TABLES

FIGURES

SECTION 12. LANDSLIDE

12.1 GENERAL BACKGROUND

The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors (USGS, 2013). According to the state geologist, Steve Mabee, slope saturation by water is a primary cause of landslides in the Commonwealth. This effect can be in the form of intense rainfall, snowmelt, changes in groundwater level, and water level changes along coastlines, earth dams, and the banks of lakes, rivers, and reservoirs. Water added to a slope can not only add weight to the slope, which increases the driving force, but can increase the pore pressure in fractures and soil pores, which decreases the internal strength of the earth materials needed to resist the driving forces.

Landslides in Massachusetts can be divided into four general groups, construction related, over steepened slopes caused by undercutting due to flooding or wave action, adverse geologic conditions, and slope saturation. Construction related failures occur predominantly in road cuts excavated into glacial till where topsoil has been placed on top of the till. This juxtaposition of materials with different permeability often causes a failure plane to develop along the interface between the two materials resulting in sliding following heavy rains. Examples can be found along the Massachusetts Turnpike. Other construction related failures occur in utility trenches excavated in materials that have very low cohesive strength and associated high water table (usually within a few feet of the surface). This occurs in sandy deposits with very few fine sediments to give the material cohesive strength and can occur in any part of the state.

Undercutting of slopes during flooding or coastal storm events is a major cause of property damage. Streams and waves erode the base of the slopes causing them to over steepen and eventually collapse. This is particularly problematic in unconsolidated glacial deposits, which covers the majority of the state. Areas where this type of failure is occurring include Cape Cod, Nantucket, Martha's Vineyard, Scituate, Newbury, and along some of the major river valleys. Adverse geologic conditions exist anywhere there are lacustrine or marine clays. Clays have relatively low strength. When over steepened or exposed in excavations these areas often produce classic rotational landslides. The clays often formed in the deepest parts of many of the glacial lakes that existed in Massachusetts following the last glaciation. Some of the major glacial lakes are Bascom, Hitchcock, Nashua, Sudbury, Concord, and Merrimack. The greater Boston area is also underlain by the Boston Blue Clay, a glacio-marine clay.

Another occurrence of landslides in Massachusetts results from slope saturation. This occurs following heavy rains and dominantly in areas with steep slopes underlain by glacial till or bedrock. Bedrock is relatively impermeable relative to the unconsolidated material that overlies it. Similarly, glacial till is less permeable than the soil that forms above it. Thus, there is a permeability contrast between the overlying soil and the underlying, and less permeable, unweathered till and/or bedrock. Water accumulates on this less permeable layer increasing the pore pressure at the interface. This interface becomes a plane of weakness. If conditions are favorable failure will occur" (Mabee, 2010).

12.2 HAZARD PROFILE

12.2.1 Location

The entire U.S. experiences landslides, with 36 states having moderate to highly severe landslide hazards. Expansion of urban and recreational developments into hillside areas leads to more people being threatened by landslides each year. Figure 12-1 shows landslide potential mapped by the USGS for the eastern U.S. Landslides are common throughout the Appalachian region and New England. The greatest eastern hazard is from sliding of clay-rich soils. Based on the U.S. data set for landslides, it appears that

areas along the Connecticut River in western Massachusetts, and the greater Boston area have the highest risk to landslide. Figure 12-2 illustrates the landslide incidence and susceptibility zones in Massachusetts.

Source: http://pubs.usgs.gov/fs/2005/3156/2005-3156.pdf

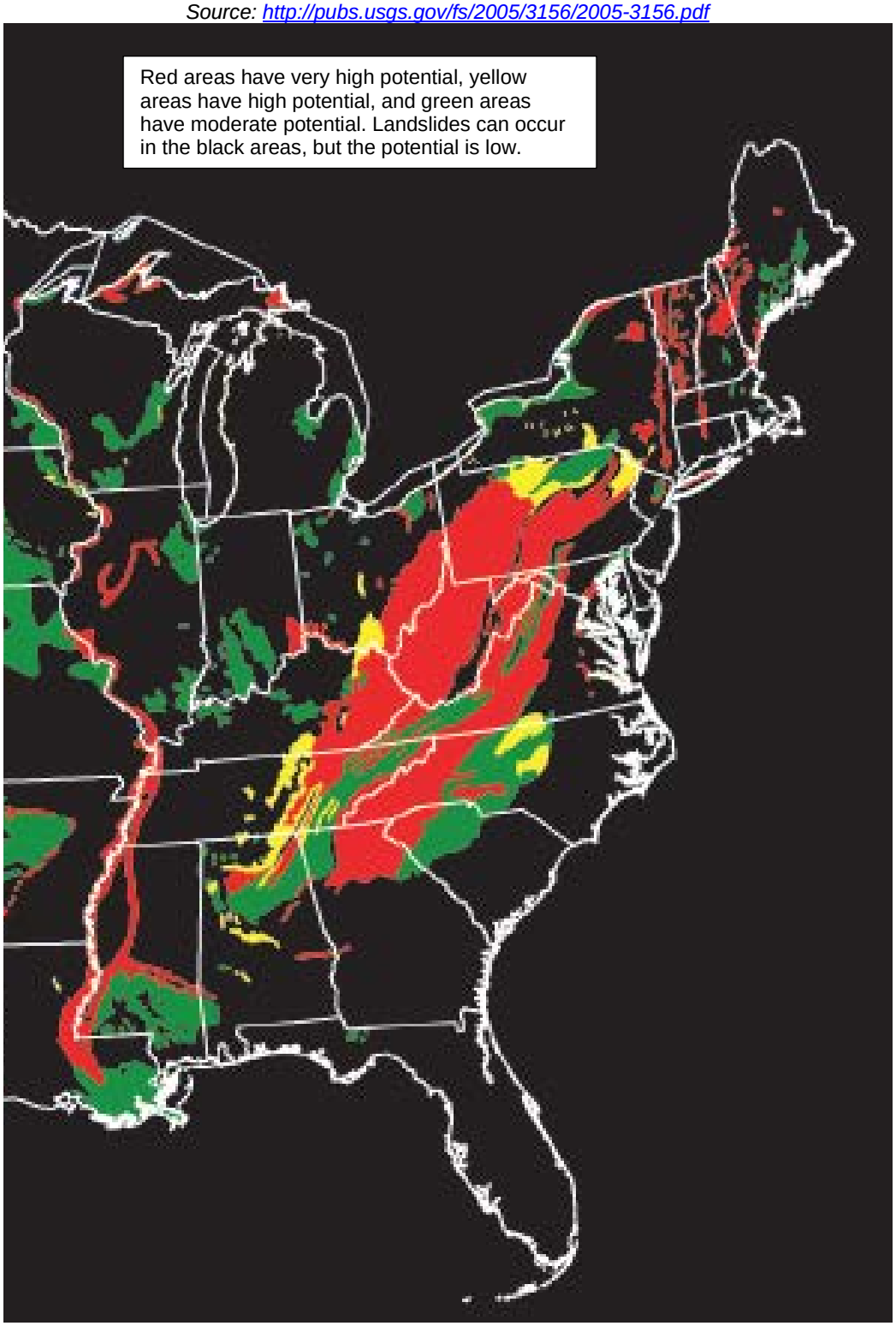

Figure 12-1. Landslide Potential of the Eastern U.S.

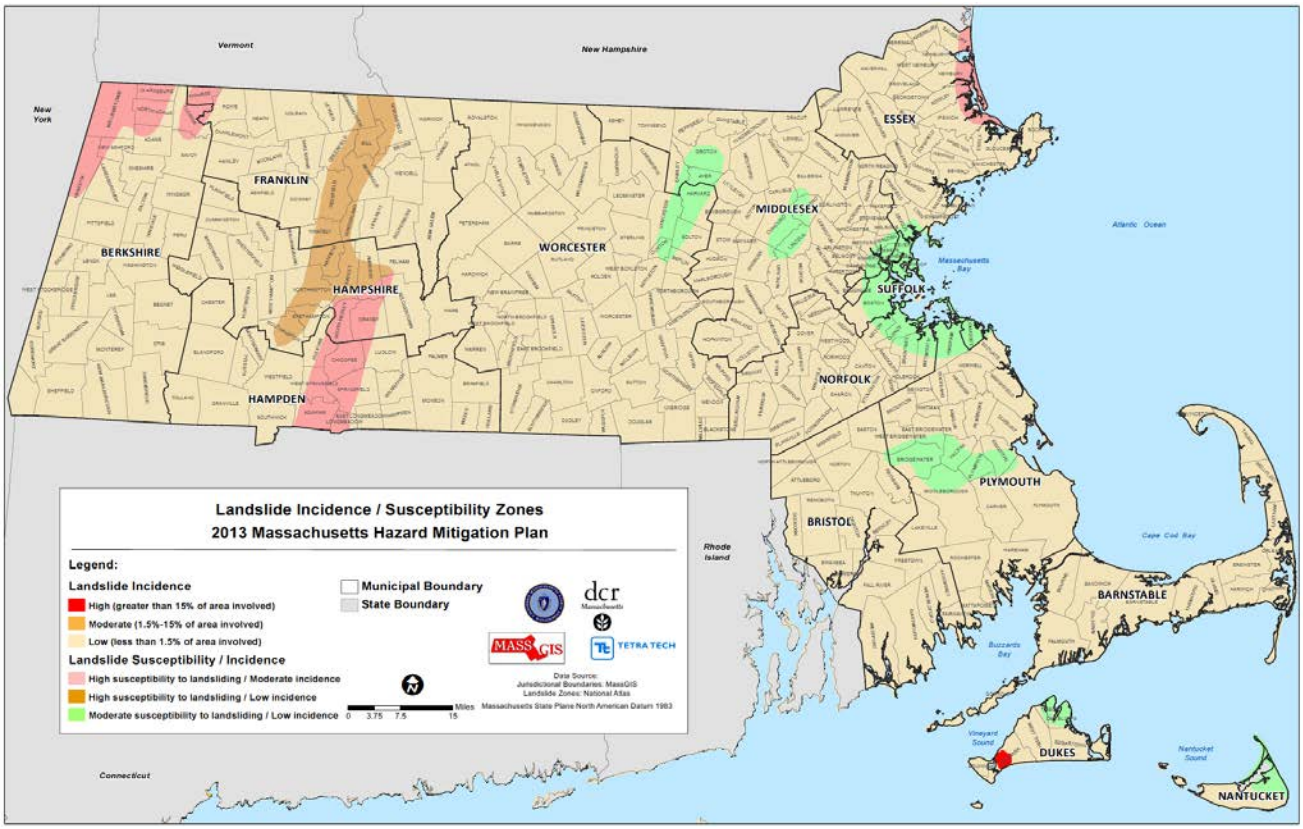

Figure 12-2. Landslide Incidence/Susceptibility Zones

12.2.2 Previous Occurrences

Nationwide landslides constitute a major geologic hazard as they are widespread, occurring in all 50 states, and cause approximately $1-2 billion in damage and more than 25 fatalities on average each year. In Massachusetts, landslides tend to be more isolated in size and pose threats to highways and structures that support fisheries, tourism, timber harvesting, mining, energy production, and general transportation. Landslides commonly occur with other major natural disasters such as earthquakes and floods that exacerbate relief and reconstruction efforts.

Many landslide events may have occurred in remote areas causing their existence or impact to go unnoticed. Therefore, this hazard profile may not identify all ground failure events that have impacted the Commonwealth. Expanded development and other land use may contribute to the increased number of landslide incidences and/or increased number of reported events in the recent record.

- In 1901, 11 landslides occurred along the east face of Mount Greylock after heavy rains (Mabee, 2010).
- In 1936, one home was destroyed and six others evacuated during a slide in North Adams (Mabee, 2010).
- On June 13, 1996, thunderstorms brought torrential rain and strong winds to several municipalities in western and central Franklin County. There were numerous reports of downed trees and power lines in Ashfield, Deerfield, Greenfield, and Whatley. Mudslides and flooding damaged the Ashfield Inn, the Greenfield Senior Citizens Center, and several homes in Greenfield.
- On April 16, 2007, a strong coastal storm brought heavy snow, strong winds, river and stream flooding, and significant coastal flooding. In Franklin County, multiple roads were closed to

flooding. In the Town of Colrain, the flooding caused a mudslide to occur, which closed a portion of Route 112.

- On September 6, 2008, remnants of Tropical Storm Hanna brought heavy rain to the area. Rainfall totals ranged between 3.5 to 5.5 inches. This resulted in widespread flooding across central Hampden County. In Wilbraham, multiple roads were flooded, including Main Street and several locations on Routes 20 and 32. Minor mudslides occurred on Route 32.
- In September 2008, a small landslide occurred in Holyoke covering several cars and a large paved area under several feet of mud and debris. It is thought the cause of this slide was saturated soils due to days of rain and poor urban drainage.
- On July 7, 2009, a system across southern New England produced showers and thunderstorms. In Middlesex County, numerous roads were flooded, and some were closed due to the rain. The most affected areas include Framingham and Marlborough. In Framingham, roads were closed due to mudslides, as well as flooding, including Routes 126 and 9.
- On March 14, 2010, widespread rainfall across portions of Massachusetts totaled between three and six inches. This resulted in major flooding across eastern Massachusetts. A state of emergency was declared which led to a FEMA disaster declaration (DR-1985). In Essex County, heavy rain resulted in the rapid erosion of a hill slope in Topsfield. This resulted in a mudslide across Route 1, which closed the road in both directions between Salem Road and the Danvers town line.
- On March 7, 2011, heavy rains fell across coastal and interior New England. The heavy rain, combined with melting snow, resulted in flooding of tributaries and major rivers. In Franklin County, in the Town of Greenfield, a water-soaked ridge near the Green River Cemetery gave way, resulting in a mudslide 13 inches deep that slid over Meridian and Water Streets. Three cars were buried, and the mud was up the foundations of three homes. This resulted in the evacuation of 17 people and approximately $100,000 in property damage.
- In August 2011, Hurricane Irene caused damage throughout portions of the Commonwealth, including a 5.8-mile section of Route 2 that was closed from West Charlemont to South County Road in Florida due to erosion and undercutting of the roadway, damage to retaining walls, debris flows, landslides, and bridge damage. Estimated cost of temporary repairs was $23.5 million (Mabee and Kopera, 2011). Figure 12-3 illustrates the location of this event. Figure 12-4 shows the largest of the landslides that took place during this event, which measured 900 feet long, 1.5 acres, and an estimated 4,950 cubic yards. Table 12-1 summarizes statistics on landslides that occurred.

In October 2011, additional slides also occurred in Deerfield after the October 31, 2011 snowstorm causing clogging of culverts under the railroad and Routes 5 and 10 leading to siltation of a wetland and subsequent flooding of nearby homes (Mabee, 2010).

12.2.3 Probability of Future Occurrences

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods, or wildfires, so landslide frequency is often related to the frequency of these other hazards. In general, landslides are most likely during periods of higher than average rainfall. The ground must be saturated prior to the onset of a major storm for significant landsliding to occur.

For the purposes of this plan, the probability of future occurrences is defined by the number of events over a specified period of time. There have been zero federally declared landslide disasters from 1954 to 2012. It is noted that the historical record may underestimate the true number of events that have taken place in the Commonwealth. Looking at the recent record, from 1996 to 2012, there were eight (8) events

that triggered one or more slides in the Commonwealth. However, according to the state geologist, there were at least 30 or more landslide related events in the last 10 to 20 years (Mabee, 2010). This roughly equates to one to three landslide events each year.

12.2.4 Severity

To determine the extent of a landslide hazard, the affected areas need to be identified and the probability of the landslide occurring within some time period needs to be assessed. Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions. As a result, the landslide hazard is often represented by landslide incidence and/or susceptibility, defined below:

- Landslide incidence is the number of landslides that have occurred in a given geographic area. High incidence means greater than 15-percent of a given area has been involved in landsliding; medium incidence means that 1.5 to 15-percent of an area has been involved; and low incidence means that less than 1.5-percent of an area has been involved.

Source: Mabee, 2012 (portion of the poster entitled Geomorphic Effects of Tropical Storm Irene on Western Massachusetts: Landslides and Fluvial Erosion along the Deerfield and Cold Rivers, Charlemont and Savoy, MA)

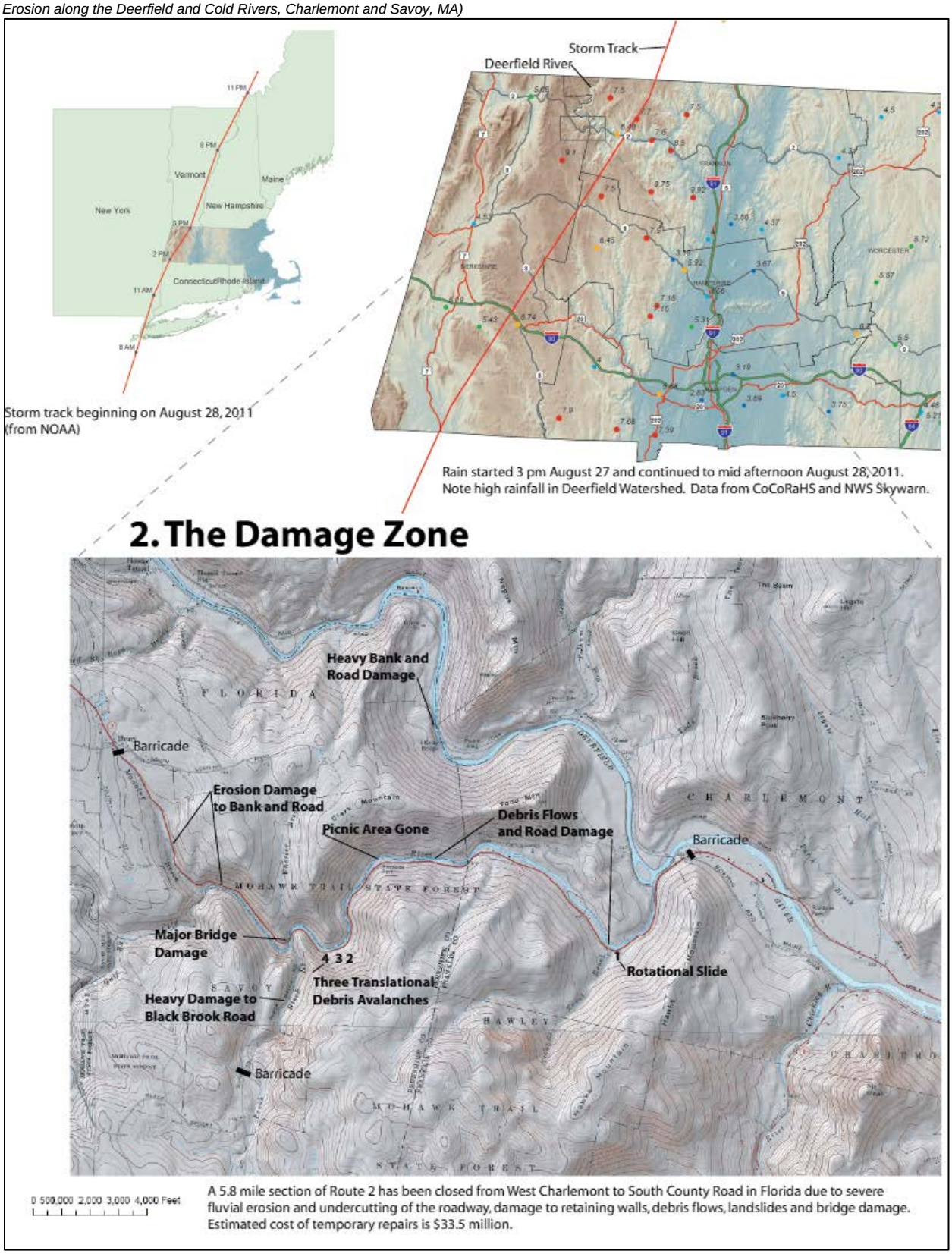

Figure 12-3. Location of August 2011 Event

Source: Mabee, 2012 (portion of the poster entitled Geomorphic Effects of Tropical Storm Irene on Western Massachusetts: Landslides and Fluvial Erosion along the Deerfield and Cold Rivers, Charlemont and Savoy, MA)

Figure 12-4. Largest August 2011 Landslide

TABLE 12-1.
STATISTICS ON THE SLIDES IN AUGUST 2011

The statistics on all the slides. Nearly 2500 feet in combined length, 3 acres of coverage and about 9800 cubic yards of material moved.

Parameter	Slide 2	Slide 3	Slide 4
Bottom Width (ft)	120	58	48
Top Width (ft)	45	42	38
Ave. Slope Angle (°)	28	33	33
Horizontal Length (ft)	868	813	520
Slope Length (ft)	902	969	620
Elevation Difference (ft)	460	522	337
Area (sq.ft)	66,881	39,854	25,149
Area (Ac)	1.54	0.91	0.58
Thickness Range (ft)	1.5-2.5	1.5-2.5	1.5-2.5
Min. Volume (CY)	3716	2214	1397
Max. Volume (CY)	6193	3690	2329
Ave. Volume (CY)	4954	2952	1863

Source: Mabee, 2012 (portion of the poster entitled Geomorphic Effects of Tropical Storm Irene on Western Massachusetts: Landslides and Fluvial Erosion Along the Deerfield and Cold Rivers, Charlemont and Savoy, MA)

- Landslide susceptibility is defined as the probable degree of response of geologic formations to natural or artificial cutting, to loading of slopes, or to unusually high precipitation. It can be assumed that unusually high precipitation or changes in existing conditions can initiate landslide movement in areas where rocks and soils have experienced numerous landslides in the past. Landslide susceptibility depends on slope angle and the geologic material underlying the slope. Landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur. High, medium, and low susceptibility are delimited by the same percentages used for classifying the incidence of landsliding.

Landslides destroy property and infrastructure and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion.

12.2.5 Warning Time

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material, and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current standard operating procedure is to monitor situations on a case-by-case basis, and respond after the event has occurred. Generally accepted warning signs for landslide activity include the following:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements or sidewalks
- Soil moving away from foundations
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels though rain is still falling or just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

12.3 SECONDARY HAZARDS

Landslides can cause several types of secondary effects, such as blocking access to roads, which can isolate residents and businesses and delay commercial, public, and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to

power and communication lines. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries, and spawning habitat.

12.4 CLIMATE CHANGE IMPACTS

With the latest regional models showing warmer and wetter winters for New England (Rawlins et al., 2012), Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.

12.5 EXPOSURE

To understand risk, the assets exposed to the hazard areas are identified within the known landslide areas. The following discusses the Commonwealth of Massachusetts' exposure to the landslide hazard including:

- Population
- State facilities
- Critical facilities
- Economy

In an attempt to estimate the Commonwealth's vulnerability to the landslide hazard, the Geology - Landslide Incidence and Susceptibility GIS layer from National Atlas was used to coarsely define the general landslide susceptible area (herein "approximate hazard area") (Figure 12-2) (Godt, 2001). According to Radbruch-Hall et al. (1982), the Landslide Incidence and Susceptibility GIS layer from National Atlas

> '…was prepared by evaluating formations or groups of formations shown on the geologic map of the United States (King and Beikman, 1974) and classifying them as having high, medium, or low landslide incidence (number of landslides) and being of high, medium, or low susceptibility to landsliding. Thus, those map units or parts of units with more than 15 percent of their area involved in landsliding were classified as having high incidence; those with 1.5 to 15 percent of their area involved in landsliding, as having medium incidence; and those with less than 1.5 percent of their area involved, as having low incidence. This classification scheme was modified where particular lithofacies are known to have variable landslide incidence or susceptibility. In continental glaciated areas, additional data were used to identify surficial deposits that are susceptible to slope movement. Susceptibility to landsliding was defined as the probable degree of response of the areal rocks and soils to natural or artificial cutting or loading of slopes or to anomalously high precipitation. High, medium, and low susceptibility are delimited by the same percentages used in classifying the incidence of landsliding. For example, it was estimated that a rock or soil unit characterized by high landslide susceptibility would respond to widespread artificial cutting by some movement in 15 percent or more of the affected area. We did not evaluate the effect of earthquakes on slope stability, although many catastrophic landslides have been generated by ground shaking during earthquakes. Areas susceptible to ground failure under static conditions would probably also be susceptible to failure during earthquakes.'

The limitations of this data set and analysis are recognized and are only used to provide a general estimate until higher resolution data are available Commonwealth-wide.

In an effort to address the limitations of the datasets associated with the ability to determine risk associated with landslides, the Massachusetts Geological Survey and University of Massachusetts - Amherst applied for and were awarded a FEMA Hazard Mitigation Grant Program grant to conduct statewide mapping and identification of landslide hazards that can be used for community level planning as well as prioritizing high risk areas for mitigation. This project is currently underway and results will be available for future updates of this plan to allow for better analysis of this hazard. Further, rapid fluvial geomorphological assessment and fluvial erosion hazard mapping for stream corridor planning and mitigation is also being conducted to better characterize this hazard in the Commonwealth.

12.5.1 Population

Due to the nature of census block data, it is difficult to determine demographics of populations vulnerable to mass movements. To estimate the population vulnerable to the landslide hazard, the Landslide Incidence and Susceptibility approximate hazard areas were overlaid upon the 2010 Census population data (U.S. Census, 2010). Please note the Census blocks do not align exactly with the hazard areas and, therefore, these estimates should be considered for planning purposes only. Further, some areas did not have a defined landslide hazard category assigned due to the differences in extent of the polygon datasets. In these cases, the adjacent landslide hazard area classification was assigned to the Census block. The Census blocks with their centroid located in each zone were used to calculate the estimated population exposed to the landslide hazard. In total, there are an estimated 265 people in the high landslide incidence zone, all located in Dukes County (or less than one-percent of the Commonwealth's total population). Further, there are approximately 417,688 in the high susceptibility (either moderate or low incidence) areas in the Commonwealth (or 6.4-percent of the Commonwealth's population). Table 12-2 summarizes the estimated population within the defined hazard areas by county.

12.5.2 State Facilities

To assess the exposure of the state-owned and leased facilities provided by DCAMM and the Office of Leasing, an analysis was conducted with the approximate landslide hazard areas. Using ArcMap, GIS software, the approximate hazard area data were overlaid with the state facility data to determine which facilities are within the defined hazard areas. Table 12-2 and Table 12-3 summarize the number of state-owned and leased buildings in the landslide hazard area by county. Figure 12-5 show the locations of state-owned and state-leased buildings in the high or moderate landslide hazard areas (1,439 structures).

TABLE 12-2.
2010 POPULATION IN THE LANDSLIDE HAZARD AREAS

		High Incidence		High Susceptibility, Moderate Incidence		High Susceptibility, Low Incidence		Moderate Susceptibility, Low Incidence		Low Incidence	
County	Population	Number	% Total	Number	% Total	Number	% Total	Number	% Total	Number	% Total
Barnstable	215,888	—	—	—	—	—	—	—	—	215,888	100
Berkshire	131,219	—	—	23,446	17.9	—	—	—	—	107,773	82
Bristol	548,285	—	—	—	—	—	—	352	0.1	547,933	100
Dukes	16,535	265	1.6	—	—	—	—	7,713	46.6	8,557	52
Essex	743,159	—	—	7,945	1.1	—	—	28,179	3.8	707,035	95
Franklin	71,372	—	—	123	0.2	32,919	46.1	—	—	38,330	54
Hampden	463,490	—	—	261,505	56.4	—	—	—	—	201,985	44
Hampshire	158,080	—	—	24,483	15.5	67,267	42.6	—	—	66,330	42
Middlesex	1,503,085	—	—	—	—	—	—	236,185	15.7	1,266,900	84
Nantucket	10,172	—	—	—	—	—	—	357	3.5	9,815	96
Norfolk	670,850	—	—	—	—	—	—	203,348	30.3	467,502	70
Plymouth	494,919	—	—	—	—	—	—	76,479	15.5	418,440	85
Suffolk	722,023	—	—	—	—	—	—	563,677	78.1	158,346	22
Worcester	798,552	—	—	—	—	—	—	24,713	3.1	773,839	97
Total	**6,547,629**	**265**	**<1**	**317,502**	**4.8**	**100,186**	**2**	**1,141,003**	**17**	**4,988,673**	**76**

Source: U.S. Census, 2010; Godt, 2001

TABLE 12-3.
STATE-OWNED AND LEASED FACILITIES EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Barnstable	—	—	—	309
Berkshire	67	—	—	291
Bristol	—	—	—	482
Dukes	—	—	4	9
Essex	18	—	5	515
Franklin	—	92	—	119
Hampden	150	—	—	316
Hampshire	26	110	—	426
Middlesex	—	—	168	939
Nantucket	—	—	—	5
Norfolk	—	—	144	536
Plymouth	—	—	268	274
Suffolk	—	—	341	53
Worcester	—	—	46	1,047
Total	**261**	**202**	**976**	**5,321**

Source: DCAMM, 2012; Godt, 2001
Note: Five facilities are located in an area where the landslide hazard area is not defined.

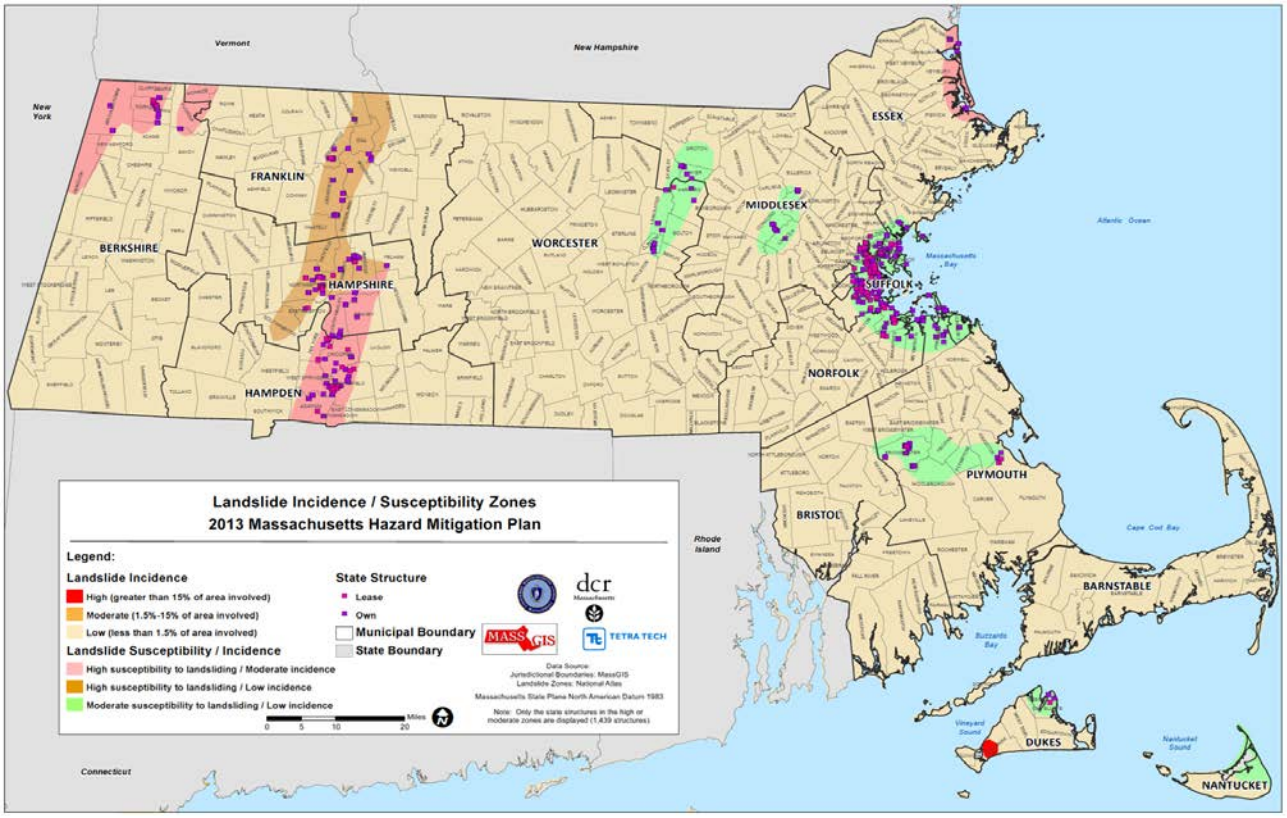

Figure 12-5. State-Owned and Leased Facilities in the High or Moderate Landslide Incidence/Susceptibility Areas

12.5.3 Critical Facilities

Critical facilities located in landslide hazard areas are exposed to the hazard. The numbers of critical facilities exposed to the landslide hazard areas are listed in Table 12-4 through Table 12-8. In addition to the facilities identified in the tables, one state emergency operations center is in a high susceptibility/moderate incidence area and one is in a low incidence area.

TABLE 12-4.
NUMBER OF POLICE EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Barnstable	—	—	—	20
Berkshire	4	—	—	29
Bristol	—	—	—	27
Dukes	—	—	4	6
Essex	1	—	1	37
Franklin	—	8	—	18
Hampden	11	—	—	17
Hampshire	2	8	—	13
Middlesex	—	—	13	51
Nantucket	—	—	—	3
Norfolk	—	—	6	26
Plymouth	—	—	5	26

TABLE 12-4.
NUMBER OF POLICE EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Suffolk	—	—	27	7
Worcester	—	—	3	64
Total	**18**	**16**	**59**	**344**

Source: MassGIS, 2012; Godt, 2001

TABLE 12-5
NUMBER OF FIRE DEPARTMENTS EXPOSED TO THE LANDSLIDE HAZARD

County	High Incidence	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Barnstable	—	—	—	—	37
Berkshire	—	4	—	—	42
Bristol	—	—	—	—	63
Dukes	1	—	—	2	5
Essex	—	—	—	3	79
Franklin	—	1	10	—	20
Hampden	—	23	—	—	28
Hampshire	—	3	8	—	17
Middlesex	—	—	—	18	146
Nantucket	—	—	—	—	1
Norfolk	—	—	—	19	40
Plymouth	—	—	—	10	57
Suffolk	—	—	—	39	8
Worcester	—	—	—	6	99
Total	**1**	**31**	**18**	**97**	**642**

Source: MassGIS, 2012; Godt, 2001

TABLE 12-6.
NUMBER OF HOSPITALS EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Barnstable	—	—	—	2
Berkshire	1	—	—	3
Bristol	—	—	—	5
Dukes	—	—	1	—
Essex	—	—	—	10
Franklin	—	1	—	—
Hampden	4	—	—	2
Hampshire	—	1	—	1
Middlesex	—	—	3	13
Nantucket	—	—	—	1
Norfolk	—	—	2	3

TABLE 12-6.
NUMBER OF HOSPITALS EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Plymouth	—	—	—	4
Suffolk	—	—	12	3
Worcester	—	—	1	9
Total	**5**	**2**	**19**	**56**

Source: MassGIS, 2012; Godt, 2001

TABLE 12-7.
NUMBER OF SCHOOLS (PRE-K – 12) EXPOSED TO THE LANDSLIDE HAZARD

County	High Incidence	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Barnstable	—	—	—	—	82
Berkshire	—	14	—	—	62
Bristol	—	—	—	—	243
Dukes	1	—	—	3	6
Essex	—	—	—	8	301
Franklin	—	—	29	—	24
Hampden	—	126	—	—	91
Hampshire	—	13	65	—	35
Middlesex	—	—	—	76	500
Nantucket	—	—	—	—	4
Norfolk	—	—	—	64	222
Plymouth	—	—	—	26	171
Suffolk	—	—	—	187	57
Worcester	—	—	—	15	342
Total	**1**	**153**	**94**	**379**	**2,140**

Source: MassGIS, 2012; Godt, 2001

TABLE 12-8.
NUMBER OF COLLEGES EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Barnstable	—	—	—	6
Berkshire	3	—	—	3
Bristol	—	—	—	12
Dukes	—	—	—	—
Essex	—	—	1	12
Franklin	—	1	—	2
Hampden	13	—	—	3

TABLE 12-8.
NUMBER OF COLLEGES EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence
Hampshire	1	3	—	1
Middlesex	—	—	9	38
Nantucket	—	—	1	—
Norfolk	—	—	6	15
Plymouth	—	—	1	5
Suffolk	—	—	43	5
Worcester	—	—	1	20
Total	**17**	**4**	**62**	**122**

Source: MassGIS, 2012; Godt, 2001

A significant amount of infrastructure can be exposed to mass movements:

- **Roads**—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems, and delays for public and private transportation. This can result in economic losses for businesses.
- **Bridges**—Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use. Table 12-9 summarizes the bridges located in the landslide hazard areas.
- **Power Lines**—Power lines are generally elevated above steep slopes, but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.

12.5.4 Economy

A landslide's impact on the economy and estimated dollar losses are difficult to measure. As stated earlier, landslides can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property, and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure. Additionally, ground failure threatens transportation corridors, fuel and energy conduits, and communication lines (USGS, 2003).

TABLE 12-9.
NUMBER OF BRIDGES EXPOSED TO THE LANDSLIDE HAZARD

County	High Susceptibility, Moderate Incidence	High Susceptibility, Low Incidence	Moderate Susceptibility, Low Incidence	Low Incidence	Outside Defined Hazard Areas
Barnstable	—	—	—	96	2
Berkshire	57	—	—	357	—
Bristol	—	—	—	348	19
Dukes	—	—	2	2	1
Essex	3	—	4	361	7
Franklin	2	65	—	212	—
Hampden	175	—	—	240	—
Hampshire	17	62	—	156	—
Middlesex	—	—	81	671	—
Nantucket	—	—	—	2	—
Norfolk	—	—	89	244	4
Plymouth	—	—	36	221	2
Suffolk	—	—	302	49	7
Worcester	—	—	24	912	—
Total	**254**	**127**	**538**	**3874**	**42**

Source: HAZUS-MH v. 2.1 default bridges; Godt, 2001
*Bridges are located outside of defined hazard areas such as over bodies of water.

For the purposes of this analysis, the replacement cost value of the general building stock located in the high incidence or high susceptibility landslide hazard areas is considered vulnerable to this hazard. Table 12-10 summarizes these values by county. Based on this approach of analysis, Franklin, Hampden, and Hampshire Counties are the most vulnerable to the landslide hazard as it relates to the building replacement cost value and the associated percentage of potential impact of approximately 50-percent of value being exposed.

12.6 VULNERABILITY

12.6.1 Population

In general, the population exposed to higher risk landslide areas is considered to be vulnerable. Further, population located downslope are vulnerable to this hazard as well. Increasing population and the fact that many homes are built on view property atop or below bluffs and on steep slopes subject to mass movement, increases the number of lives endangered by this hazard.

TABLE 12-10.
BUILDING AND CONTENT REPLACEMENT COST VALUE IN LANDSLIDE HAZARD AREAS

County	Total Replacement Cost Value	High Incidence	% Total	High Susceptibility, Moderate Incidence	% Total	High Susceptibility, Low Incidence	% Total
Barnstable	$47,450,250,000	—	—	—	—	—	—
Berkshire	$20,566,219,000	—	—	$3,609,042,000	17.5	—	—
Bristol	$74,946,506,000	—	—	—	—	—	—
Dukes	$4,894,499,000	$144,916,000	3.0	—	—	—	—
Essex	$100,099,771,000	—	—	$1,357,094,000	1.4	—	—
Franklin	$10,130,548,000	—	—	$22,597,000	0.2	$5,052,163,000	49.9
Hampden	$67,212,508,000	—	—	$39,696,615,000	59.1	—	—
Hampshire	$20,961,384,000	—	—	$2,966,193,000	14.2	$10,264,349,000	49.0
Middlesex	$244,161,008,000	—	—	—	—	—	—
Nantucket	$3,610,072,000	—	—	—	—	—	—
Norfolk	$111,344,832,000	—	—	—	—	—	—
Plymouth	$70,614,087,000	—	—	—	—	—	—
Suffolk	$115,439,212,000	—	—	—	—	—	—
Worcester	$112,858,251,000	—	—	—	—	—	—
Total	**$1,004,289,147,000**	**$144,916,000**	**< 1**	**$44,042,499,000**	**4.4**	**$15,316,512,000**	**1.5**

Source: HAZUS-MH v. 2.1; Godt, 2001

12.6.2 State Facilities

To estimate the potential losses to state-owned and leased structures, the exposure analysis methodology was used. As discussed, there are 6,765 state-owned/leased structures in the Commonwealth. Table 12-11 and Table 12-12 identify the replacement cost value of the state-owned and leased buildings located in the landslide hazard areas by county and agency, respectively. The values shown assume 100-percent loss to each structure and its contents. This estimate is considered high because structure and content losses generally do not occur to the entire inventory exposed.

TABLE 12-11.
REPLACEMENT COST VALUE OF STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY LANDSLIDE RISK AND COUNTY

County	High Susceptibility, Low Incidence	High Susceptibility, Moderate Incidence	Low Incidence	Moderate Susceptibility, Low Incidence	**Total**
Barnstable					**$1,146,314,361**
Lease	—	—	$17,181,274	—	
Own	—	—	$1,129,133,087	—	
Berkshire					**$1,852,000,832**
Lease	—	$14,797,914	$26,640,718	—	
Own	—	$448,678,247	$1,361,883,953	—	
Bristol					**$3,012,210,350**
Lease	—	—	$149,664,578	—	
Own	—	—	$2,862,545,772	—	
Dukes					**$16,224,048**
Lease	—	—	$6,000,330	$258,630	
Own	—	—	$8,583,402	$1,381,686	
Essex					**$4,473,201,429**
Lease	—	—	$136,866,724	—	
Own	—	$40,489,911	$4,160,832,458	$135,012,336	
Franklin					**$813,236,929**
Lease	$12,650,102	—	$11,512,252	—	
Own	$280,365,221	—	$508,709,354	—	
Hampden					**$5,051,650,248**
Lease	—	$133,102,974	$22,480,470	—	
Own	—	$1,809,364,515	$3,086,702,289	—	
Hampshire					**$4,687,387,853**
Lease	$26,043,416	—	$6,998,780	—	
Own	$1,027,877,514	$17,755,949	$3,608,712,194	—	
Middlesex					**$9,881,996,655**
Lease	—	—	$274,107,566	$51,862,192	
Own	—	—	$7,977,083,190	$1,578,943,706	
Nantucket					**$31,381,244**
Lease	—	—	$941,186	—	
Own	—	—	$30,440,058	—	
Norfolk					**$5,141,831,256**
Lease	—	—	$82,325,618	$65,496,734	
Own	—	—	$4,448,605,755	$545,403,149	
Plymouth					**$3,182,404,153**
Lease	—	—	$77,885,394	$15,098,192	
Own	—	—	$1,211,391,815	$1,878,028,752	
Suffolk					**$8,247,560,162**
Lease	—	—	$99,245,614	$388,582,320	
Own	—	—	$91,187,408	$7,668,544,820	
Worcester					**$9,444,698,995**
Lease	—	—	$205,010,236	$12,824,580	
Own	—	—	$7,971,118,166	$1,255,746,013	
Total					**$56,982,098,514**
Lease	**$38,693,518**	**$147,900,888**	**$1,116,860,740**	**$534,122,648**	
Own	**$1,308,242,736**	**$2,316,288,622**	**$38,456,928,901**	**$13,063,060,461**	

TABLE 12-12.
STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY STATE AGENCY

	High Susceptibility, Low Incidence		High Susceptibility, Moderate Incidence		Low Incidence		Moderate Susceptibility, Low Incidence		
State Agency	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Total
Alcoholic Beverages Control Commission	—	—	—	—	—	—	$1,619,110	100.0	$1,619,110
Attorney General	—	—	$2,149,464	46.7	$2,451,108	53.3	—	—	$4,600,572
Berkshire Community College	—	—	—	—	$239,840,975	100	—	—	$239,840,975
Board of Higher Education	—	—	—	—	—	—	$1,402,696	100	$1,402,696
Board of Library Commissioners	—	—	—	—	—	—	$1,846,748	100	$1,846,748
Bridgewater State University	—	—	—	—	$3,760,852	0.6	$625,789,112	99.4	$629,549,964
Bristol Community College	—	—	—	—	$381,670,168	100	—	—	$381,670,168
Bunker Hill Community College	—	—	—	—	—	—	$280,704,380	100	$280,704,380
Bureau of State Buildings	—	—	$33,722,612	1.2	$512,120,650	18.7	$2,185,641,270	80	$2,731,484,532
Cape Cod Community College	—	—	—	—	$201,526,780	100	—	—	$201,526,780
Chelsea Soldiers' Home	—	—	—	—	—	—	$420,265,816	100	$420,265,816
Children's Trust Fund	—	—	—	—	—	—	$2,200,228	100	$2,200,228
Civil Defense Headquarters	—	—	—	—	$82,566,828	100	—	—	$82,566,828
Committee For Public Counsel Services	$1,063,910	2.6	$3,440,744	8.4	$19,200,888	46.8	$17,319,410	42.2	$41,024,952
Commonwealth Zoo Commission	—	—	—	—	$46,269,164	60.9	$29,707,477	39.1	$75,976,641
Council of Government	—	—	—	—	—	—	$17,497,010	100	$17,497,010
Department of Agricultural Resources	$641,232	100.0	—	—	—	—	—	—	$641,232
Department of Business and Technology	—	—	—	—	$141,072	100	—	—	$141,072
Department of Children and Families	—	—	$19,629,180	11.7	$120,480,542	71.5	$28,307,188	16.8	$168,416,910
Department of Conservation and Recreation	$11,409,166	0.3	$170,039,562	4.4	$2,517,110,340	64.5	$1,204,373,937	30.9	$3,902,933,006
Department of Corrections	—	—	—	—	$3,438,171,288	62.4	$2,075,367,406	37.6	$5,513,538,694

TABLE 12-12.
STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY STATE AGENCY

	High Susceptibility, Low Incidence		High Susceptibility, Moderate Incidence		Low Incidence		Moderate Susceptibility, Low Incidence		
State Agency	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Total
Department of Developmental Services	$5,062,526	0.2	$1,711,822	0.1	$2,314,669,658	99.1	$13,335,305	0.6	$2,334,779,311
Department of Early Education and Care	—	—	—	—	$5,612,384	50.9	$5,422,954	49.1	$11,035,338
Department of Education	—	—	—	—	$130,950,398	100	—	—	$130,950,398
Department of Environmental Protection	—	—	$26,698,134	28.1	$68,157,522	71.9	—	—	$94,855,656
Department of Fire Services	—	—	—	—	$62,035,434	100	—	—	$62,035,434
Department of Fish and Game	$23,122,970	17.9	$49,636	—	$86,863,616	67.3	$19,074,841	14.8	$129,111,063
Department of Food and Agriculture	—	—	$4,528,850	100.0	—	—	—	—	$4,528,850
Department of Industrial Accidents	—	—	—	—	$7,190,884	32.9	$14,693,832	67.1	$21,884,716
Department of Mental Health	$369,879,787	14.7	$7,233,600	0.3	$1,951,204,071	77.4	$192,669,584	7.6	$2,520,987,041
Department of Public Health	$2,348,512	0.1	—	—	$1,721,263,231	96.6	$57,585,594	3.2	$1,781,197,337
Department of Public Utilities	—	—	—	—	—	—	$8,941,446	100	$8,941,446
Department of State Police	$116,500,840	18.5	$11,687,852	1.9	$481,668,002	76.6	$19,195,552	3.1	$629,052,246
Department of Telecommunications and Cab	—	—	—	—	—	—	$2,709,472	100	$2,709,472
Department of Transitional Assistance	—	—	$17,777,892	14.8	$77,859,726	64.9	$24,316,584	20.3	$119,954,202
Department of Transportation	$217,084,939	14.2	$189,413,934	12.4	$980,929,747	64.4	$136,549,148	9.0	$1,523,977,768
Department of Veterans Services	—	—	$7,192,502	51.4	$6,793,108	48.6	—	—	$13,985,610
Department of Youth Services	—	—	—	—	$470,628,630	100	—	—	$470,628,630
Department of Elementary and Secondary Education	—	—	—	—	$31,345,824	100	—	—	$31,345,824
Department of Workforce Development	—	—	$4,685,536	28.4	$8,831,102	53.6	$2,964,094	18.0	$16,480,732

TABLE 12-12.
STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY STATE AGENCY

	High Susceptibility, Low Incidence		High Susceptibility, Moderate Incidence		Low Incidence		Moderate Susceptibility, Low Incidence		
State Agency	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Total
Disabled Persons Protection Commission	—	—	—	—	—	—	$2,137,440	100	$2,137,440
Div. of Health Care Finance and Policy	—	—	—	—	—	—	$10,687,200	100	$10,687,200
Division of Administrative Law Appeals	—	—	—	—	—	—	$2,514,164	100	$2,514,164
Division of Banks	—	—	—	—	$1,396,282	21	$5,258,636	79.0	$6,654,918
Division of Capital Asset Management	—	—	$1,649,468	0.1	$2,807,365,464	89.2	$339,142,464	10.8	$3,148,157,396
Division of Insurance	—	—	—	—	—	—	$9,660,694	100	$9,660,694
Division of Professional Licensure	—	—	—	—	—	—	$9,404,202	100	$9,404,202
Division of Standards	—	—	—	—	$1,517,316	100	—	—	$1,517,316
Emergency Management Agency	—	—	$3,160,504	100.0	—	—	—	—	$3,160,504
Exec. Office of Energy and Environmental Affairs	—	—	—	—	$605,696	2.5	$23,551,116	97.5	$24,156,812
Exec. Office of Health and Human Services	—	—	$3,282,306	5.6	$21,124,854	36.3	$33,803,346	58.1	$58,210,506
Fitchburg State University	—	—	—	—	$658,051,935	100	—	—	$658,051,935
Framingham State University	—	—	—	—	$525,548,586	100	—	—	$525,548,586
Greenfield Community College	$5,955,640	2.9	—	—	$196,362,192	97.1	—	—	$202,317,832
Holyoke Community College	—	—	$3,953,560	1.0	$404,228,384	99	—	—	$408,181,944
Holyoke Soldiers' Home	—	—	—	—	$210,550,728	100	—	—	$210,550,728
Information Technology Division	—	—	$21,182,030	100.0	—	—	—	—	$21,182,030
Judicial Conduct Commission	—	—	—	—	—	—	$772,150	100	$772,150
Massachusetts Bay Community College	—	—	—	—	$135,991,622	100	—	—	$135,991,622
Massachusetts Bay Community College	—	—	—	—	$46,338,516	100	—	—	$46,338,516

TABLE 12-12.
STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY STATE AGENCY

	High Susceptibility, Low Incidence		High Susceptibility, Moderate Incidence		Low Incidence		Moderate Susceptibility, Low Incidence		
State Agency	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Total
Massachusetts College of Art and Design	—	—	—	—	—	—	$527,402,394	100	$527,402,394
Massachusetts College of Liberal Arts	—	—	$363,904,867	91.5	$33,748,500	8.5	—	—	$397,653,367
Massachusetts Commission Against Discrimination	—	—	—	—	$278,134	100	—	—	$278,134
Massachusetts Commission for the Blind	—	—	—	—	$7,542,492	100	—	—	$7,542,492
Massachusetts Commission for the Deaf and Hard of Hearing	—	—	—	—	$2,556,646	100	—	—	$2,556,646
Massachusetts Cultural Council	—	—	—	—	—	—	$2,749,014	100	$2,749,014
Massachusetts Department of Revenue	—	—	$3,900,828	7.9	$28,035,734	57	$17,259,562	35.1	$49,196,124
Massachusetts Developmental Disabilities Council	—	—	—	—	—	—	$1,218,074	100	$1,218,074
Massachusetts Gaming Commission	—	—	—	—	—	—	$1,499,146	100	$1,499,146
Massachusetts Maritime Academy	—	—	—	—	$232,687,325	100	—	—	$232,687,325
Massachusetts National Guard	$816,248	21.0	—	—	$3,065,126	79.0	—	—	$3,881,374
Massachusetts Parole Board	—	—	—	—	$8,325,594	87.9	$1,149,408	12.1	$9,475,002
Massachusetts Rehabilitation Commission	$1,122,156	1.8	$3,986,858	6.5	$33,630,212	54.6	$22,908,548	37.2	$61,647,774
Massachusetts Sheriff's Association	—	—	—	—	—	0.0	$567,224	100	$567,224
Massachusetts State Lottery Commission	—	—	$1,637,012	3.3	$48,255,914	96.7	—	—	$49,892,926
Massachusetts Teachers' Retirement System	—	—	$710,966	13.0	—	0.0	$4,755,804	87	$5,466,770
Massasoit Community College	—	—	—	—	$383,445,357	100	—	—	$383,445,357
Mental Health Legal Advisors	—	—	—	—	—	0.0	$677,302	100	$677,302

TABLE 12-12.
STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY STATE AGENCY

	High Susceptibility, Low Incidence		High Susceptibility, Moderate Incidence		Low Incidence		Moderate Susceptibility, Low Incidence		
State Agency	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Total
Middlesex Community College	—	—	—	—	$72,531,208	19.8	$293,117,142	80.2	$365,648,350
Military Division	$412,052	0.03	$193,324,940	13.1	$1,071,151,128	72.5	$212,042,939	14.4	$1,476,931,058
Mount Wachusett Community College	—	—	—	—	$475,216,655	97.4	$12,824,580	2.6	$488,041,235
Municipal Police Training Committee	—	—	—	—	$5,829,868	100	—	—	$5,829,868
North Shore Community College	—	—	—	—	$246,720,408	100	—	—	$246,720,408
Northern Essex Community College	—	—	—	—	$330,017,350	100	—	—	$330,017,350
Office For Refugees and Immigrants	—	—	—	—	$1,199,104	100	—	—	$1,199,104
Office of Environmental Law Enforcement	—	—	—	—	$420,540	100	—	—	$420,540
Office of Labor and Workforce Development	—	—	—	—	$38,062,268	100	—	—	$38,062,268
Office of the Chief Medical Examiner	—	—	$830,130	4.1	—	—	$19,345,938	95.9	$20,176,068
Office of the D.A. Bristol	—	—	—	—	$8,113,188	100	—	—	$8,113,188
Office of the D.A. Cape and Island	—	—	—	—	$1,595,866	100	—	—	$1,595,866
Office of the D.A. Eastern	—	—	—	—	$9,641,990	100	—	—	$9,641,990
Office of the D.A. Hampden	—	—	$3,168,488	100.0	—	—	—	—	$3,168,488
Office of the D.A. Middle	—	—	—	—	$5,615,856	100	—	—	$5,615,856
Office of the D.A. Norfolk	—	—	—	—	$6,447,854	100	—	—	$6,447,854
Office of the D.A. Northern	—	—	—	—	$14,448,294	91.2	$1,400,024	8.8	$15,848,318
Office of the D.A. Northwestern	$7,491,192	100	—	—	—	—	—	—	$7,491,192
Office of the D.A. Plymouth	—	—	—	—	$5,324,630	100	—	—	$5,324,630
Office of the D.A. Suffolk	—	—	—	—	—	—	$14,452,034	100	$14,452,034
Office of the State Auditor	—	—	$648,980	10.7	$5,438,450	89.3	—	—	$6,087,430
Office of the State Treasurer	—	—	—	—	—	—	$3,825,216	100	$3,825,216

TABLE 12-12.
STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY STATE AGENCY

	High Susceptibility, Low Incidence		High Susceptibility, Moderate Incidence		Low Incidence		Moderate Susceptibility, Low Incidence		
State Agency	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Total
Public Employee Retirement Admin. Comm.	—	—	—	—	—	—	$3,874,110	100	$3,874,110
Quinsigamond Community College	—	—	—	—	$301,965,647	100	—	—	$301,965,647
Registry of Motor Vehicles	—	—	—	—	$20,878,316	100	—	—	$20,878,316
Roxbury Community College	—	—	—	—	—	—	$272,730,036	100	$272,730,036
Salem State University	—	—	—	—	$1,022,777,330	100	—	—	$1,022,777,330
Secretary of State	—	—	—	—	$26,693,420	30	$62,377,670	70.0	$89,071,090
Sex Offenders' Registry	—	—	—	—	$4,048,044	100	—	—	$4,048,044
Sheriff's Department Berkshire	—	—	—	—	$222,443,410	100	—	—	$222,443,410
Sheriff's Department Bristol	—	—	—	—	$59,784,324	100	—	—	$59,784,324
Sheriff's Department Essex	—	—	—	—	$313,169,686	100	—	—	$313,169,686
Sheriff's Department Franklin	$153,896	0.1	—	—	$102,711,202	99.9	—	—	$102,865,098
Sheriff's Department Hampden	—	—	$93,329,692	13.3	$607,535,874	86.7	—	—	$700,865,566
Sheriff's Department Hampshire	$97,011,962	100	—	—	—	—	—	—	$97,011,962
Sheriff's Department Middlesex	—	—	—	—	$287,588,762	74.9	$96,216,182	25.1	$383,804,944
Sheriff's Department Nantucket	—	—	—	—	$814,810	100	—	—	$814,810
Sheriff's Department Norfolk	—	—	—	—	$7,812,590	68.5	$3,591,394	31.5	$11,403,984
Sheriff's Department Suffolk	—	—	—	—	—	—	$874,251,452	100	$874,251,452
Sheriff's Department Worcester	—	—	—	—	$8,659,992	100	—	—	$8,659,992
Springfield Technical Community College	—	—	$1,154,896,536	100.0	—	—	—	—	$1,154,896,536
State Reclamation and Mosquito Control B	—	—	—	—	$10,574,716	100	—	—	$10,574,716
Trial Court	$99,888,933	2.0	$110,661,024	2.2	$3,129,719,233	61.1	$1,780,207,152	34.8	$5,120,476,342
University of Massachusetts at Amherst	$386,970,294	9.6	—	—	$3,644,481,845	90.4	$120,218	—	$4,031,572,357

TABLE 12-12.
STATE-OWNED AND LEASED BUILDINGS EXPOSED TO THE LANDSLIDE HAZARD BY STATE AGENCY

	High Susceptibility, Low Incidence		High Susceptibility, Moderate Incidence		Low Incidence		Moderate Susceptibility, Low Incidence		
State Agency	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Replacement Cost Value	% of Total	Total
University of Massachusetts at Boston	—	—	—	—	—	—	$1,380,001,842	100	$1,380,001,842
University of Massachusetts at Dartmouth	—	—	—	—	$766,501,758	100	—	—	$766,501,758
University of Massachusetts at Lowell	—	—	—	—	$2,527,775,117	100	—	—	$2,527,775,117
University of Massachusetts Medical School	—	—	—	—	$1,475,508,795	90.2	$160,187,098	9.8	$1,635,695,893
Westfield State University	—	—	—	—	$581,908,920	100	—	—	$581,908,920
Worcester State University	—	—	—	—	$390,694,594	100	—	—	$390,694,594
Total	**$1,346,936,254**	**2.4**	**$2,464,189,510**	**4.3**	**$39,573,789,641**	**69.4**	**$13,597,183,109**	**23.9**	**$56,982,098,514**

Source: DCAMM, 2012; Godt, 2001

12.6.3 Critical Facilities

Several types of infrastructure are exposed to landslides, including transportation, water, sewer, and power. Highly susceptible areas of the Commonwealth include mountain and coastal roads and transportation infrastructure. At this time all critical facilities, infrastructure, and transportation corridors located within the high incidence and high susceptibility hazard areas are considered vulnerable until more information becomes available.

From 1986 to 1990, the estimated Massachusetts Department of Transportation's (MassDOT) average annual cost of highway contracts to address landslide problems was $1,000,000. In addition, the average annual MassDOT maintenance expense needed to keep highways safe from landslide related activities was $2,000,000. These estimates only apply to state highways. The cost associated with remediation work and cleanup of debris from only four landslide-related events during the October 2005 rain event that affected Massachusetts was $2,300,000. The recent damage to a 6-mile stretch of Route 2 caused by tropical storm Irene (2011) which included debris flows, four landslides, and fluvial erosion and undercutting of infrastructure cost $23 million just for the temporary repairs. Accordingly, landslides have a significant cost to taxpayers, yet this hazard is not well known because most earth movements occur during extreme rainstorms and it is the rain and associated flooding that receives the majority of the publicity.

12.6.4 Economy

In general, the built environment located in the high susceptibility zones and the population, structures, and infrastructure located downslope are vulnerable to this hazard. In an attempt to estimate the general

building stock vulnerable to this hazard, the associated building replacement values (buildings and contents) were determined for the identified Census blocks within the approximate hazard areas. These values estimate the costs to repair or replace the damage caused to the building. These dollar value losses to the Commonwealth's total building inventory replacement value would impact the local tax base and economy. Based on building inventory replacement, Franklin, Hampden, and Hampshire Counties, which have approximately 50-percent of their building replacement cost value in the high incidence or high susceptibility hazard areas, are the most vulnerable counties to this hazard. Table 12-10 lists the replacement value (structure and contents) of general building stock exposed to this hazard by county.