3.13 - Landslide Hazard Profile

The following chart provides the definition of a landslide:

Term	Definition
Landslide	The downward movement of a slope and materials under the force of gravity. The Term includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Landslide materials may be composed of natural rock, soil, artificial fill or combinations of these materials.

Another hazard to which the State is vulnerable is landslides. Landslide materials may be composed of natural rock, soil, artificial fill or combinations of these materials. Depending on where they occur, landslides can pose significant risks to health and safety or interruption to transportation and other services. A map of landslide susceptible areas in the State is included as **Figure 3-200**. The Mitigation Plan development team reviewed past material and researched the current information as it affects New York State. Contents of this section result from research and outreach including the following sources:

- *United States Geological Survey and New York State Geological Survey* – a review of technical information, graphics presenting historical, probability indicators.

- *United States Geological Survey New York Water Science Center Ithaca NY Hydro geologist Bill Kappel* - a review of the landslide profile and possible future program on landslide susceptibility in New York State

- *New York State Geological Survey* – Outreach to the New York State Geologist Bill Kelly and Glacial Geologist Andy Kozlowski.

- *New York State Emergency Management Office* situation report archives for historical events.

Geographic Location/Extent/Severity – Landslide Hazard

The potential for landslides exists across the entire State and the entire Northeast United States. Scientific and historical landslide data exists which indicates that some areas of the state have a substantial landslide risk. According to information that can be found on FEMA's web site http://www.fema.gov/hazards/landslides/landsli.shtm there is a risk of landslides as determined by scientific information and proven by historical incidence, however, New York State is not identified among those locations (other States) having the most serious landslide threat. According to information provided by USGS and NYSGS it is estimated that 80% of New York State has a low susceptibility to landslide hazard. In general the highest potential for landslides can be found along major river and lake valleys that were formerly occupied by glacial lakes resulting in glacial lake deposits (glacial lake clays) and usually associated with steeper slopes. A good example of this is the Hudson and Mohawk River valley.

The USGS provides a generally accepted landslide hazard overview map (see **Figure 3-200**) indicating landslide susceptibility and incidence using the following classifications;

Table 3-63

LANDSLIDE INCIDENCE COLOR CODE	
LIGHT OLIVE color	**Low** (less than 1.5% of area involved)
SALMON PINK color	**Moderate** (1.5%-15% of area involved)
RED color	**High** (greater than 15% of area involved)
LANDSLIDE SUSCEPTIBILITY/INCIDENCE	
LIGHT BLUE color	Moderate susceptibility/low incidence
YELLOW color	High susceptibility/low incidence
AMBER color	High susceptibility/moderate incidence

Additionally, the USGS provides support narrative for the landslide hazard classifications listed above as follows:

> *Susceptibility not indicated where same or lower than incidence. Susceptibility to landsliding was defined as the probable degree of response of [the area] rocks and soils to natural or artificial cutting or loading of slopes, or to anomalously high precipitation. High, moderate, and low susceptibility are delimited by the same percentages used in classifying the incidence of landsliding. Some generalization was necessary at this scale, and several small areas of high incidence and susceptibility were slightly exaggerated.*

Based on discussion with the geologist staff at the NYS Geological Survey (NYSGS), in general they concur with the overall indications presented by the (USGS) landslide susceptibility/incidence map. The map characterizes the states varying vulnerability to the landslide hazard. The information provided by the geologist staff with NYS GS supporting the landslide hazard map is included in the following discussion. The support information which identifies each landslide risk classification also describes the areas of the State associated with each classification as well as the causal factors involved.

RED - The map indicates in red shade an area of high landslide incidence. The area runs along the Hudson River Valley in eastern NY State. The contributing factors as

described by NYSGS is a combination of glacial lake clay soils and moderately steep slopes, both lending to landslides with glacial lake clay soils being a predominant factor.

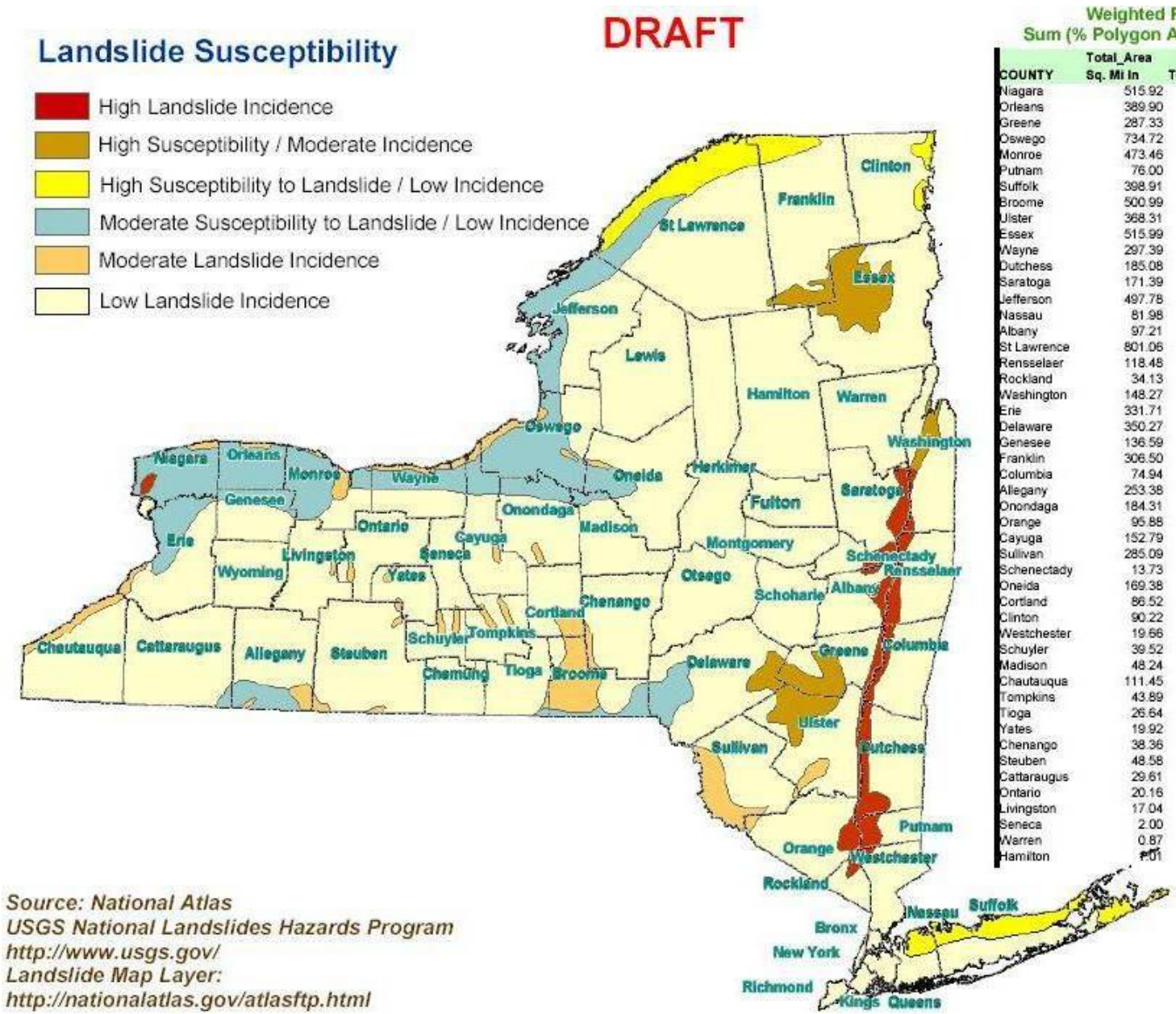
AMBER - The map indicates in amber shade two areas of high susceptibility to land sliding and moderate incidence. These areas identify the Adirondack Mountains high peaks area in the north country of NY State including Essex and Franklin counties and The Catskill Plateau (the highlands) of southeastern NY State including Greene, Ulster, and Delaware counties primarily due to the steep slopes resulting in bed rock topples and soil slides also known as debris slides.

YELLOW - The map indicates in bright yellow shade primarily two (2) general areas of high susceptibility to land sliding and low incidence. These areas include the St. Lawrence-Champlain Valley in the north which contains marine clay soils (quick clays) which can lend to landslides. The second area in yellow shade is the north shore of Long Island. The predominant factor lending to landslides are the steep bluffs and include soils containing sandy and glacial till which cannot stand up to the steep slopes.

LIGHT BLUE/SALMON PINK - The map also indicates in light blue and salmon pink shade significant areas of moderate susceptibility to landsliding and low incidence and moderate landslide incidence respectively. These areas include most Counties on the shores and inland of the Great Lakes Erie and Ontario which has soil containing sands and fluvial materials that do not stand up well to landslide tendency. This classification also includes the moderately steep slopes and glacial deposits that do not stand up well to landslide tendency at the shores of the Finger Lakes in west-central and counties in the Southern-Tier of NY State.

LIGHT YELLOW – The map indicates in light yellow shade the remainder of NYS or approximately 80% a low landslide incidence.

Figure 3-200



Weighted Rank =
Sum (% Polygon Area x LSRank)

COUNTY	Total_Area Sq. Mi In	TotAreaIn	Weighted Rank
Niagara	515.92	97.80%	3.04
Orleans	389.90	99.12%	2.93
Greene	287.33	43.70%	2.27
Oswego	734.72	72.44%	2.10
Monroe	473.46	71.38%	2.05
Putnam	76.00	30.90%	1.85
Suffolk	398.91	43.36%	1.73
Broome	500.99	70.05%	1.60
Ulster	368.31	31.74%	1.49
Essex	515.99	28.16%	1.41
Wayne	297.39	49.05%	1.37
Dutchess	185.08	22.45%	1.35
Saratoga	171.39	20.32%	1.22
Jefferson	497.78	38.67%	1.16
Nassau	81.98	28.52%	1.14
Albany	97.21	18.24%	1.09
St Lawrence	801.06	29.03%	1.07
Rensselaer	118.48	17.81%	1.07
Rockland	34.13	17.12%	1.03
Washington	148.27	17.62%	0.92
Erie	331.71	31.64%	0.92
Delaware	350.27	23.88%	0.87
Genesee	136.59	27.56%	0.83
Franklin	306.50	18.09%	0.81
Columbia	74.94	11.57%	0.69
Allegany	253.38	24.48%	0.67
Onondaga	184.31	22.90%	0.66
Orange	95.88	11.45%	0.58
Cayuga	152.79	20.81%	0.58
Sullivan	285.09	28.62%	0.57
Schenectady	13.73	6.55%	0.39
Oneida	169.38	13.48%	0.39
Cortland	86.52	17.27%	0.35
Clinton	90.22	8.56%	0.34
Westchester	19.66	4.15%	0.25
Schuyler	39.52	11.54%	0.23
Madison	48.24	7.30%	0.22
Chautauqua	111.45	10.25%	0.21
Tompkins	43.89	8.93%	0.18
Tioga	26.64	5.10%	0.13
Yates	19.92	5.30%	0.11
Chenango	38.36	4.27%	0.09
Steuben	48.58	3.46%	0.07
Cattaraugus	29.61	2.24%	0.07
Ontario	20.16	3.04%	0.06
Livingston	17.04	2.66%	0.06
Seneca	2.00	0.51%	0.01
Warren	0.87	0.09%	0.01
Hamilton	1.01	0.06%	0.00

Source: National Atlas
USGS National Landslides Hazards Program
http://www.usgs.gov/
Landslide Map Layer:
http://nationalatlas.gov/atlasftp.html

The landslide incidents information included on **Figure 3-201** was compiled from a "Landslide Inventory Map of New York" produced by the New York State Geological Survey in cooperation with the United States Geological Survey. This map indicates the location of identified landslides in New York State. An introduction included on the map reads as follows.

> *"This map brings together for the first time information on landslides in New York from: reports listed by Alger and Brabb (1985, p. 69-70); unpublished landslide studies by A.R. Eschner, R.H. Fickies and T.J. Robak; and interviews or mail canvasses of Federal, State and Local engineers and geologists. Locations of landslides from these sources were plotted by measuring the distance from landmarks. Large differences in scale, instability of paper source maps, and other technical problems led to errors of as much as one mile in transferring some locations. Therefore, the location of landslides shown is only approximate. Certainly, many more landslides exist in New York that have not been recognized or recorded in public documents. The absence of a landslide symbol on this map, therefore, does not mean that an area is free of landslide. Conversely, the clustering of landslide symbols in an area does not necessarily imply that the area is unsafe, but rather that many landslides have been reported and that prudence requires investigation by qualified geologists and engineers before development takes place. This map should be considered preliminary, because as yet a systematic landslide evaluation of all areas in New York using standard photographic interpretation techniques has not been completed. The selected bibliography provides more information on landslides in New York State, landslide processes, and landslide classification.*

Affecting Conditions – Landslide Hazard

Some natural variables that contribute to determining the overall risk of landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. A landslide hazard susceptibility map created by New York State Emergency Management Office based on the United States Geological Survey landslide susceptibility map is included as **Figure 3-200.** The map categorizes the State using color codes provided by the USGS landslide susceptibility map and the NYS GS landslide incidence map. The landslide susceptibility map was created including two (2) primary characteristics that define landslide potential, terrain slopes and soil makeup or type.

Soils: Most New York State soil consists of dense glacial till which stands up well to landslide tendency. However, there are certain types of soil that exist throughout the State that have a higher risk of landslide susceptibility and incidence. In particular, glacial lake clay soils which are abundant throughout NYS have a higher risk for landslide occurrence.

Terrain: Logically, the steeper the slope the higher risk for landslide occurrence assuming other conditions that lead to landslides are present. However, according to the New York State Geological Survey, landslides can occur with very little slope, sometimes classified as earth slumping or earth flow. The threshold is estimated at 10 degrees slope or higher (> 10 degrees) when the susceptibility becomes significant.

Similarly, a tall slope or hill (referred to as a "*relief*") would lend to a high risk. Geologists at the NYS geological survey identify relief (height) greater than 40ft as the general threshold where the potential becomes more significant.

Triggers: Another significant factor in landslide occurrence is what sets off the landslide or the causes of the landslide (trigger): Causes or triggers of landslides on marginally stable slopes can be both

naturally occurring or human induced and includes three (3) primary factors; water saturation of the ground, loading, or increased weight at the top or high end of the slope, and taking away or removing weight from the bottom.

Figure 3-201

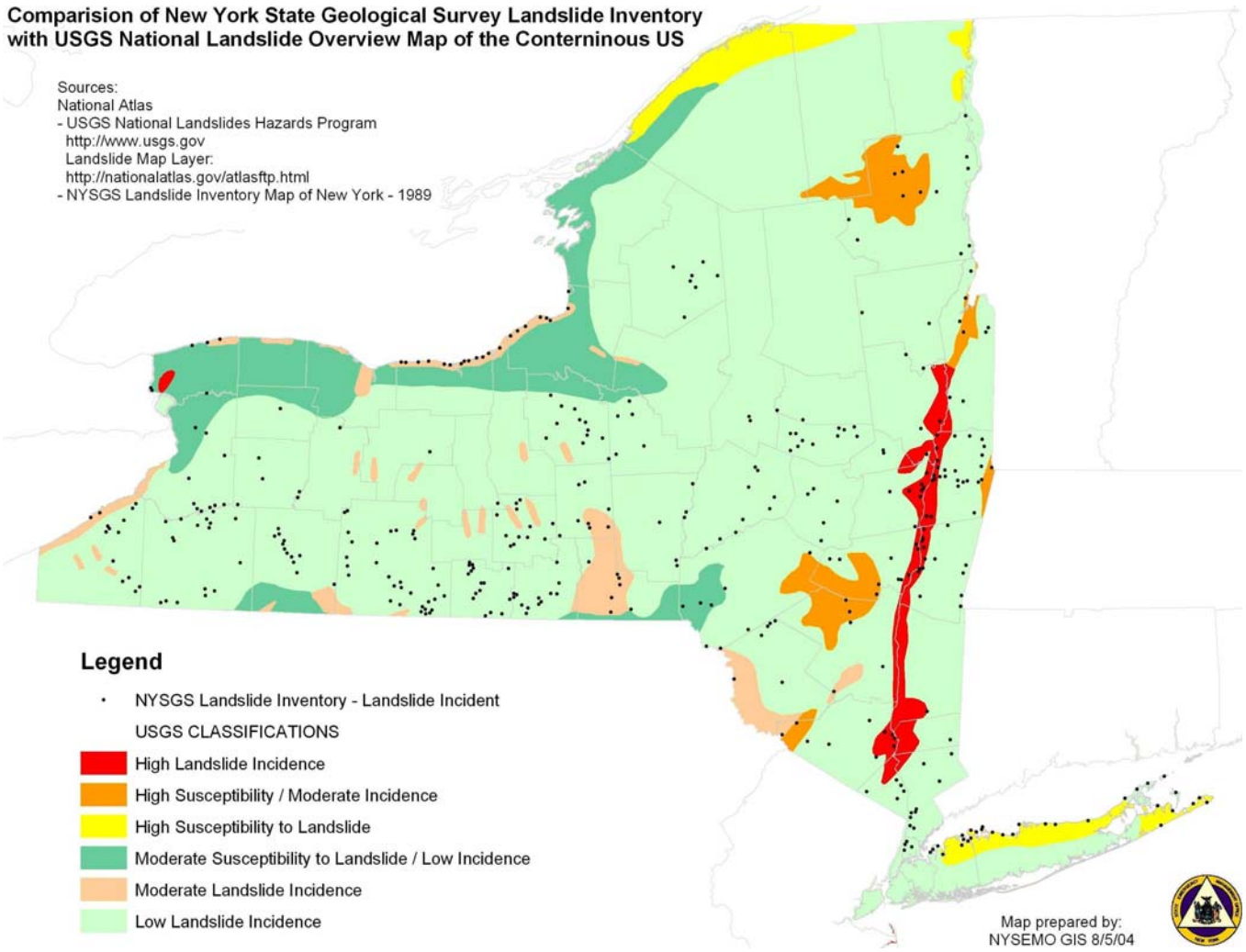
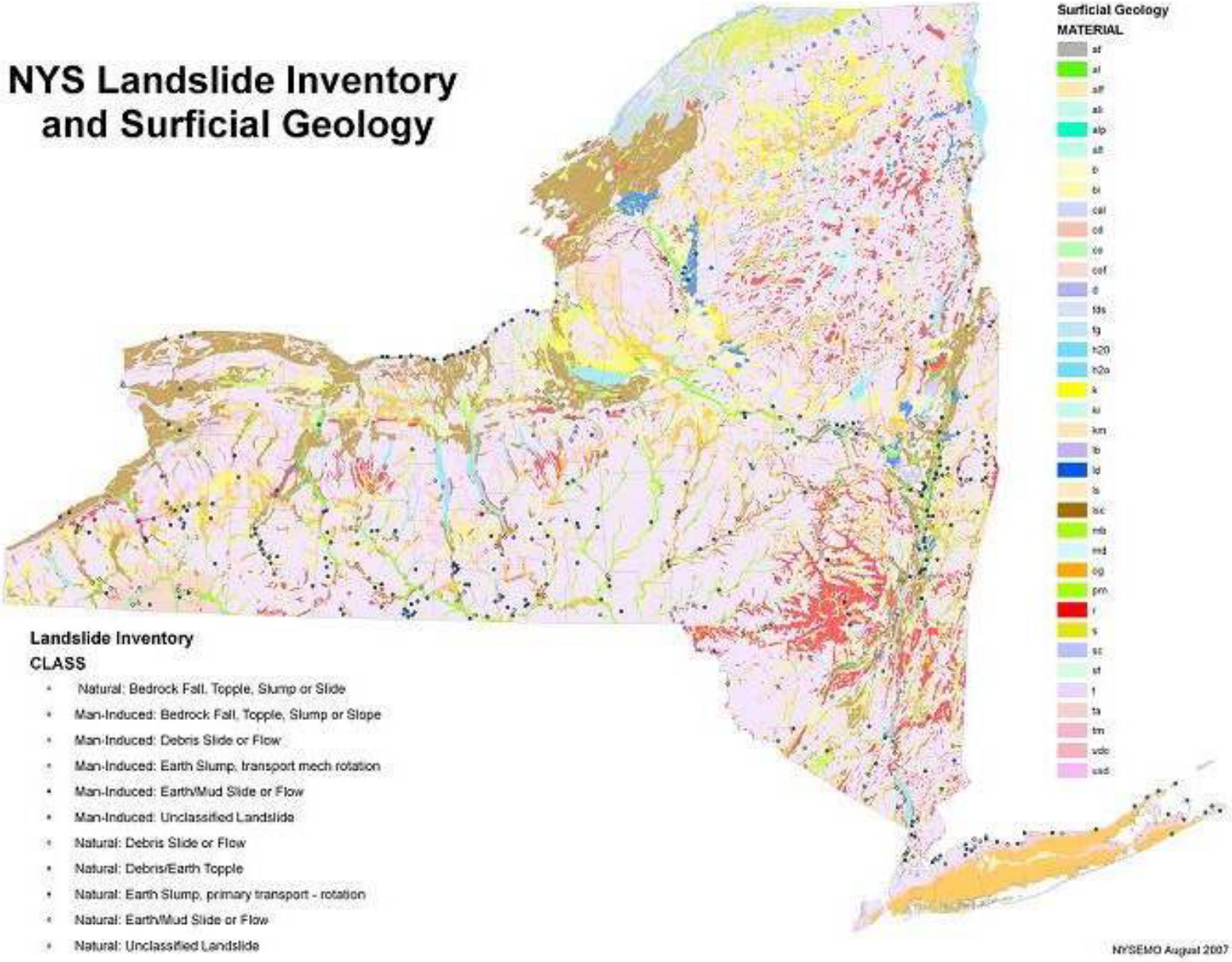


Figure 3-202


NYS Landslide Inventory
and Surficial Geology
Surficial Geology
MATERIAL
Landslide Inventory
CLASS
Natural: Bedrock Fall, Topple, Slump or Slide
Man-Induced: Bedrock Fall, Topple, Slump or Slope
Man-Induced: Debris Slide or Flow
Man-Induced: Earth Slump, transport mech rotation
Man-Induced: Earth/Mud Slide or Flow
Man-Induced: Unclassified Landslide
Natural: Debris Slide or Flow
Natural: Debris/Earth Topple
Natural: Earth Slump, primary transport - rotation
Natural: Earth/Mud Slide or Flow
Natural: Unclassified Landslide
NYSEMO August 2007

Previous Landslide Hazard Occurrences

As mentioned previously, the landslide information on **Figure 3-201** and **Figure 3-202** was compiled from a "Landslide Inventory Map of New York" and produced by the New York State Geological Survey (NYSGS) in cooperation with the United States Geological Survey. The inventory includes reference to 326 landslides which occurred and were reported in New York State between1837 and 1988. The following figures provide spatially the location of the 326 landslide occurrences documented by NYSGS in relation to the USGS classifications and surficial geology. This figure indicates a certain amount of correlation as well as demonstrating the need for further study. The following **Table 3-64** summarizes the same landslide inventory map data combined with NYSGS surficial geology.

Table 3-64
LANDSLIDE EVENTS - 1837 to 2007

County	Number of Events (1)	County	Number of events (1)
Albany	6	Onondaga	10
Allegany	12	Ontario	1
Broome	7	Orange	3
Cattaraugus	17	Otsego	7
Chautauqua	14	Oswego	8
Chemung	15	Putnam	3
Chenango	6	Rensselaer	22
Clinton	1	Rockland	6
Columbia	14	Saratoga	5
Delaware	6	Schenectady	3
Essex	8	Seneca	1
Erie	4	Steuben	39
Fulton	2	Suffolk	14
Genesee	1	Sullivan	1
Lewis	7	Tioga	12
Livingston	2	Tompkins	10
Madison	2	Ulster	1
Monroe	1	Warren	1
Montgomery	13	Wayne	12
Nassau	11	Westchester	11
New York City	4	Yates	1
Niagara	5		**NY Total = 329**

Note 1. Number is approximate. Information taken from Landslide Inventory Map of New York pub. 1989, produced by NYSGS. Numerical data includes mud slides, rock slides, and landslides. Schenectady County All Hazard Mitigation Plan September 2006, Revised June 2007. USGS Open File Report 94-615.

The following two tables **Table 3-65 and 3-66,** as excerpt from the landslide inventory map, show known fatal and non-fatal landslides in New York State. The table indicates 75 total fatalities occurring from 13 separate landslide events through the period. This

table does not include the January 19, 1996 landslide occurring in Schenectady County which resulted in one fatality.

Table 3-65

FATAL LANDSLIDES - 1837 to 2007

Date	County	No. Fatalities	Description	County Data Sheet Number (1)
1837 - Jan. 1	Rensselaer	5	A steep escarpment of glacial lake clay at Troy suddenly failed, destroying several homes, a brick kiln and a stable.	13A
1843 - Feb. 17	Rensselaer	17	At Troy, near the location of the 1833 slide, clay was being mined from the base of the hill. Several homes were destroyed.	13A
1887 – April 13	Montgomery	2	Debris slide onto railroad. Train derailed. Engineer and fireman killed.	12
1905	Niagara	1	Rockfall at Niagara Gorge killed a trolley driver.	6A
1906 - Jan. 8	Rockland	22	Clay mining in the village of Haverstraw resulted in the failure of a near vertical wall in glacial lake clay. Thirteen (13) homes toppled into pit.	4
1915 - Aug. 2	Columbia	5	Near the city of Hudson. An earth lateral spread in glacial lake clays destroyed a powerhouse, killing five (5) workers.	2A
1917 - July 1	Niagara	12	Railroad embankment slide in Niagara Gorge. Train toppled into river.	6B
1920 - Sept. 6	Niagara	3	Rockfall near Cave of Winds	6C
1921 - Dec. 16	Ulster	2	Near Village of Glasco. Failure of wall in clay bank killed two (2) workers.	6
1934 - April 8	Orange	3	Debris flow down Storm King Mountain onto highway; destroyed three (3) automobiles.	3
1956 - June 7	Niagara	1	Three (3) large rockfalls in the Niagara Gorge destroyed the Schoellkopf Power Station.	1
1988 - Jan. 21	Westchester	1	Rockfall on NYS Thruway near Tarrytown	1A
1996 - Jan. 19	Schenectady	1	Closed Street for approx 1 week Total City Storm Damage $2.6 million	

Source: Landslide Inventory Map of NY pub. 1989, produced by NYSGS. Schenectady County All Hazard Mitigation Plan September 2006, Revised June 2007

Table 3-66

NON - FATAL LANDSLIDES - 1963 to 2007

Date	County	Description
1963 - June 29	Essex	Near village of Lake Placid. Two landslides sent debris onto Route 73 trapping 40 to 50 automobiles.
1982 - April 16	Dutchess	Stormville Mountain. Rockslide blocked 200ft section of I84 for at least three (3) days.
1982 -June 24	Albany	Bethlehem. Landslide behind Del Lanes Bowling Alley threatened City of Albany's water supply line.
April 27, 1993	Onondaga	a landslide severely damaged three homes near the town of LaFayette in the Tully Valley, four additional homes had to be evacuated
1998 - May 7	Columbia and Renss.	Mudslides blocked Route 9J and Amtrack passenger lines near Stuyvesant.
1999 - Sept. 18	Adirondack High Peaks Area	At least five (5) landslides in this area. Primarily Wright Peak, Algonquin Peak, and Mt. Colden. Hikers trapped.
2000 - May17,June10, June16, July17	Albany	Bethlem. Landslide closed Route 443 (Delaware Ave.) for less than one month, with lane restrictions for some months following, and threatened Albany's water supply line.
2000 -May 20	Putnam	Rockslide closed six (6) mile portion of Route 9D and Breakneck Tunnel for one day. MTA schedules affected.
2001 - April 9	Montgomery	Mudslide blocked Route 5 about two (2) miles east of Amsterdam.
2001 - April 9	Onondaga	Town of Lafayette. Close to RR. Closed one road in town of Lysander.
2003 - Mar. 19	Greene	Closed driving lane of NYS Thruway (I87) for one day.
2003 - June 25	Suffolk	High ocean bluff collapse in Montauk. Possibly one house affected.
2004 - March 8,	Schenectady	$200k Evacuation of six homes, two houses demolished closed traffic; Drilling and soil analysis has been conducted.

Source: Landslide Inventory Map of New York pub. 1989, produced by NYSGS Schenectady County All Hazard Mitigation Plan September 2006, Revised June 2007. USGS Open File Report 94-615.

The following narrative includes reference to 2 historical landslide events in Schenectady and Albany Counties (excerpt from the County local plans, NYSEMO Situation Reports, and USGS Open File Report).

Schenectady County, City of Schenectady (Eastern NY @ the Mohawk River Valley Capital District)

- Landslides within Schenectady County have historically been associated with the silty sands and clays deposited in glacial Lake Albany that subsequently were eroded by the Mohawk River over the thousands of years after the glacial lake drained creating the steep bluffs that line Downtown Schenectady. These bluffs exhibit angles of repose between 30 and 45 degrees and are covered with dense vegetation containing many mature trees. Over time gravity takes its toll and evidence of slope movement can be inferred by observing the J shape of the tree trunks on the slope. In the past ten years several significant landslides have occurred as noted in the following **Table 3-67**. The January 1996 (part of a previously discussed major winter storm event) slide resulted in one death and significant property damage to one business on Broadway. And the other event characterized as a slow slump due to soil saturated from rains and thaw occurred in March of 2004 resulted in the demolition of two residential structures, and temporary evacuation of four other nearby structures, on First Ave. and temporary closure of Broadway and three businesses located at the base of the hill. The apparent hiatus of landslides between 1996 and early 1900's is not because there were no landslides, but related to the lack of adequate research on landslides in the Country.

Table 3-67
Historic Landslide Events

Landslides and Date	Area Affected	Property Damage Estimate National Weather Service	FEMA Local Government Reimbursement
April 2004	Slope below Bellevue Little League - City of Schenectady	Leaking water service saturated soil and landslide occurred down to railroad track	
March 8, 2004	Schenectady, 1st Ave. & Broadway – City of Schenectady	$200k Evacuation of six homes, two houses demolished closed traffic; Drilling and soil analysis has been conducted.	
Aug. 4, 2003	I-890- City of Schenectady	Slumping I-890, @Michigan Ave., Closed 1 lane 1-3 days	
Jan. 19, 1996	Schenectady, Broadway Tel Oil below Summit Ave. City of Schenectady	One Death, Closed Street for approx one week	Total City Storm Damage $2.6 million no data was available directly related to the landslide.
Oct. 7-8, 1903	Landslide Veeder Ave. onto Broadway City of Schenectady	Pushed one house off foundation	
Sept. 18, 1853	Landslide Schermerhorn Ravine between Bellevue and Mt. Pleasant City of Schenectady	Blocked railroad for short period.	

Source: Major Floods on the Mohawk River (NY): 1832-2000 Mat Scheller; Karen Luey; John I. Garver, Ph.D. Schenectady County All Hazard Mitigation Plan September 2006, Revised June 2007

The 1996 Broadway landslide occurred as a result of rainfall and rapid snow melt. It resulted in one death and closing of Broadway for approximately a 48 hour period for removal of mud and trees that flowed off the hill west of Summit Ave. Several other reported landslides (in relation to flood reports) are included above in **Table 3-67**. An earth-slide in Sept. 18, 1853 on the railroad tracks in Schermerhorn's ravine caused a detention of the cars for a few hours. Veeder's mill dam, we understand, was partially damaged. An autumn flood October 7 –8 of 1903; caused a landslide from Veeder Ave onto Centre St. now Broadway the account of the landslide that knocked a house off its foundation and filled the basement with landslide debris.

Other events include: Summer of 2003 minor slump of hillside on the east side of I-890 south of Michigan Ave. Closing of one lane for less than 24 hours. In addition there have been three areas in the Town of Princetown that have experienced land slides over the past twenty five years. Kelley Station Road at the railroad crossing of Rt. 7 had a landslide in the 1980's due to a heavy rainfall event, and that slope continues to be susceptible to slumping. Ennis Road near the Sand Sea Kill has experienced slope stability problems due to erosion of the bank during storm events that fill the Sand Sea Kill, (note that condition should be remedied by June 2007 through the work funded by a Hazard Mitigation Grant Program award made this past year.) and most recently during the June flood of 2006 the Sand Sea Kill eroded the slope adjoining Pattersonville/Rynex Corners Rd.

***Albany County, Town of Bethlehem (eastern NY Capital District)* –** May 16, 2000 a landslide occurred along in an area of commerce along Delaware Avenue and adjacent the Normans Kill Creek in the Town of Bethlehem. Damages were estimated to reach $20-$25 million including direct damages to buildings and infrastructure, business loss, municipal support, and construction cost to stabilize and relocate the creek channel and move a water supply line.

Onondaga County, Tully Valley, near the Town of Lafayette (15 miles south of Syracuse, western central NY) - On April 27, 1993, a landslide severely damaged three homes near the town of Lafayette in the Tully Valley, 24 km (15 miles) south of Syracuse, New York. Four additional homes had to be evacuated. This landslide, which occurred after heavy precipitation of 190 mm (7.5 in) during April in conjunction with melting of a winter snow pack, led to considerable concern among the local authorities as well as the population about the stability of the slopes in the Finger Lakes region. The Tully Valley landslide was the largest in New York in the past 75 years (Fickies, 1993). The scarp is approximately 450 m (1500 feet) wide and the landslide measures 600 m (1800 feet) from crown to toe. The toe of the landslide overrode Tully Farms Road and destroyed 22 hectares (55 acres) of farmland (Fickies, 1993). Material involved in this landslide mainly consists of red lake clay deposits of glacial origin, covered by glacial till and colluvium of varying thickness.

A logistic regression analysis was performed within a Geographic Information System (GIS) environment to develop a model of landslide susceptibility for the Tully Valley study area (Wieczorek and Jaeger, 1994). Presence of glacial clays, slope angle, and

glacial lake levels were used as explanatory variables for landslide incidence. The spatial probability of landsliding, categorized as low, moderate and high, is portrayed within 90-m square cells on the susceptibility map.

Probability of Future Landslide Hazard Events:

Given the history of occurrences in New York State, it is certain that future landslides will occur. Therefore, we can express the probability of future landslides in New York State as high. This Plan expresses the probability of future landslides using recognized scientific method and simple historic landslide event frequency to project potential future occurrences.

Using documented historical occurrences (NYSGS Landslide Inventory Study) to estimate the probability of future landslides, New York State can expect on average approximately two (2) major landslides each year, a greater number of smaller but still significant slides/slumps/flows each year and at least one landslide causing a fatality, is expected once every 12 years.

In summary, although historical data indicates a high frequency of landslide occurrence, the New York State Geological Survey estimates that 80% of the State has a low susceptibility to landslides. The frequency of damaging landslides within and adjacent to New York State has been and can be classified, relative to other higher risk states, as low. However, the fact that high landslide susceptibility exists and landslides have occurred in the past suggests that the states infrastructure and many people are at risk from damaging landslide hazards in New York State.

Jurisdictions Most Threatened By and Vulnerable to Landslide Hazard:

Table 3-68 presents the results of New York State's vulnerability assessment indicating Counties most vulnerable to landslide hazard as determined by a final rating score. Each county jurisdiction accumulates points based on the value of each variable indicator, the higher the indication for landslide exposure the more points assigned, resulting in a final rating score (see the following scoring table). The results of NYS's landslide vulnerability assessment present a gross indication of Counties most threatened by and vulnerable to landslide hazard using readily available information. NYS believes the analysis methodology is sound in that it provides a reasonable assessment of vulnerability using key available indicators. NYS acknowledges its limitations for complete accuracy and recognize some of the reasons why. Many generally recognized indicators for landslide vulnerability are not readily available and are not comprehensive and standardized enough to be easily included into our analysis at this time. Additionally, data may exist but is not practical to apply to a statewide level analysis. Gaps include building attributes and associated level of vulnerability, local or site specific conditions, building positional accuracy, local level accuracy of surficial soils information. Further, we recognize that its applicability may not be appropriate beyond a general indication, especially at the local level. We have established activities in our mitigation strategy that will expend hazard risk assessment using local risk assessment information. We also

included a recent proposal written by USGS Water Science Center in the end of this section of Landslide Hazard Profile. This project of USGS Water Science Center, if approved, would have the potential to greatly advance the accuracy of landslide hazard risk assessment through collection of better data, future more detailed analysis, and continued application of GIS technology. For this current version of Mitigation Plan, our methodology includes use of a generally accepted landslide hazard map provided by USGS. We recreated this map, as a GIS layer to run the analysis which provided the results in **Table 3-68**.

Table 3-68
Jurisdiction Most Threatened by Landslides and Vulnerable to Landslides Loss
(Excluding population data)

County	Rating Score	*Landslide Susceptibility	# of Landslide Events**	# of Structures (top 3 category areas only)
Rensselaer	13	1.07	22	44593
Suffolk	13	1.73	14	461456
Nassau	12	1.14	11	395748
Albany	11	1.09	6	83117
Broome	11	1.60	7	60079
Monroe	11	2.05	1	210552
Erie	10	0.92	8	277470
Niagara	10	3.04	5	66394
Onondaga	10	0.66	10	132013
Rockland	10	1.03	6	73767
Wayne	10	1.37	12	30592
Westchester	10	0.25	11	211689
Chautauqua	9	0.21	14	45310
Orange	9	0.58	3	92068
Oswego	9	2.10	0	40083
Putnam	9	1.85	3	32303
Saratoga	9	1.22	5	66122
Steuben	9	0.07	39	34710
Ulster	9	1.49	1	58343
Allegany	8	0.67	12	18096
Cattaraugus	8	0.07	17	29499
Columbia	8	0.69	14	23405
Dutchess	8	1.35	0	79721
Delaware	7	0.87	6	21904
Essex	7	1.41	4	17157
Greene	7	2.27	0	19884
Jefferson	7	1.16	0	37938
Schenectady	7	0.39	3	44729
St. Lawrence	7	1.07	0	36213
Sullivan	7	0.57	1	33201
Tompkins	7	0.18	10	24171
Cayuga	6	0.58	0	26291
Chemung	6	0.00	15	26831

County	Rating Score	*Landslide Susceptibility	# of Landslide Events**	# of Structures (top 3 category areas only)
Clinton	6	0.34	1	24229
Oneida	6	0.39	0	69590
Orleans	6	2.93	0	13110
Tioga	6	0.13	12	17232
Bronx	5	0.00	0	89896
Chenango	5	0.09	6	18194
Franklin	5	0.81	0	17453
Genesee	5	0.83	1	17646
Kings	5	0.00	0	258603
Madison	5	0.22	2	21705
New York City	5	0.00	4	56385
Ontario	5	0.06	1	32618
Queens	5	0.00	0	343289
Richmond	5	0.00	0	111561
Warren	5	0.01	1	26234
Washington	5	0.92	0	20361
Livingston	4	0.06	2	18476
Montgomery	4	0.00	13	14829
Otsego	4	0.00	7	21815
Cortland	3	0.35	0	13599
Fulton	3	0.00	2	20226
Lewis	3	0.00	7	11475
Schuyler	3	0.23	0	7378
Seneca	3	0.01	1	11423
Yates	3	0.11	1	9542
Herkimer	2	0.00	0	22928
Hamilton	1	0.00	0	6252
Schoharie	1	0.00	0	12026
Wyoming	1	0.00	0	12844

	Rating Score	*Landslide Susceptibility (calculated)	# of Landslide Events**	# of Structures (HAZUS)
Rating Score - Variables Distributions and Point Values	score value 1	.01-.15	1-5	1-17K
	score value 2	.15-.50	6-10	18-24K
	score value 3	.51-1.0	11-15	25-40K
	score value 4	1-1.5	16-20	41-80K
	score value 5	1.5 – 3 +	21 +	81-462K

State Facilities – Assessing Vulnerability and Estimating Loss for Landslide Hazard:

Table 3-69 and **Figure 3-202** presents the result of the landslide hazard vulnerability assessment and loss analysis for state facilities. The results depict a gross estimate of potential landslide losses to those identified vulnerable State facilities in terms of dollar value of exposed property. For this plan, landslide hazard vulnerability analysis and loss estimation methodology was supported by GIS technology and involved collaboration with key state agencies. Collaboration resulted in the identification of two (2) state databases that provided key facility information. The NYS Offices of General Services (OGS) fixed asset data base and Cyber Security Critical Infrastructure Coordination (CSCIC) database included fields that provide facility location data and replacement value in dollars. The analysis involved creation of a GIS layer for state facilities using the coordinate information and an overlay onto a landslide hazard layer developed using a USGS landslide risk value map. In this plan we acknowledge the limitations of this analysis to provide site specific accuracy and that its applicability may not be appropriate beyond a general indication. Instead the analysis results may be best used as a guide to help target facilities that would benefit from further analysis. We have established activities in our mitigation strategy that will advance the accuracy of the State facilities risk assessment through further analysis. Future analysis may include expressing potential loss based on historical landslide loss information, continued application of GIS technology, and use of site specific data such as percent slope and soil type and building attribute information which will allow targeting of the most vulnerable facilities.

Table 3-69
Landslide Hazard Exposure (by incidence and susceptibility)
New York State Agency Facilities

NY State Agency	**Total Facilities**	**Moderate Incidence** Total number # and percent %	**Moderate Incidence** Critical facilities total # and %	**Moderate Susceptibility - Low Incidence** Total number # and percent %	**Moderate Susceptibility - Low Incidence** Critical facilities total # and %	**Low Incidence** Total number # and percent %	**Low Incidence** Critical facilities total # and %
Department of Environmental Conservation	1880	18 (1.0 %)	0	73 (3.9%)	0	1549 (82.4%)	0
	$104,611,361	$510,303 (0.5%)	0	$5,712,522 (5.5%)	0	$80,168,069 (76.6%)	0
Department of Transportation	908	32 (3.3%)	0*	92 (9.4%)	0*	667 (68.1%)	0*
	$232,514,852	$6,003,127 (2.6%)	0*	$24,854,486 (10.7%)	0*	$166,979,671 (71.8%)	0*
Office of General Services	130	1 (0.8%)	1 (0.8%)	6 (4.6%)	6 (4.6%)	30 (23.1%)	30 (23.1%)
	$2,133,659,048	$12,021,237 (0.6%)	$12021237 (0.6%)	$18,350,458 (0.9%)	$18,350,458 (0.9%)	$118,120,618 (5.5)%	$118,120,618 (5.5)%
State Emergency Management Office	4	0	0	0	0	0	0
	$3,365,434	0	0	0	0	0	0
Number of facilities Total	**2922**	**51 (1.7 %)**	**1**	**171 (5.9%)**	**6**	**2246 (76.9%)**	**30**
~ Replacement Value of Structure ($)	**$2,472,819,244**	**$18,534,667 (0.8%)**	$12,021,237	**$48,917,466 (2.0%)**	$18,350,458	**$ 365,268,358 (14.8 %)**	$118,120,618

Source: NYS Fixed Asset information -Offices of General Services and Cyber Security Critical Infrastructure Coordination data bases, USGS Landslide Hazard Susceptibility Map. Analysis supported by GIS technology.

Table 3-69
Landslide Hazard Exposure for State Facilities

NY State Agency	Total Facilities	High Incidence Total number # and percent %	High Incidence Critical facilities total # and %	High Susceptibility - Moderate Incidence Total number # and percent %	High Susceptibility - Moderate Incidence Critical facilities total # and %	High Susceptibility - Low Incidence Total number # and percent %	High Susceptibility - Low Incidence Critical facilities total # and %
Department of Environmental Conservation	1880	18	0	172	0	45	0
		1.0 %		9.1%		2.4%	
	$104,611,361	$2,313,327	0	$10,148,184	0	$5,313,127	0
		2.2 %		9.7%		5.1%	
Department of Transportation	908	27	0*	11	0*	35	0*
		2.8%		1.1%		3.6%	
	$232,514,852	$9,111,610	0*	$1,166,121	0*	$5,843,392	0*
		3.9%		.5%		2.5%	
Office of General Services	130	88	88 (67.7%)	0	0	0	0
		67.7%					
	$2,133,659,048	$1,948,923,321	$1,948,923,321 (91.3%)	0	0	0	0
		91.3%					
State Emergency Management Office	4	1 (25%)	1 (25%)	0	0	0	0
	$3,365,434	$1,422,523	$1,422,523	0	0	0	0
Number of facilities Total	**2922**	**134**	**89**	**183**	**0**	**80**	**0**
		4.58%		**6.26%**		**2.74%**	
~ Replacement Value Structure ($)	**$2,472,819,244**	**$ 1,961,770,781**	**$1,950,345,844**	**$11,314,305**	**0**	**$11,156,519**	**0**
		79.3%		**.46%**		**.45%**	

Source: NYS Fixed Asset information -Offices of General Services and Cyber Security Critical Infrastructure Coordination data bases, USGS Landslide Hazard Susceptibility Map. Analysis supported by GIS technology.

Estimating Potential Loss for Landslide Hazard by Jurisdiction

This version of the NYS Hazard Mitigation Plan does not include a description of potential dollar loss estimations by jurisdiction for the landslide hazard because of the absence of certain essential information. Additionally, unlike flood or earthquake hazard, there are not any standard loss estimation models or methodologies for the landslide hazard. A preliminary dollar loss estimate could have been calculated based on known information such as total structures for general occupancy class, indicated higher landslide hazard areas (USGS landslide hazard susceptibility map) as determined earlier in this plan, and residential structure dollar value estimates, however, many assumptions and generalizations would need to be made for unknowns. Unknowns or available data that has not been gathered or analyzed includes; inventory estimates of the more vulnerable structures such as those near steep slopes, steep slopes prone to erosion or structures near previous landslide occurrence areas, as well as historical, or critical structures and the type of and dollar damage figures. The many generalizations and guess work would result in figures with little accuracy and potentially misleading indications of a jurisdictions vulnerability and potential loss to the landslide hazard. Therefore, this version of the NYS risk assessment will instead include an identification of needed data and establish actions necessary to estimate potential losses. As local mitigation plans with landslide hazard risk assessments data becomes available, it will be incorporated into a state risk assessment repository for integration into the State risk assessment. Additionally, application of GIS technology will continue, including exploring the possibility of incorporating certain characteristics that lend to landslide occurrence such as; slope, surficial soils, and real property data layers in support of future landslide hazard vulnerability analysis.

Landslide Susceptibility – A Pilot Study of Schenectady County, NY

William Kappel, USGS; William Kelly, NYSGS; Andrew Kozlowski, NYSGS; Daniel O'Brien, NYSEMO; Jason McWhirter, NYSEMO; Ran Zhang, NYSEMO; James Kalohn, Schenectady County Economic Development and Planning Department; Mark Storti, Schenectady County Economic Development and Planning Department; Tony Minnitti, NYSDOT; Steve Emerick, NYSCSCIC

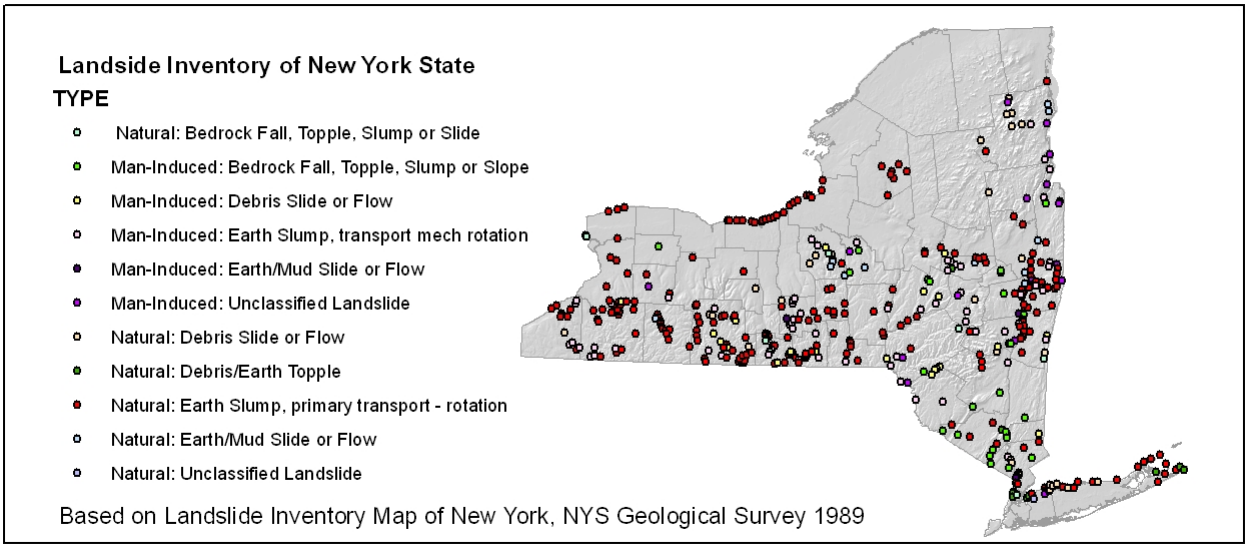
Background

A major impediment in developing an effective mitigation strategy for landslides has been the lack of mapping that delineates, with the necessary degree of geographic specificity, the slopes that are most susceptible to landslide. Consequently, there is a great deal of uncertainty about this hazard in respect to where to target mitigative actions and how to factor this hazard into local land use planning. A contrasting analogy can be made with flood hazard where extensive floodplain mapping has been undertaken through the National Flood Insurance Program (NFIP). Based on the delineation of the floodplain, mitigation measures and policies have been adopted as well as providing for the ability to make more informed decisions about the need for insurance. In the case of landslides, no such map products exist.

With only a limited understanding of the areas that are most susceptible to landslides, communities often make land use decisions and approve site plans that do not factor this hazard. Opportunities to take mitigative action such as slope stabilization are missed as hazardous areas go unidentified. Exacerbating conditions such as leaking water lines that drain into vulnerable slopes fail to get the appropriate maintenance priority or drainage discharges that need to be rerouted go unchecked. Best practices, such as avoiding additional loading on vulnerable slopes with debris or other materials or not to excavate from the bottom of these slopes, are rarely presented in clear and consistent messages to the public. In a state of lack of awareness, property owners are often taken by surprise and find themselves uninsured when damaging events occur.

The reasons for limited areas where landslide studies and hazard maps are available has much to do with an analysis that has been manually intensive, time consuming, and cost prohibitive. This situation is further magnified by the number and widespread areas in New York State that have experienced landslides (see **Figure 3-203**). The studies that have been focused primarily on a manual comparison of slope and the presence of soils prone to sliding, such as the 1982 NYS Geological Survey's "Geologic Hazards and Thickness of Overburden of the Albany, New York 15 Minute Quadrangle" by Robert H. Fickies and Peter T. Regan, New York State Museum and Science Service Map and Chart Series 36.

Figure 3-203



Since this 1982 study there have been key developments in the area of Geographic Information Systems (GIS) that has provided an opportunity to use the power of the computer to analyze and map what was previously done by hand. In addition there has been the conversion of key datasets critical to landside analysis into digital formats – particularly slope and soils. These datasets can be overlaid on a GIS with the ability to map locations of areas that have the coinciding soil properties and slope conditions that are most susceptible to sliding.

The recognition that significant progress in the area of landslide hazard mapping may be within reach given both GIS technology and the expanding availability of key digital datasets was previously noted in the 2004 New York State Hazard Mitigation Plan. This was also the agenda topic of a June 2006 meeting of Federal and State scientists and emergency management officials that was hosted by the USGS New York Water Science Center, Troy, NY. At this meeting a proposal entitled "Evaluation of Landslide Potential in New York State" drafted by the USGS, New York Water Science Center, Ithaca, NY was circulated. The proposal outlined an approach to generating a "Landslide Susceptibility Map for New York State" and the development of a landslide "Fact Sheet" targeted at local government officials. While the USGS proposal was well received, funding for the proposal remained elusive during the following year.

Pilot Study Purpose

While the June 2006 USGS proposal was supported in concept by the attending officials, there was no example product available that could be used to help convey what was being proposed that could be used to educate and generate additional support from a wider audience. In efforts to move the proposal forward, a "proof of concept" pilot study was discussed in July 2007 between the New York State Emergency Management Office, USGS and the New York State Geological Survey. At this time, the updating of the New York State Multi-Hazard Mitigation Plan was underway. This plan lays out a strategic direction to mitigating the impacts of natural disasters, including identifying specific activities that are needed to advance our understanding of risk – the framework of mitigation. The plan update provided an important opportunity to highlight the potentials to advance the landslide hazard risk assessment.

Pilot Study Organized

With a consensus between SEMO, USGS, and NYSGS that a pilot study would be useful and timely, a recommendation was made by the SEMO Planning Section to inquire if Schenectady County would be interested in participating in as well as serving as the focal study region of a pilot study. This recommendation was based on the county's landslide history; landslides focus within their Local Hazard Mitigation Plan; and interest in mitigating landslides through applications to Hazard Mitigation Grant Program (HMGP).

Based on an initial inquiry to Schenectady County and their expressed interest to learn more about what a pilot study would entail, a preliminary meeting was held with the county on August 13, 2007. In addition to representatives from SEMO, NYSGS, USGS and Schenectady County, representatives from the New York State Department of Transportation and the New York State Office of Cyber Security and Critical Infrastructure Coordination (CSCIC) were also in attendance.

This August 2007 meeting resulted in Schenectady County expressing tentative interest in participating in the pilot study with their final approval requiring further review by the County's legal staff. There was a concern that the study not place the county into a

situation of liability, which is understandable given the uncertainty with a project with no precedence. The liability concern was heightened by the initial pilot scope that was to include the risk to water, sewer and storm water infrastructure as well as these systems potential contribution to the landslide hazard due to potential leaking or run-off onto vulnerable slopes.

The County's need to take time to conduct a more thorough legal assessment on whether to participate would require time that was in short supply considering that the final submission date for the State Hazard Mitigation Plan was December 31, 2007 and the need for the study to be completed prior to that date. With a potential delay that threatened the ability to complete a project on time, a decision was made by the core pilot study agencies NYSEMO, NYSGS, and USGS, to proceed irrespective of the county's decision to participate. The pilot would focus only on the natural factors contributing to landslide susceptibility, a "Phase I" of sorts, leaving the integration of infrastructure as a potential "Phase II" effort. This decision was based on an opinion from SEMO management that the correct course of government is to do its best to understand the hazards it faces even if the knowledge that is gained from studying these hazards exposes previously unseen risks that call for remedies not factored in budgets as well as expose actions or inactions of government that may have compounded that risk.
This "Phase I" with an optional "Phase II" follow-up approach not only freed the group from the necessity of the county's participation, but also may provide a future model as this would enable State and Federal work to proceed according to its priorities, delivering initial useful products to Local government that in-turn could be advanced to a "Phase II" study in collaboration with the Local government who is often the owner of the infrastructure in question.

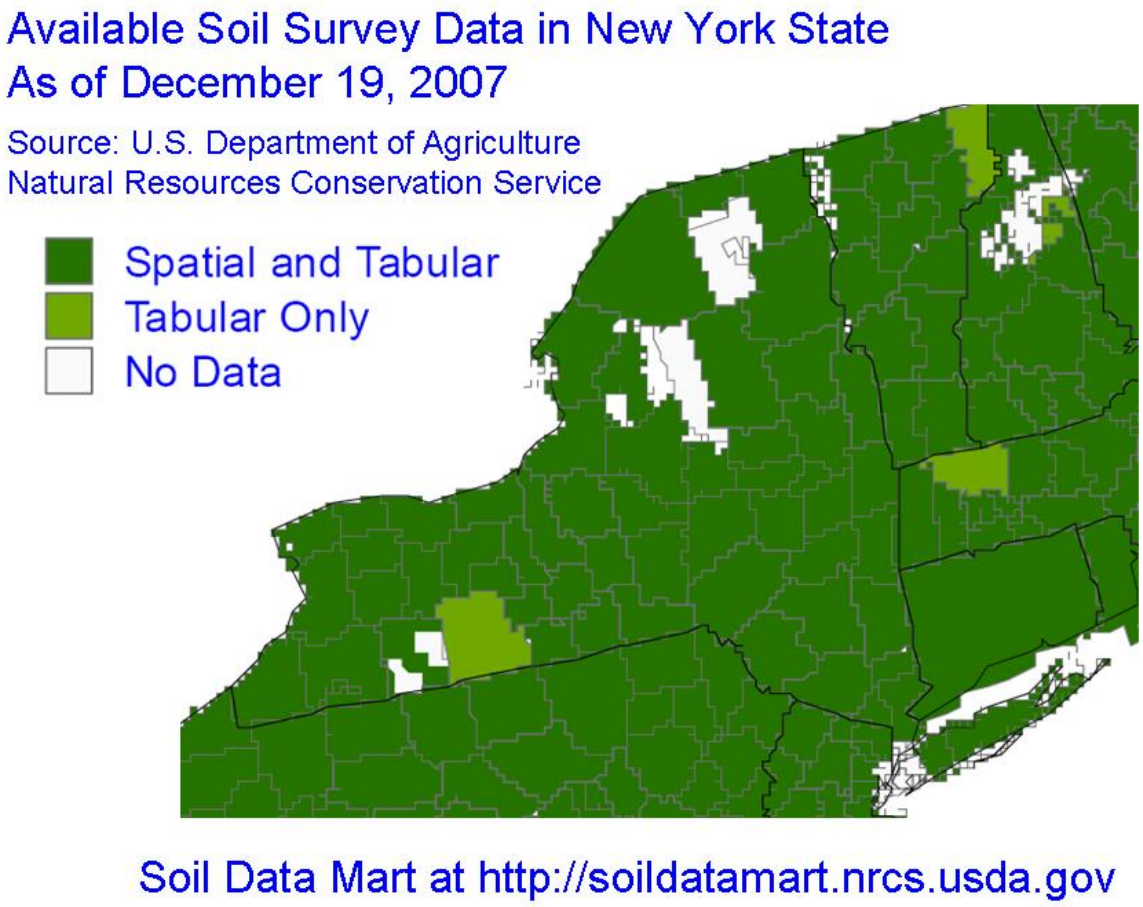
Fortunately, shortly after the decision was reached by the core agencies to proceed, Schenectady County made a decision to participate in the study. Given time constraints it was agreed that the project would focus on the geologic factors – a "Phase I" study, with the county's role focusing primarily on developing a GIS database of past landslide events. This information would be critical for model validation.

While a "Phase I" study does not necessarily require participation from local government it is most advantageous if a collaborative effort can be established. This was made most evident by the contribution Schenectady County has made to this pilot study. The knowledge that Local officials have of their geography, history of events, much of which is first hand, is of great value to understanding the landslide hazard. It is also important to recognize that it is Local government that is in the best position to mitigate the landslide hazard through land use regulation and other practices.

Pilot Study Methodology

An important aspect of the methodology used in this pilot study is that 5 of the 6 variables used to determine landslide susceptibility are derived from one source - the U.S. Department of Agriculture Natural Resource Conservation Service's SSURGO Digital Soil Survey, accessible for download at: http://soildatamart.nrcs.usda.gov .

Figure 3-204

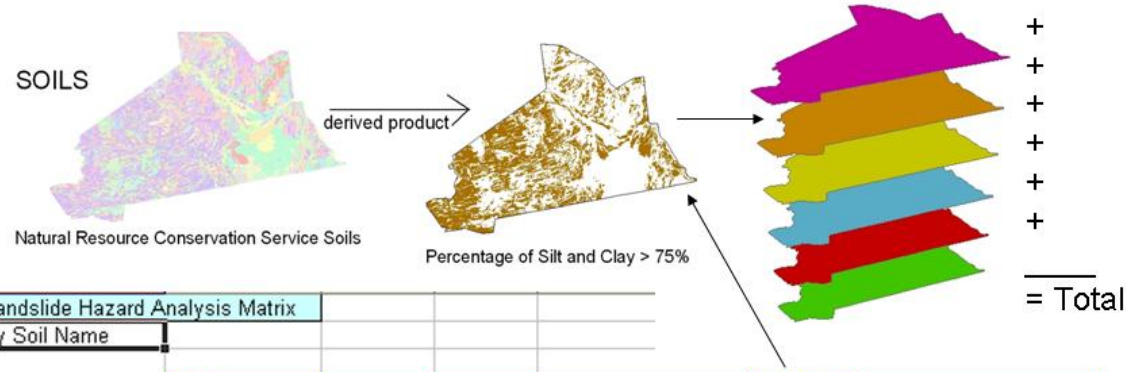


The NRCS web site provides for the ability to select a County of one's choosing and download the SSURGO soil survey database, including information in tabular and spatial (GIS) format. The spatial GIS data includes a GIS shapefile (polygon) of soil units attributed with the soil unit's letter key (field named "MUSYM"), while the tabular data includes a Microsoft Office Access Application with the ability to generate soil reports that provide a great number of data on each soil unit.

Included in the tabular data are soil properties that factor into calculating landslide susceptibility. The soil unit properties contained in the soil survey that were identified by the pilot study geologists Kappel, Kelly, and Kozlowski as landslide susceptibility indicators include: 1) American Association of State Highway and Transportation Officials (ASSHTO) Soil Classification; 2) Liquid Limit; 3) Hydrologic Group; 4) Physical Soil Properties (%silt and %clay); and 5) Hazard of Erosion. In this pilot study methodology, each of these soil unit properties was assigned a weighted value relative to their contributing factor in predicting landslide susceptibility (see **Figure 3-205** – relative weights are shown in parentheses).

Figure 3-205

United States Geological Survey / New York State Geological Survey's Preliminary Landslide Analysis Algorithm



Landslide Hazard Analysis Matrix
by Soil Name

Factor	Soil Classification - AASHTO	Slope	Liquid Limit	Hydrologic Group	Physical Soil Properties	Hazards of Erosion
Rating	1 - 14.	10. - 50.	2 - 8.	1 - 4.	1 - 4.	1. - 12.
Factor rating or range and numerical rating - in parathesis	1 (2) 2 (4) 3 (6) 4 (8) 5 (10) 6 (12) 7 (14)	% slope 0-2, (10) 3-7, (20) 8-15, (30) 16-25, (40) >25 (50)	0-65 as: 00-15, (2) 16-30, (4) 31-45, (6) 46+ (8)	A thru D A sand & gravel (1) B sandy-coarse (2) C mod.f. texture (3) D clay/silt texture (4)	% silt and clay as: 0-25, (1) 26-50, (2) 51-75, (3) 76-100, (4)	Word/# modifier: slight 0.0 (1) moderate 0.33 (4) severe, 0.65 (8) very severe > 65 (12)

Landslide Risk Assessment

To access the identified soil unit properties, the Microsoft Office Access Application is used to generate soil reports that can be exported to an Excel format. With some database preparation, including deletion of cells containing long sentences, text descriptions and deletion of blank records and cells, this file can be linked to the GIS soil unit shapefile. Using the (MUSYM) field as database link, the pertinent attribute information for landslide susceptibility is established within the GIS layer.

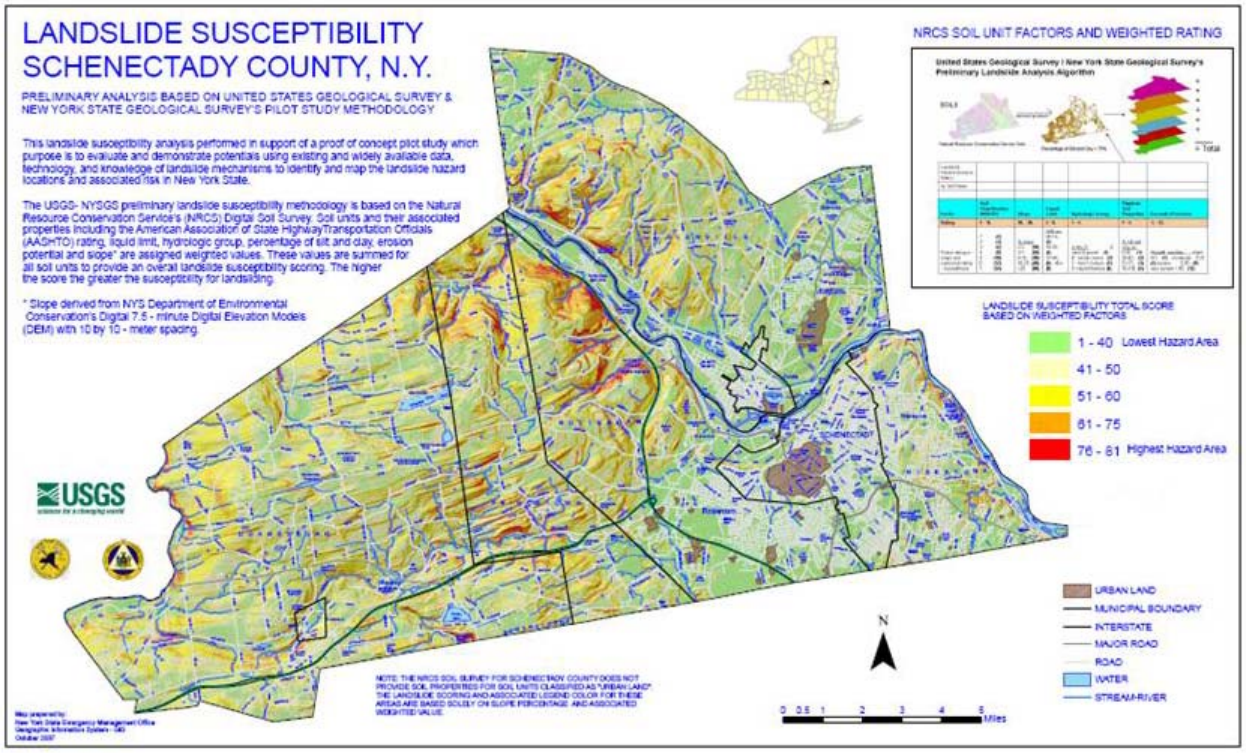
The landslide susceptibility variable that receives the highest weighted value in this methodology is slope. While the SSURGO soil units contain information on slope (indicated by the letters "A", "B" or "C" that are appended to soil text abbreviation (MUSYM)), the slope values that were used in this study were based on a slope analysis derived from a countywide Digital Elevation Model (DEM) compiled from the NYS Department of Environmental Conservation's 7.5 Minute Quadrangle DEMS. It was believed this would provide a more accurate indicator of slope than the SSURGO source.

The slope map generated from the NYS Department of Environmental Conservation's 7.5 Minute Quadrangle DEMS was combined (ESRI "Union" command) with the SSURGO Soil Survey GIS layer that was previously attributed with the landslide susceptibility

variables. At this point each discrete soil unit had all six variable values and the corresponding weighted values as individual fields in the attribute table. The six fields containing the weighted values of the six variables were then summed to establish a landslide susceptibility "total score". The "total score" ranged from areas with numbers as low as 4 to as high as 81.

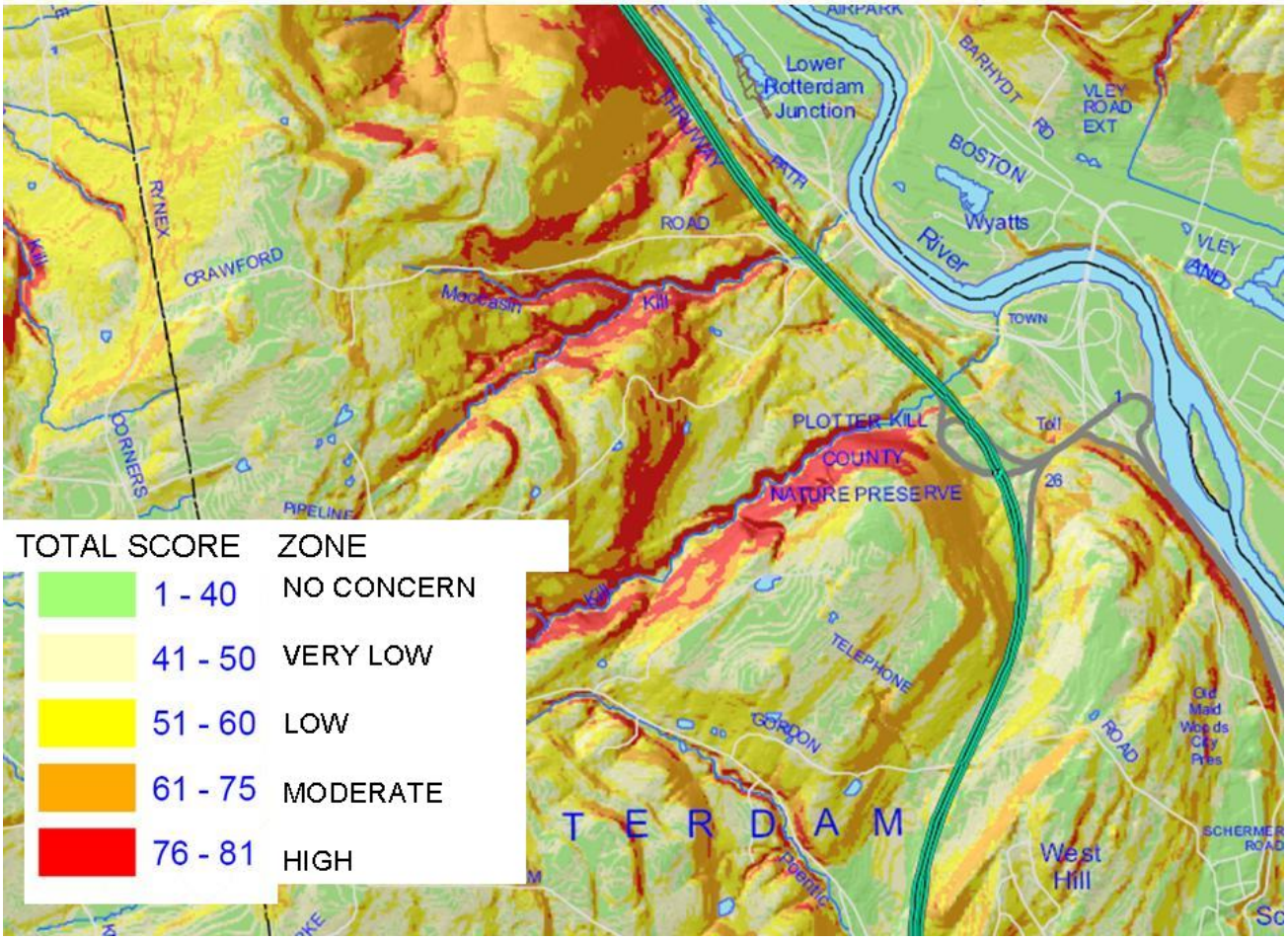
Figure 3-206

Thumbnail Overview of 26"x 42" Map Showing Results of Pilot Study: Landslide Susceptibility Schenectady County, N.Y.



Range groupings were established from "total score" values to assign landslide susceptibility descriptive zones as "HIGH" – greater than 75 (RED); "MODERATE" – 61 – 75 (ORANGE); "LOW" – 51 – 60 (YELLOW); "VERY LOW" – 41 – 50 (BEIGE); "NO CONCERN" – less than 41 (GREEN). See **Figure 3-207**.

Figure 3-207



Model Limitation in NRCS Soil Survey Areas Classified as "Urban"

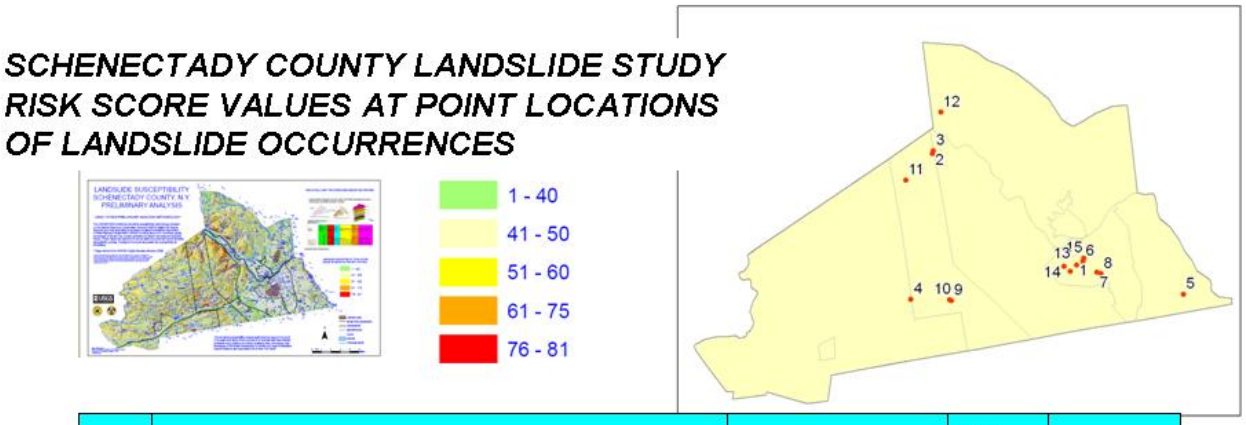
As the NRCS Soil Surveys were developed primarily for agricultural purposes, portions of the Schenectady County that are highly developed, primarily in the City of Schenectady, have soil units that are classified as "Urban". The SSURGO database does not include soil properties for the "Urban" soils. Consequently, while slope values for these areas can be calculated from the DEMs, the remaining 5 variables and their associated weighted values were not able to be derived from the Soil Survey. As a result, the "total score" values in these areas do not reflect the appropriate level of hazard and have been excluded from the study.

Pilot Study Validation

A validation of the model was performed by comparing the locations of past landslide events to the landslide susceptibility map. Schenectady County Economic Development and Planning Department provided a GIS point file of 15 landslide events. These landslides are larger events taken from recent memory and historical records where a general location was easily supplied. There have been many others, usually of lesser magnitude, which have not been geographically located (latitude / longitude) and therefore were not used in this initial assessment.

The GIS file of landslide events was overlaid on the landslide susceptibility map with each landslide event tagged with the "total score" value at the respective point location. The results showing the total score value and associated zone color for each landslide event is shown in **Figure 3-208**.

Figure 3-208

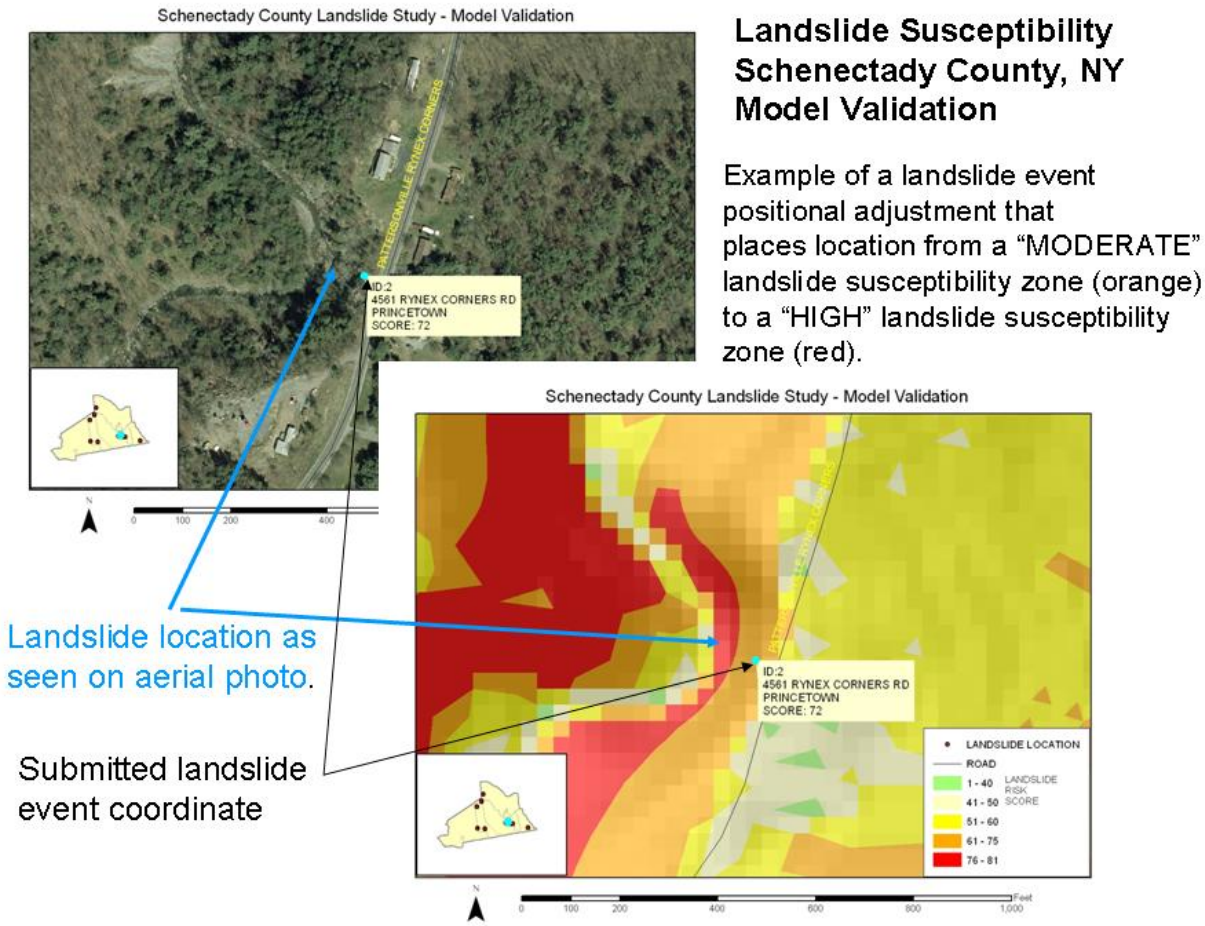


ID	LOCATION	MUNICIPALITY	RISK SCORE	MAP COLOR
1	797 BROADWAY	SCHENECTADY	61	
2	4561 RYNEX CORNERS RD	PRINCETOWN	72	
3	4853 PATTERSONVILLE-RYNEX CORNERS RD	ROTTERDAM	78	
4	4169 SCOTCH RIDGE RD	DUANESBURG	68	
5	2654 TROY-SCHENECTADY RD	NISKAYUNA	77	
6	585 BROADWAY	SCHENECTADY	76	
7	RAMP OFF I-890	SCHENECTADY	61	
8	RAMP OFF I-890	SCHENECTADY	21	
9	248 KELLEY STATION RD	PRINCETOWN	48	
10	KELLEY STATION RD	PRINCETOWN	38	
11	ENNIS RD	PRINCETOWN	76	
12	WOLF HOLLOW RD	GLENVILLE	58	
13	BELLEVUE LITTLE LEAGUE	SCHENECTADY	61	
14	SCHERMERHORN RAVINE	SCHENECTADY	41	
15	VEEDER/BROADWAY	SCHENECTADY	76	

On first inspection, only 5 of the 15 landslide events fall within a "HIGH" landslide susceptibility zone. On further inspection, however, using an orthoimagery backdrop, it becomes apparent that a slight adjustment in the point location of the landslide to fall more directly on the visible slide area would result in 10 of the 15 landslide events in a "HIGH" landslide susceptibility area. In addition, several of the locations where the

landslide score was low, appear to be related to road construction embankments. Since the model is based on natural soils characteristics and slope, these changes are not accounted for in this model. With these landslide events eliminated from the validation, 10 of 13 landslide events fall within a “HIGH” landslide susceptible zone.

Figure 3-209



The “HIGH” landslide susceptibility zone comprises only 2% of the total area of Schenectady County. Given that only a limited area of the County is classified as “HIGH” susceptibility and that 10 of 13 landslide events fall within this zone, the model has shown, in this instance, to be an excellent predictor of the landslide hazard.

Model Refinements

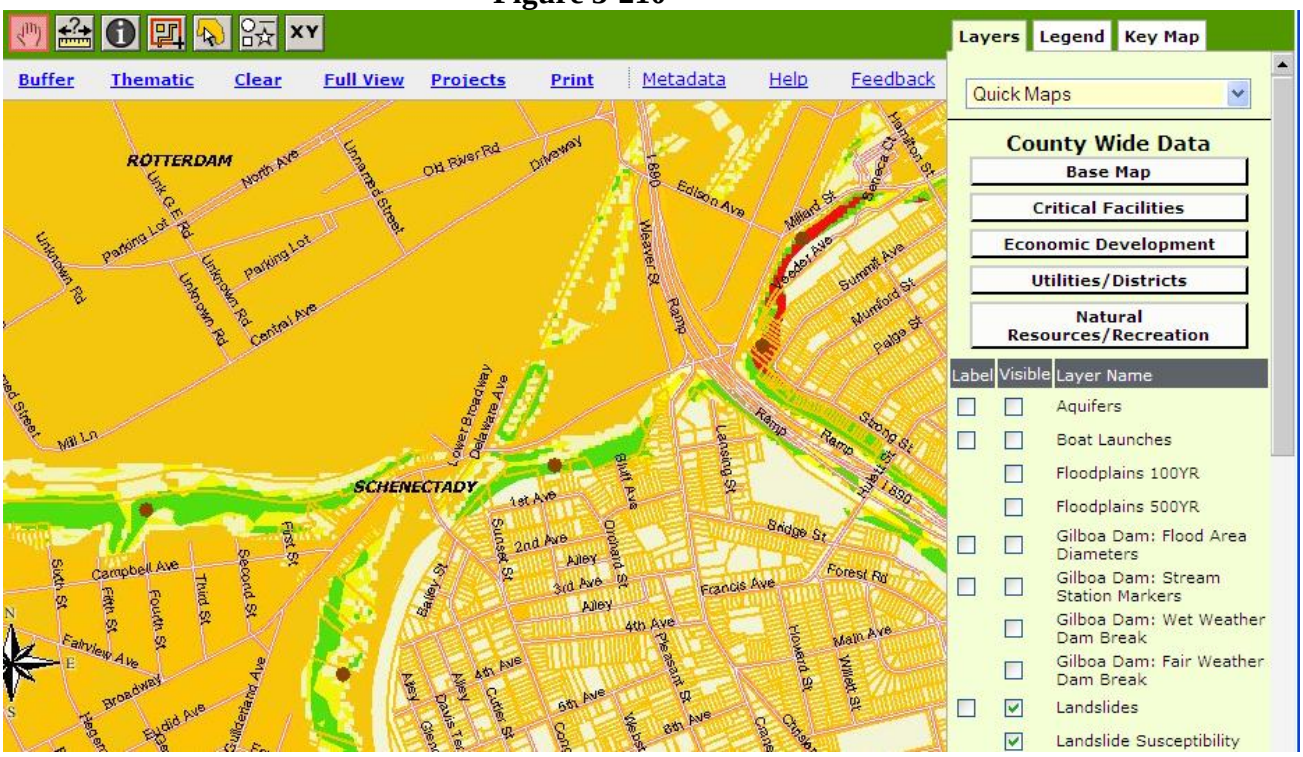
As a pilot study, the methodology used can be considered preliminary. It would likely be refined through additional studies. Approaches that address the lack of data for “Urban” soils will need to be devised as well as other shortcomings such as the limited information of soil depths. A “Phase II” study that looks at the inclusion of infrastructure would also be of benefit in furthering the identified hazardous areas.

While the NYSDEC DEM provides an acceptable slope resolution, the use of Light Imaging Detection and Ranging (LIDAR) terrain data that is becoming more widely available through FEMA Flood Map Modernization Program will provide better slope input as well as may be useful in identifying previous undocumented landslides. An effort should be made to ensure when collecting LIDAR data for a floodplain mapping, the surrounding slopes are also included. FEMA should consider the multi-hazard utility of LIDAR into its data collection plan.

Conclusion

The Landslide Susceptibility Pilot Study of Schenectady County provides a "proof of concept" example, reinforcing previous statements by the USGS and New York State Multi-Hazard Mitigation Plan that significant advancements can be made in mapping the landslide hazard in New York State. Given existing widely available data, GIS technology, and knowledge of landslide mechanisms, landslide susceptibility maps can be generated in a cost effective manner. The geographic resolution of these maps is sufficient for land use planning and would provide a foundation for mitigation. Importantly, as a digital product, these landslide susceptibility maps can be easily integrated into systems that make the data widely available to the general public or for internal government review as is demonstrated by the integration of the landslide susceptibility GIS map layer into County's "Schenectady Internet Mapping System (SIMS)" - (see **Figure 3-210**).

Figure 3-210



While this pilot demonstrates that landslide susceptibility maps can be generated in a more cost effective manner than was previously possible, it does not imply that resources

will not be needed to expand this work to other Counties and eventually Statewide. Of particular need is staffing. The New York State Geological Survey has traditionally been the lead agency on landslide hazard analysis and for many years had staff supporting this responsibility. This staff position has remained unfilled following a retirement several years ago. In addition the agency no longer has its own in-house GIS staff and now relies on limited shared NYS Museum GIS staff.

The enhancement of staffing and resources at the NYS Geological Survey would enable this agency to better serve its traditional role and responsibilities with landslides as well as serve as lead agency for a multi-agency program focusing on landslide evaluation and susceptibility mapping. This program should include, but not limited to NYSDOT, NYSEMO, and possibly NYSCSCIC, which may be in the best position to serve as an interactive clearinghouse for reporting and mapping landslide occurrences.

Irrespective of how the State may organize itself in the future to better map landslide susceptibility as well as support landslide hazard mitigation in general, coordination with the USGS and with Local government, an important end user of this information, will be critical to a successful program. The theme of Federal-State-Local partnership that is demonstrated with the Landside Susceptibility Pilot Study of Schenectady County should be carried forward in future efforts. This theme of partnership is also consistent with recommendations made by the National Research Council of the National Academies in its report "Partnerships for Reducing Landslide Risk – Assessment of the National Landslide Hazards Mitigation Strategy", available at:
http://www.nap.edu/catelog/10946.html