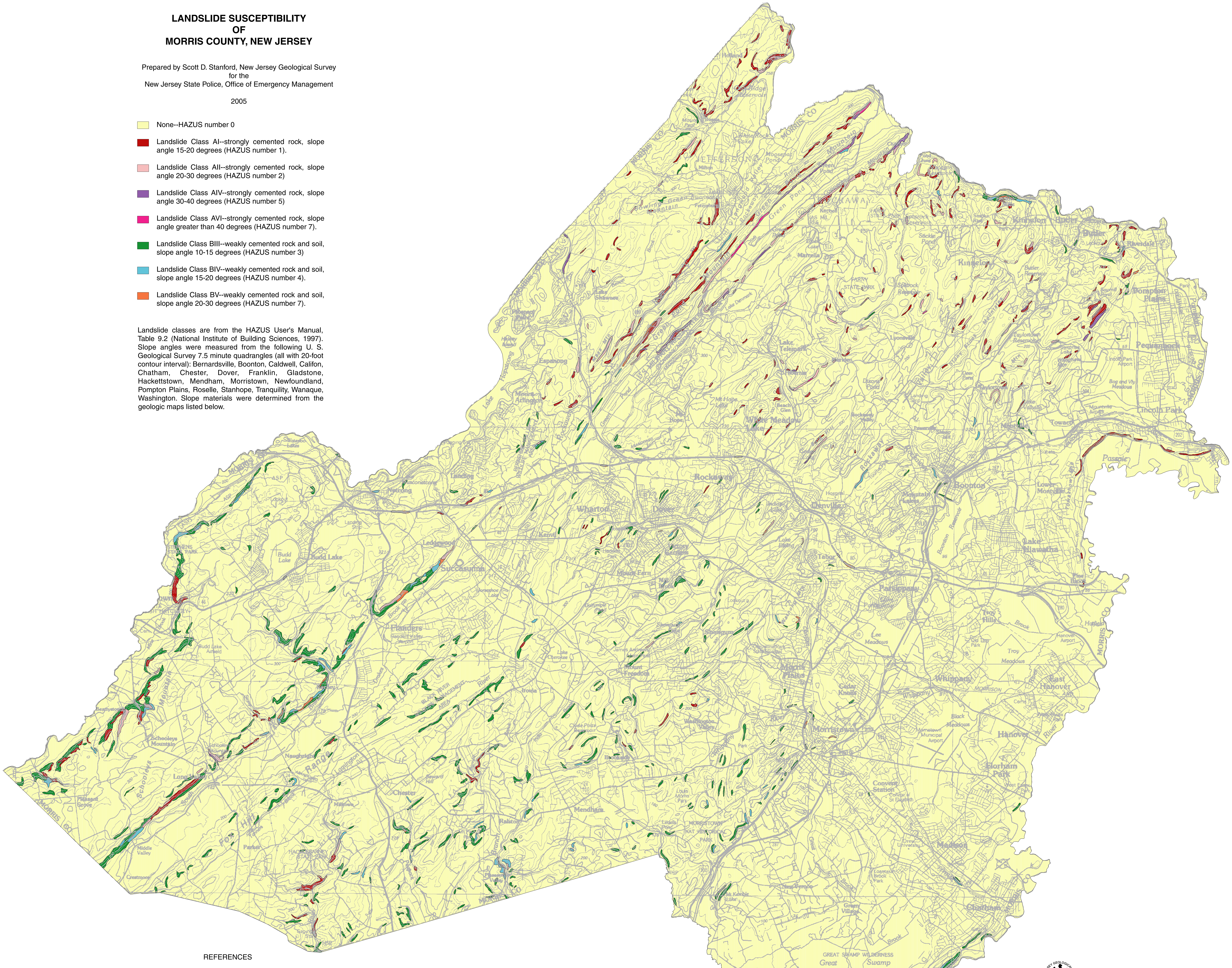
LANDSLIDE SUSCEPTIBILITY
OF
MORRIS COUNTY, NEW JERSEY

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

2005

- None--HAZUS number 0
- Landslide Class AI--strongly cemented rock, slope angle 15-20 degrees (HAZUS number 1).
- Landslide Class AII--strongly cemented rock, slope angle 20-30 degrees (HAZUS number 2)
- Landslide Class AIV--strongly cemented rock, slope angle 30-40 degrees (HAZUS number 5)
- Landslide Class AVI--strongly cemented rock, slope angle greater than 40 degrees (HAZUS number 7).
- Landslide Class BIII--weakly cemented rock and soil, slope angle 10-15 degrees (HAZUS number 3)
- Landslide Class BIV--weakly cemented rock and soil, slope angle 15-20 degrees (HAZUS number 4).
- Landslide Class BV--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 (all with 20-foot contour interval): Bernardsville, Boonton, Caldwell, Califon, Chatham, Chester, Dover, Franklin, Gladstone, Hackettstown, Mendham, Morristown, Newfoundland, Pompton Plains, Roselle, Stanhope, Tranquility, Wanaque, Washington. Slope materials were determined from the geologic maps listed below.



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NEW JERSEY GEOLOGICAL SURVEY 1835

SCALE 1: 48 000

1 1/2 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 20 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

BASE FROM U. S. GEOLOGICAL SURVEY NEWARK AND MIDDLETOWN 1:100,000 METRIC TOPOGRAPHIC MAPS, 1986

13°
MAGNETIC NORTH
TRUE NORTH

APPROXIMATE MEAN
DECLINATION, 1998