for the entire Northern Virginia region. Loss estimates do not take into account the potential for collateral hazards such as liquefaction, fire or landslide.

Table 4.65. 2006 Estimates of Potential Losses for Earthquakes

Planning Area	500-Year Event	1,000-Year Event	2,500-Year Event	Annualized Losses
Region I. Arlington County	$12,171,000	$37,673,000	$139,293,000	$32,000
Region II. Fairfax County, City of Alexandria, City of Fairfax, City of Falls Church, Town of Herndon, Town of Vienna	$73,295,000	$236,459,000	$849,044,000	$218,000
Region III. Loudoun County, Town of Leesburg, Town of Purcellville	$12,349,000	$39,305,000	$141,866,000	$33,000
Region IV. Prince William County, City of Manassas, City of Manassas Park, Town of Dumfries	$20,085,000	$64,809,000	$228,090,000	$58,000
Total	**$117,900,000**	**$378,246,000**	**$1,358,293,000**	**$341,000**

2010 HAZUS-MH MR4 Analysis

Due to the region's relatively low seismic risk, buildings and infrastructure throughout the region are not designed to withstand major ground shaking events. This means that if such events do occur, while unlikely, the losses would likely be substantial. HAZUS^{MH} was used to update damage and loss estimates for the probabilistic ground motions associated with each of eight return periods (100, 250, 750, 1000, 2000, and 2500 years). The building damage estimates were then used as the basis for computing direct economic losses. These include building repair costs, contents and business inventory losses, costs of relocation, capital-related, wage, and rental losses. Annualized loss was computed, in HAZUS^{MH}, by multiplying losses from the eight potential ground motions by the respective annual frequencies of occurrence, and summing the values.

HAZUS^{MH} can be used to evaluate a variety of hazards and associated risk to support hazard mitigation. This revision utilized only Level 1 analysis for the earthquake module. Level 1 analysis involves using the provided hazard and inventory data with no additional local data collection. This is an acceptable level of information for mitigation planning; a future version of this plan can be enhanced with Level 2 and 3 analyses. The estimates of social and economic impacts contained in this report were produced using HAZUS^{MH} loss estimation methodology software, which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

During the 2010 update of the hazard mitigation plan, it was decided to run the probabilistic annualized loss scenario in HAZUS^{MH} on a countywide basis. Based on analysis, the region can expect over $2.4 million in annualized damages. Fairfax County accounts for 49.6% of the total, or 52.2% of the total including damages of the towns within the county. Prince William County accounts for 12.7% of the total, or 12.8% including the damages occurring within the county. Figure 4.44 illustrates the total annualized loss per census tract for the region. The Goochland County Scenario modeled a 6.5 magnitude earthquake with a depth of 10 meters. As discussed above, this would be a reasonable and likely scenario for the region. The results of this magnitude earthquake would result in over $616.4 million dollars in damages. Close to 50% of the damages would be located in Fairfax County, followed by Prince William County (19.4%). Figures 4.45 and 4.46 show the distribution of total direct economic loss for residential building occupancies and total building loss. Table 4.66 summarizes the results of the countywide analysis for the probabilistic and Goochland County scenarios. Town information has been extracted from the county totals based on the census blocks located within the towns.

Table 4.66. HAZUS^{MH} Annualized and Goochland County, VA scenario.		
Jurisdiction	**Annualized Loss**	**Goochland County Scenario**
Arlington County	$256,214	$50,596,616
Fairfax County	$1,194,034	$305,516,774
Town of Herndon	*$32,972*	*$6,502,171*
Town of Vienna	*$29,422*	*$6,231,392*
Town of Clifton	*$475*	*$157,123*
Loudoun County	$222,490	$40,023,317
Town of Leesburg	*$29,955*	*$4,527,822*
Town of Purcellville	*$911*	*$149,581*
Town of Middleburg	*$129*	*$27,861*
Town of Round Hill	*$53*	*$7,490*
Prince William County	$304,948	$119,524,967
Town of Dumfries	*$2,492*	*$1,143,557*
Town of Haymarket	*$165*	*$50,753*
Town of Occoquan	*$635*	*$233,037*
Town of Quantico	*$1,032*	*$468,964*
City of Alexandria	$198,495	$42,904,170
City of Fairfax	$49,175	$11,398,801
City of Falls Church	$20,589	$4,217,152
City of Manassas	$53,304	$18,694,282
City of Manassas Park	$11,457	$4,096,617
Total	**$2,408,945**	**$616,472,447**

Comparison of the 2006 and 2010 HAZUS^{MH} results reveal a difference in over $2 million for the annualized loss estimates. Several factors may have led to this gap; the 2006 analysis, completed on a four region basis, may have only taken the 500-, 1000- and 2500-year events into consideration for the annualized estimate and not the eight return-periods used in the 2010 HAZUS^{MH} analysis.

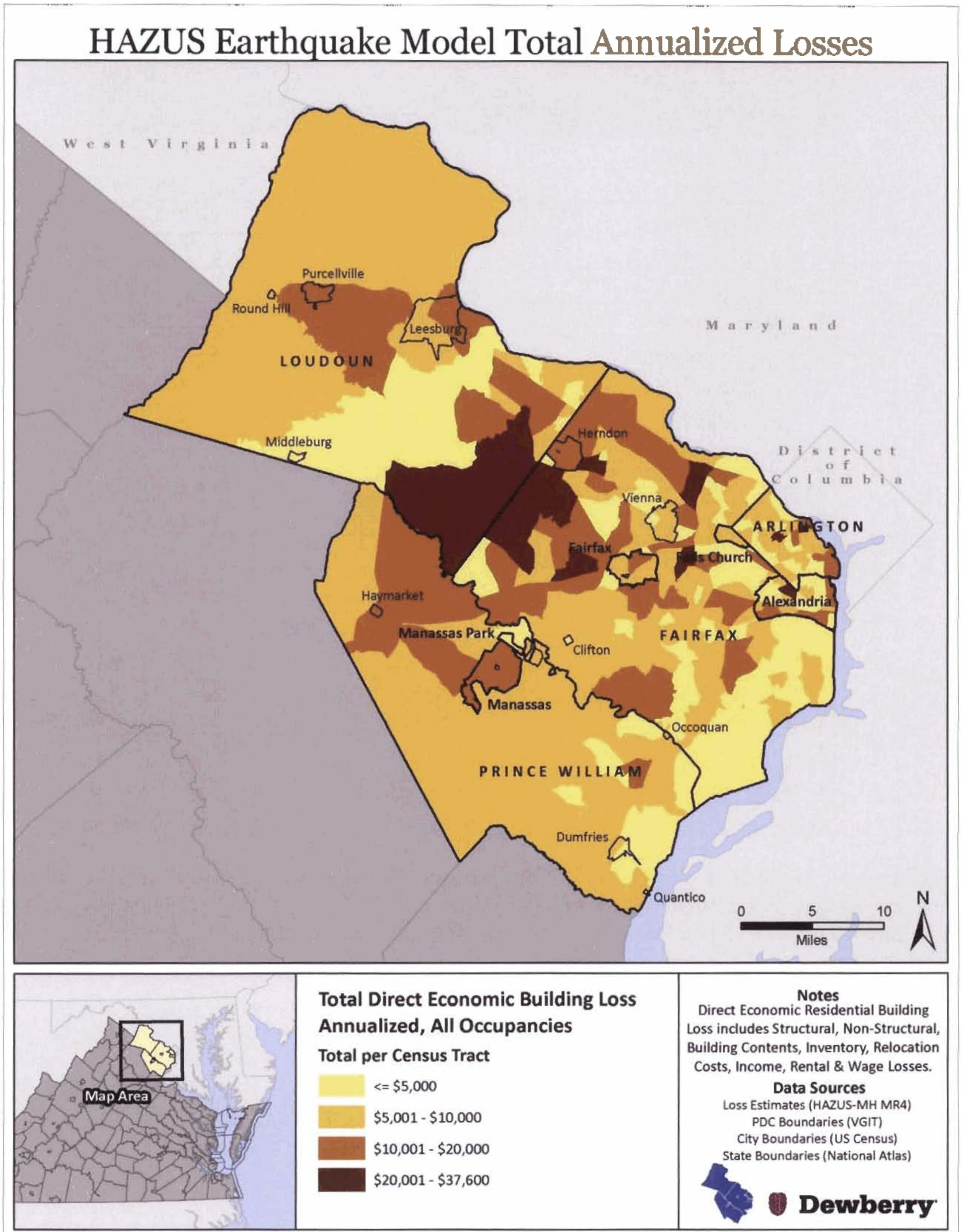


Figure 4.44. Total Annualized Loss from HAZUS^{MH}

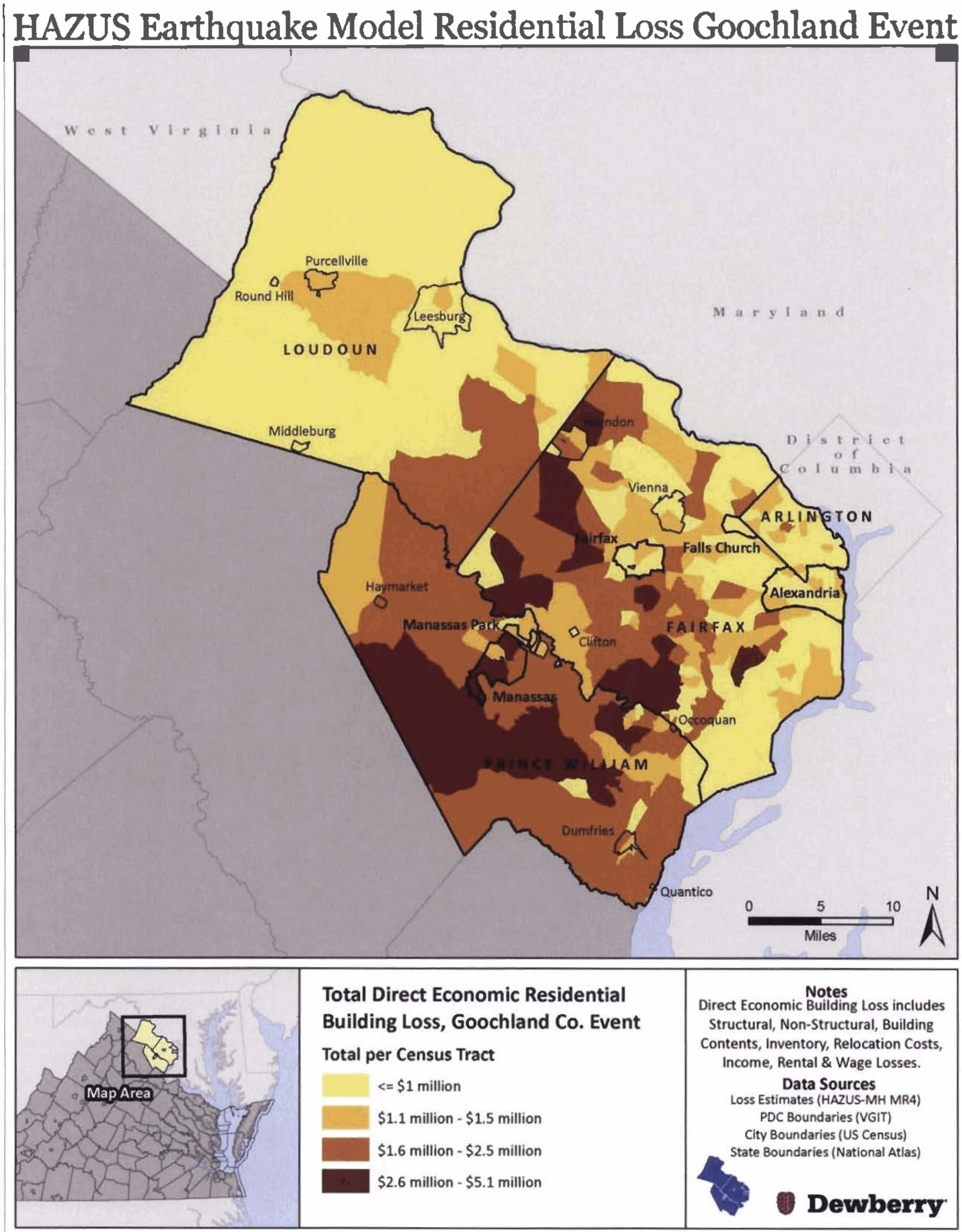


Figure 4.45. Total Residential Loss for Goochland County, VA epicenter event from HAZUS[MH]

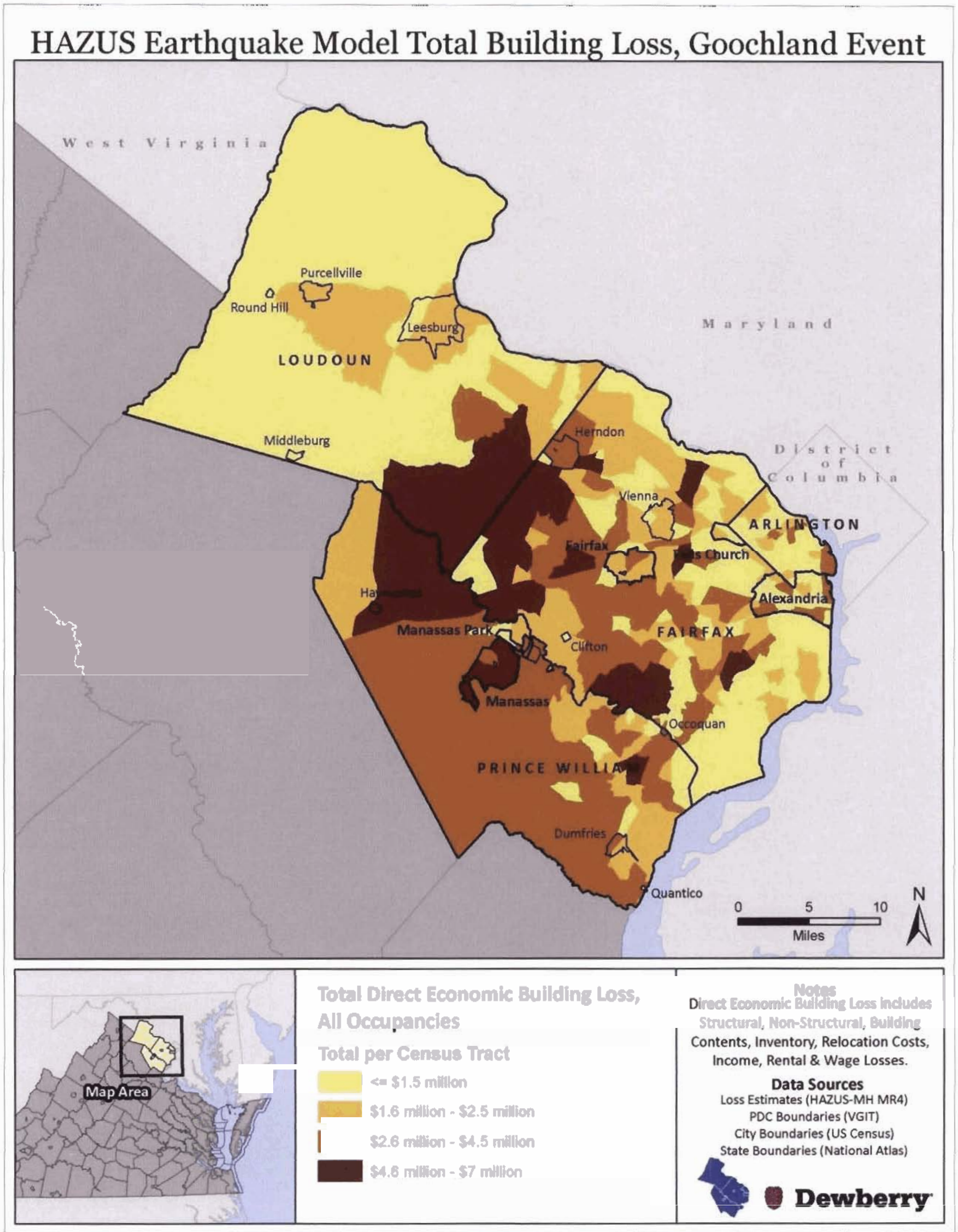


Figure 4.46. Total Building Loss for Goochland County, VA, epicenter event from HAZUS^{MH}

Critical Facility Risk

Based on the Goochland County HAZUS^{MH} scenario, on the day of the earthquake the region would have 85% of hospital beds available (functionality) for use by patients already in the hospital and those injured by the earthquake. All essential facilities would have functionality of greater than 50% on the day of the earthquake. After one week, 94% of the beds would be back in service. The model also estimates 457 households to be displaced from the Goochland County scenario. Of these, 250 people (out of a total population of 1,815,197) will seek temporary shelter.

The Goochland County HAZUS^{MH} scenario estimates six police stations, and one fire station would have less than 80% functionality on day one of the event, after day three, functionality would be above 90%. These include:

- Prince William County Criminal (Police)
- McLean Police Department
- Prince William County Criminal
- Prince William Criminal Division
  Quantico Police Department
- Fire Protection/Prevention Branch

The majority of schools would have less than 90% functionality on days one through three following an earthquake; functionality greatly improves after day seven.

Existing Buildings and Infrastructure Risk

As discussed in the community profiles above, there is an estimated 564,000 buildings in the region with a total building replacement value (excluding contents) of $158,996 million dollars. The majority of the buildings in the region are associated with residential housing. Wood frame construction makes up 69% of the building inventory.

One-third of the estimated losses with the probabilistic scenario (annualized loss) are related to business interruption in the region. The largest loss is sustained by residential occupancies which make up over 55% of the total loss estimates. The 2010 HAZUS^{MH} analysis above provides additional information for each of the jurisdictions.

Based on the Goochland County HAZUS^{MH} scenario, there would be about 8,292 buildings with at least moderate damage. Approximately 111 buildings would be damaged beyond repair. Table 4.67 summarizes the expected damage and number of buildings damaged, by occupancy.

Table 4.67. Expected Building Damage by Occupancy.										
Occupancy Type	None		Slight		Moderate		Extensive		Complete	
	Count	%	Count	%	Count	%	Count	%	Count	%
Agriculture	1,611	0.30	96	0.41	31	0.43	4	0.41	0	0.22
Commercial	28,621	5.37	1,758	7.56	673	9.47	96	8.89	7	6.4
Education	1,536	0.29	87	0.38	33	0.46	4	0.39	0	0.34
Government	942	0.18	53	0.23	20	0.28	2	0.22	0	0.16
Industrial	7,304	1.37	437	1.88	174	2.45	23	2.1	2	1.37
Other Residential	37,982	7.13	1,843	7.93	665	9.36	74	6.84	6	5.4
Religion	2,680	0.50	148	0.64	60	0.84	10	0.89	1	0.8
Single Family	452,034	84.86	18,824	80.98	5,448	76.71	864	80.26	95	85.3
Total	**532,710**		**23,246**		**7,104**		**1,077**		**111**	

Overall Loss Estimates and Ranking

During the 2006 plan creation, annualized loss for earthquake was estimated at $341,000 for the region. For the 2010 plan update, HAZUS^{MH} was utilized to come up with the probabilistic annualized loss estimates of $2,408,947.

For the 2010 update, the Northern Virginia planning region could expect over $2 million in annualized damages due to earthquakes. Fairfax County had the highest annualized loss for the entire Commonwealth based on the updated analysis and the Virginia State plan analysis (Table 4.68). Approximately 19% of Virginia's earthquake loss is from the Northern Virginia region of the State. The slight differences in annualized damages from the State plan and plan update can be attributed to several factors: different versions of HAZUS software, updated building stock information, and level of analysis completed.

Table 4.68. Annualized loss estimate comparison of updated HAZUS^{MH} results and the 2010 Virginia hazard mitigation plan loss estimates.		
Jurisdiction	2010 Commonwealth of VA Plan	HAZUS^{MH} Derived Annualized Loss
Arlington County	$356,165	$256,214
Fairfax County	$1,734,714	$1,256,903
Loudoun County	$345,482	$253,538
Prince William County	$415,002	$309,272
City of Alexandria	$270,594	$198,495
City of Fairfax	$71,004	$49,175
City of Falls Church	$28,303	$20,589
City of Manassas	$71,952	$53,304
City of Manassas Park	$11,181	$11,457
Total	**$3,304,397**	**$2,408,947**

No earthquake events were recorded in the NCDC database for the Northern Virginia region; as a result, no NCDC annualized loss estimates were calculated.

The hazard ranking for earthquake is based on events reported in the NCDC Storm Events database and a generalized geographic extent. The geographic extent ranking category used the PGA values for the 2500 Return Period. This return period represents a 0.04%-annual-chance of occurrence in any given year. The Northern Virginia planning region was ranked as "Medium" for earthquakes. The majority of the jurisdictions ranked Medium and the Cities of Falls Church and Manassas Park ranked as Medium-Low. Figure 4.47 shows the seven parameters that were used to derive the overall risk ranking. As discussed in the risk assessment methodology section, parameters that did not have recorded events in the NCDC database were given the lowest default score (1).

During the 2006 plan, annualized loss for the region was quantified as $341,000 based on HAZUS[MH] results. According to the qualitative assessment performed in 2006 using the PRI tool, the earthquake hazards scored a PRI value of 1.9 (on a scale of 0 to 4, with 4 being the highest risk level). Table 4.69 summarizes the risk levels assigned to each PRI category.

Table 4.69. 2006 Qualitative Assessment for Earthquakes

	Probability	Impact	Spatial Extent	Warning Time	Duration
Risk Level	Unlikely	Minor	Large	Less than 6 hours	Less than 6 hours

The 2006 PRI assessment is valid and supports the updated ranking and loss estimates.

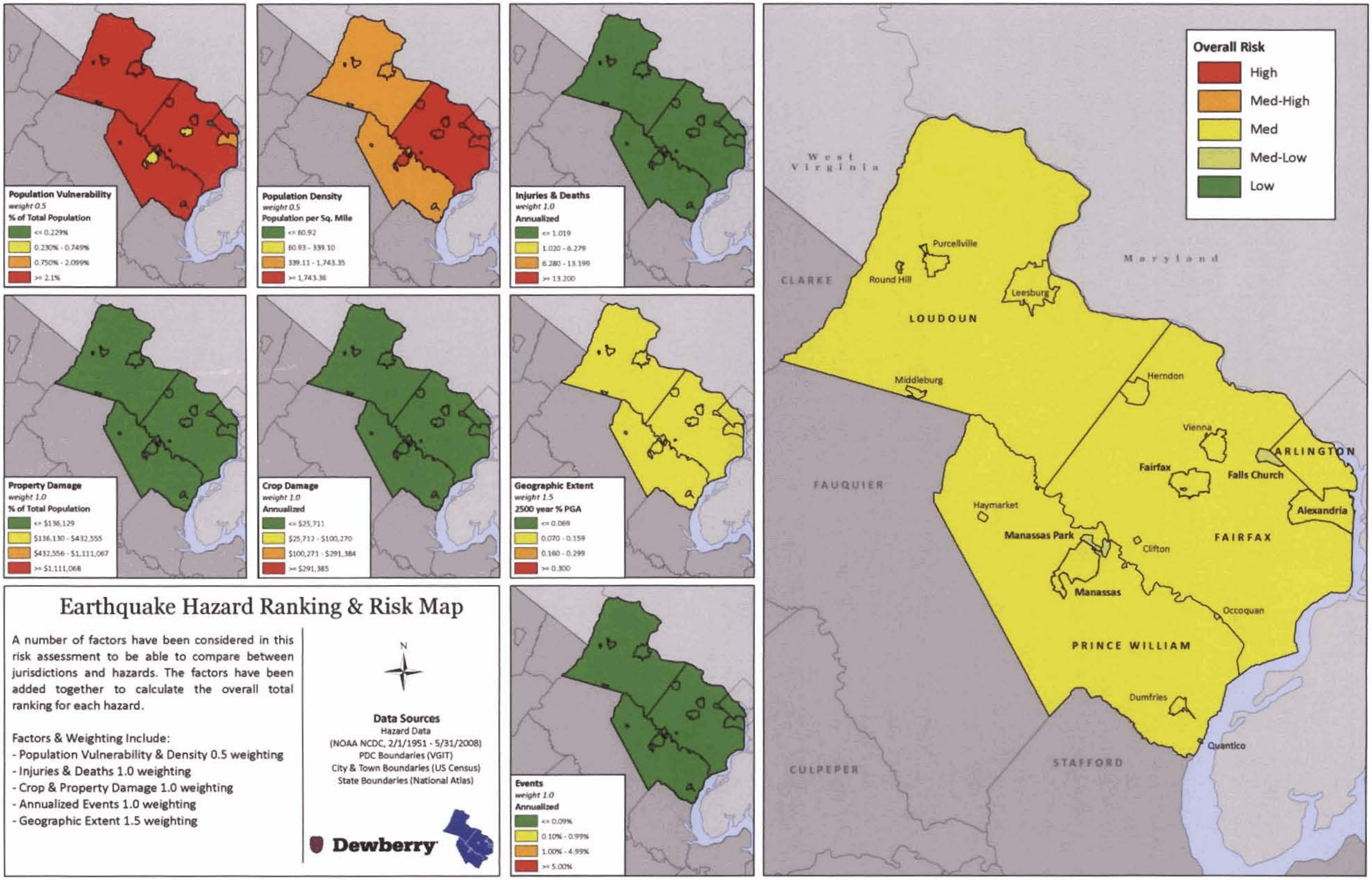


Figure 4.47. Earthquake Ranking and Risk.

XI. Landslides

NOTE: As part of the 2010 plan update, the Landslides hazard was reexamined and a new analysis performed. This new analysis included, but was not limited to: 1) refreshing the hazard profile; 2) updating the previous occurrences; 3) determining annualized number of hazard events and losses by jurisdiction using NCDC and other data sources where available; 4) updating the assessment of risk by jurisdiction based on new data; and 5) ranking of the hazard by jurisdiction using the methodology described in detail in Chapter 4, Section IV Ranking and Analysis Methodologies. Each section of the plan was also reformatted for improved clarity, and new maps and imagery, when available and appropriate, were inserted.

A. Hazard Profile

1. Description

Landslides are the downward movement of large volumes of surface materials under gravitational influences[28]. Types of movement include: rotational, translational, block, falls, topples, avalanche, earth flow, creep, and lateral spreading.[29] Landslide materials in motion generally consist of fractured or weathered rock, loose or unconsolidated soils, and vegetative debris. Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes due to construction or erosion, earthquakes, volcanic eruptions, and changes in groundwater levels.

There are several types of landslides: rock falls, rock topple, slides, and flows. Rock falls are rapid movements of bedrock, which result in bouncing or rolling. A topple is a section or block of rock that rotates or tilts before falling to the slope below. Slides are movements of soil or rock along a distinct failure surface. Mudflows, sometimes referred to as mudslides, lahars, or debris avalanches, are fast-moving rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as heavy rainfall or rapid snowmelt, changing the soil into a flowing river of mud or "slurry." Slurry can flow rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. Slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way. As the flows reach flatter ground, the mudflow spreads over a broad area where it can accumulate in thick deposits.

Among the most destructive types of debris flows are those that accompany volcanic eruptions. A spectacular example in the United States was a massive debris flow resulting from the 1980 eruptions of Mount St. Helens, in the State of Washington. Areas near the bases of many volcanoes in the Cascade Mountain Range of California, Oregon, and Washington are at risk from the same types of flows during future volcanic eruptions.

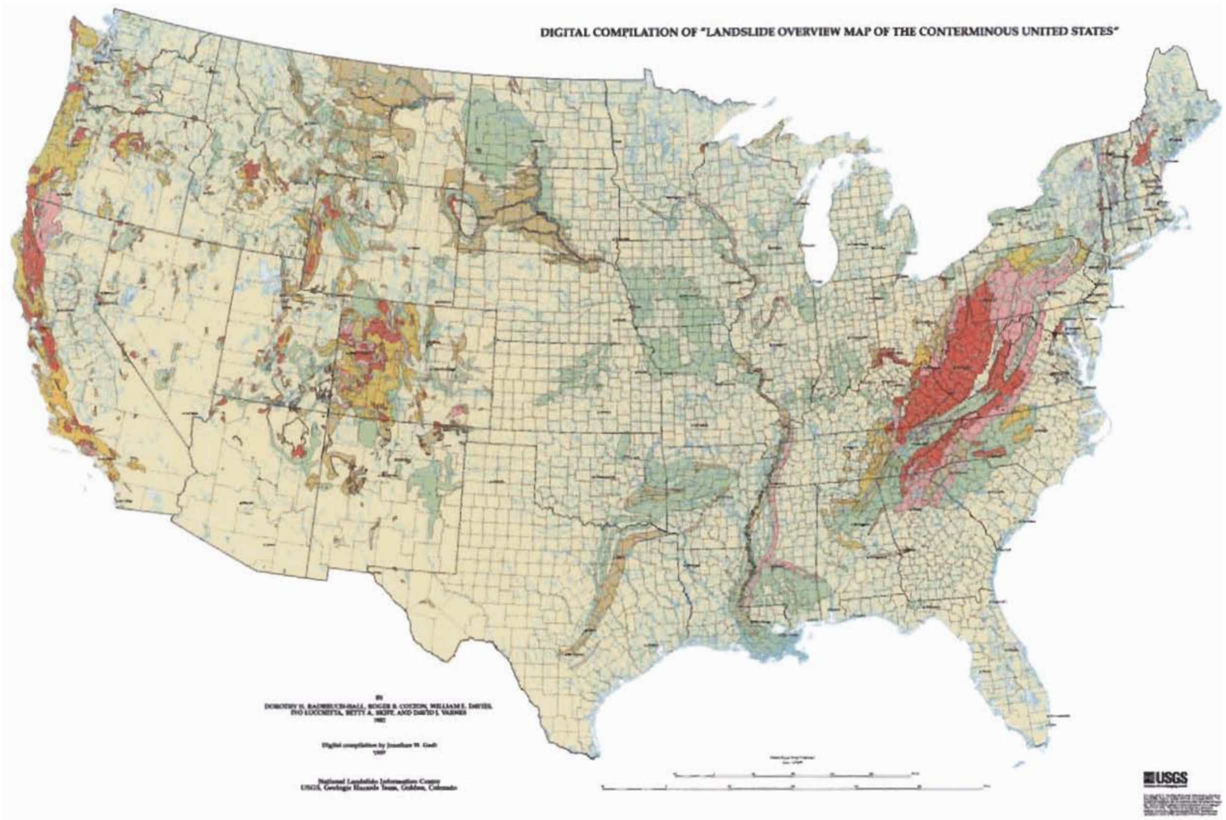
2. Geographic Location/Extent

In the United States, it is estimated that landslides cause up to $2 billion in damages and from 25 to 50 deaths annually. Globally, landslides cause billions of dollars in damage and thousands of deaths and injuries each year. Figure 4.47 delineates areas where large numbers of landslides have occurred and areas that are susceptible to landslides in the conterminous United States.

This map layer is provided in the USGS Professional Paper 1183, "Landslide Overview Map of the Conterminous United States."

While mountainous areas in Virginia are the most susceptible to landslide events, landslide and subsidence hazards do exist elsewhere in the State, including the Northern Virginia region – though these events are quite rare and limited in terms of their impact on people and property. Minor landslide events are possible in localized, steep-sloped areas of the Northern Virginia region during extremely wet conditions. These areas are primarily located in western Loudoun County, as well as some areas of moderate risk in extreme eastern areas of Fairfax and Prince William counties. Figure 4.48 provides a general indication of where landslide events are most likely to occur in Virginia based on landslide incidence and susceptibility data provided by the USGS.

Areas that are generally prone to landslide hazards include: previous landslide areas; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. Areas that are typically considered safe from landslides include: areas that have not moved in the past; relatively flat-lying areas away from sudden changes in slope; and areas at the top or along ridges, set back from the tops of slopes.



EXPLANATION

LANDSLIDE INCIDENCE

- Low (less than 1.5% of area involved)
- Moderate (1.5%-15% of area involved)
- High (greater than 15% of area involved)

LANDSLIDE SUSCEPTIBILITY/INCIDENCE

- Moderate susceptibility/low incidence
- High susceptibility/low incidence
- High susceptibility/moderate incidence

Susceptibility not indicated where same or lower than incidence. 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, 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.

Figure 4.47. Landslide Overview Map of the Conterminous United States
Source: USGS

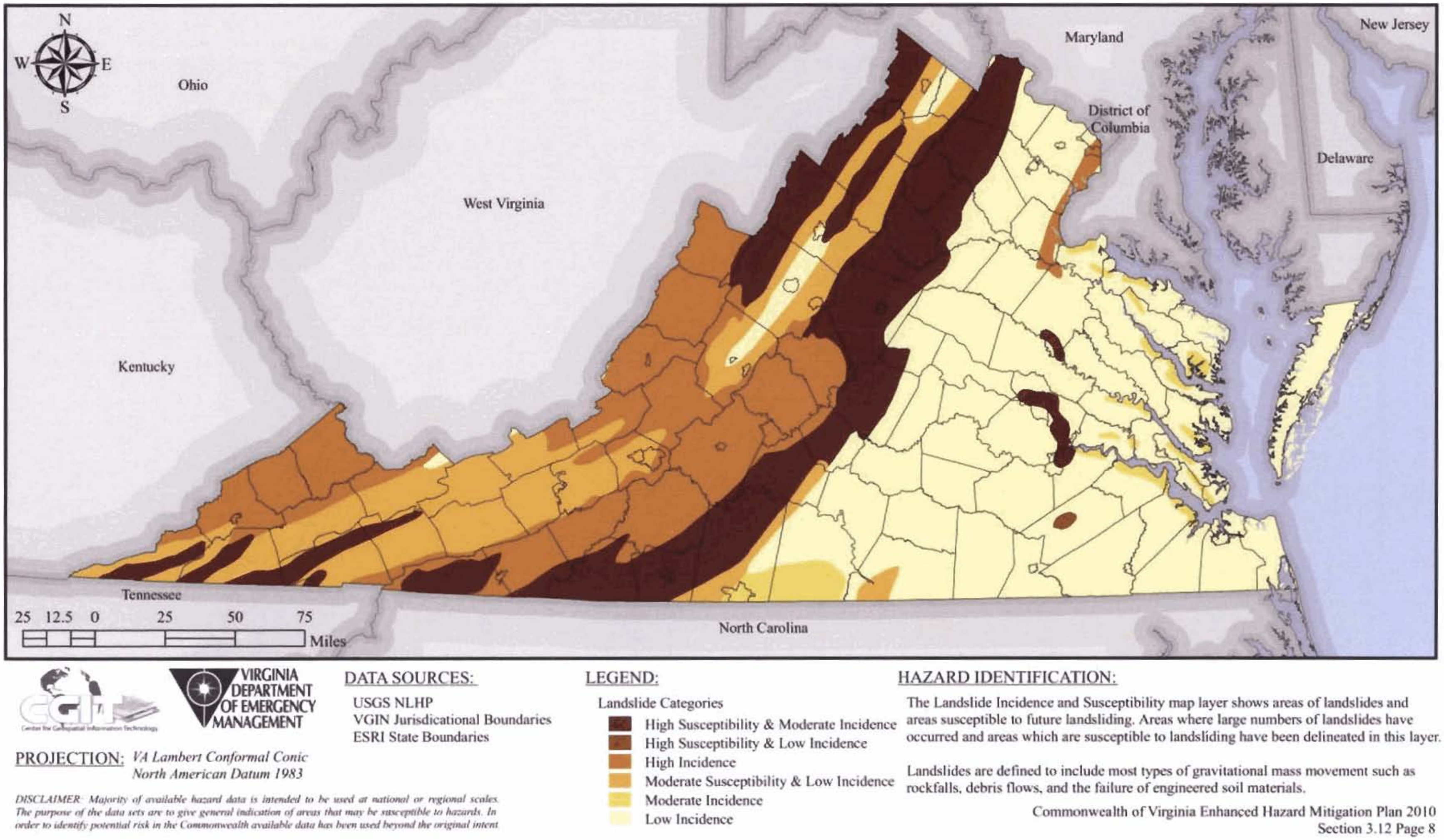


Figure 4.48. Landslide Incidence and Susceptibility.
Source: Commonwealth of Virginia Hazard Mitigation Plan

3. Magnitude or Severity

Landslides are frequently associated with periods of heavy rainfall or rapid snow melt. Such landslides tend to worsen the effects of flooding that often accompanies these weather events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly.

4. Previous Occurrences

There are no historical records of major landslide events in the Northern Virginia region, as they are relatively uncommon events. Minor landslide events are possible and have been known to occur in localized, steep-sloped areas of the region during extremely wet conditions. Though there are no documented occurrences, landslides are more likely to occur in western portions of Loudoun County than other areas of the region. Small landslides and minor subsidence issues have also been recorded in eastern areas of Fairfax County, possibly due to the presence of marine clay, though no major damages have ever been recorded.

In June 2003, a minor landslide occurred in the Lansdowne area of Loudoun County, breaching a retaining wall, disrupting underground utility lines, and threatening 10 homes. According to local officials this was a very isolated incident brought on by heavy spring rains and should not indicate that the area is prone to recurring landslides.

B. Risk Assessment

The landslide data set shows areas in the United States where large numbers of landslides have occurred and areas that are susceptible to landslides. This data set is a digital representation of USGS Open-File Report 97-289, which is a PDF version of the 1997 USGS Digital representation of Landslide Overview Map (scale 1:4,000,000). The report classifies the major physical subdivision of the United States and assesses the vulnerability based on subdivision characteristics. Figures 4.49 highlights the areas of increased incidence and susceptibility. The purpose of this dataset is to provide a general indication of areas that may be susceptible to landsliding. It is not suitable for site selection or local planning initiatives.

1. Probability of Future Occurrences

Landslide probability is highly site-specific, and cannot be accurately characterized on a statewide basis, except in the most general sense. Relative risk ranking is intended only for general comparison to the other hazards that impact the region. The magnitude of landslides is dependent on the amount of liquid and landmass in motion and the amount of development in the area. Often a landslide will be more severe in areas with higher slopes and poorly drained soils. Some areas that are generally prone to landslides include old landslide sites, the base of slopes, the base of minor drainage hollows, the base or top of old fill slope, the base or top of a steep cut slope, and developed hillsides where leach field septic systems are used.

2. Impact & Vulnerability

Landslides can cause serious damage to highways, buildings, homes, and other structures that support a wide range of economies and activities. Landslides commonly coincide with other natural disasters. Expansion of urban development contributes to greater risk of damage by landslides.

3. Risk

While some slope stability problems have been associated with marine clay in Fairfax County (marine clay becomes loose as moisture content increases, and is subject to slope creep if the natural slope is steepened during site development) the county has identified areas of marine clay and has established regulations requiring special engineering investigations and design procedures in the areas.

With future growth, various non-structural methods, such as zoning and grading ordinances, as well as structural methods, should be analyzed in terms of cost-effective alternatives. Zoning and grading ordinances to avoid building in areas of potential hazard or to regulate construction to minimize the potential for landslides is one non-structural method to reduce the likely consequences of debris flows. Loudoun County has adopted zoning ordinances preventing the development of building sites with steep slopes along the Blue Ridge (defined in the ordinance as exceeding a 15% grade, equivalent to an eight degree slope), which substantially reduces the hazards of landslides and debris flows within that area.

Critical Facility Risk

The vulnerability of each identified critical facility was assessed using GIS analysis by comparing their physical location with the extent of known hazard areas that can be spatially defined through GIS technology. Of those critical facilities identified in the region, many were indeed determined to be in known hazard areas upon further GIS analysis and thereby determined to be "potentially at-risk." Tables 4.70 and 4.71 summarize the number of potentially at-risk buildings or facilities in the region to landslide by jurisdiction and facility type. These determinations are based solely on best available data for critical facility locations and delineable hazard areas, and the actual level of risk for each facility may only be determined by further on-site assessments.

The majority of critical facilities (both HAZUS^{MH} and locally supplied) are located in the low incidence and susceptibility landslide risk. Approximately 14% of the HAZUS^{MH} and 22% of the locally supplied facilities are located in the high incidence moderate susceptibility zone. Loudoun County has 13 locally supplied critical facilities (16 HAZUS^{MH}) located in the high susceptibility moderate incidence risk. Figures 4.50 and 4.51 show the location of critical facilities in relation to the different landslide susceptibility and incidence zones.

The names and information for the HAZUS^{MH} and local critical facilities in the landslide risk zones are available in the Critical Facility-Risk Appendix D2.

It should be noted that the landslide incidence data is highly generalized, owing to the small scale and the scarcity of precise landslide information for much of the country, and is unsuitable for local planning or actual site selection.

Table 4.70. Number of Local Critical Facilities Potentially At-Risk to Landslide			
Jurisdiction	**High Incidence**	**High Susceptibility Moderate Incidence**	**Low**
Arlington County	30	-	79
Fairfax County	58	-	280
Town of Clifton	-	-	1
Town of Herndon	-	-	9
Town of Vienna	-	-	11
Loudoun County	-	13	50
Town of Leesburg	-	2	16
Town of Middleburg	-	1	-
Town of Purcellville	-	4	-
City of Alexandria	*	-	46*
City of Fairfax	-	-	9
City of Falls Church	-	-	1
TOTAL	**132**	**20**	**458**

* Critical facilities have been removed from the "High Incidence" category to "Low" risk based on committee feedback from the City of Alexandria.

Table 4.71. Number of HAZUS-MH Critical Facilities Potentially At-Risk to Landslide			
Jurisdiction, Facility	**High Incidence**	**High Susceptibility Moderate Incidence**	**Low**
Arlington County	7	-	43
Fairfax County	57	-	298
Town of Clifton	-	-	1
Town of Herndon	-	-	10
Town of Vienna	-	-	13
Loudoun County	-	16	57
Town of Leesburg	-	2	22
Town of Middleburg	-	3	-
Town of Purcellville	-	4	-
Town of Round Hill	-	1	-
Prince William County	12	-	117
Town of Dumfries	-	-	3
Town of Haymarket	-	-	1
Town of Occoquan	-	-	1
Town of Quantico	1	-	-
City of Alexandria	*	-	36*
City of Fairfax	-	-	22

Table 4.71. Number of HAZUS^MH Critical Facilities Potentially At-Risk to Landslide			
Jurisdiction, Facility	**High Incidence**	**High Susceptibility Moderate Incidence**	
City of Falls Church	-	-	6
City of Manassas	-	-	26
City of Manassas Park	-	-	4
TOTAL	**110**	**26**	**626**

* Critical facilities have been removed from the "High Incidence" category to "Low" risk based on committee feedback from the City of Alexandria.

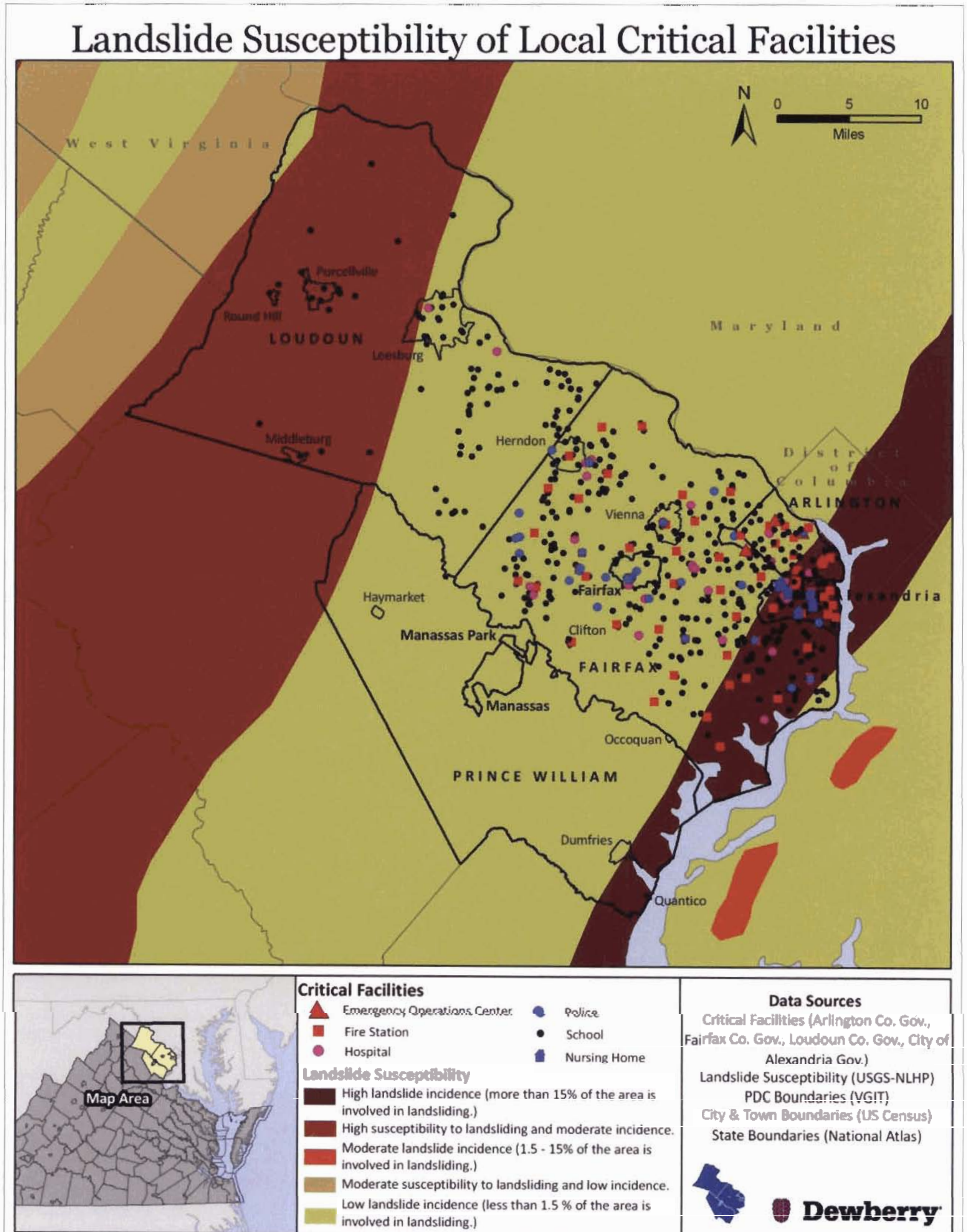


Figure 4.50. Landslide Susceptibility of Local Critical Facilities

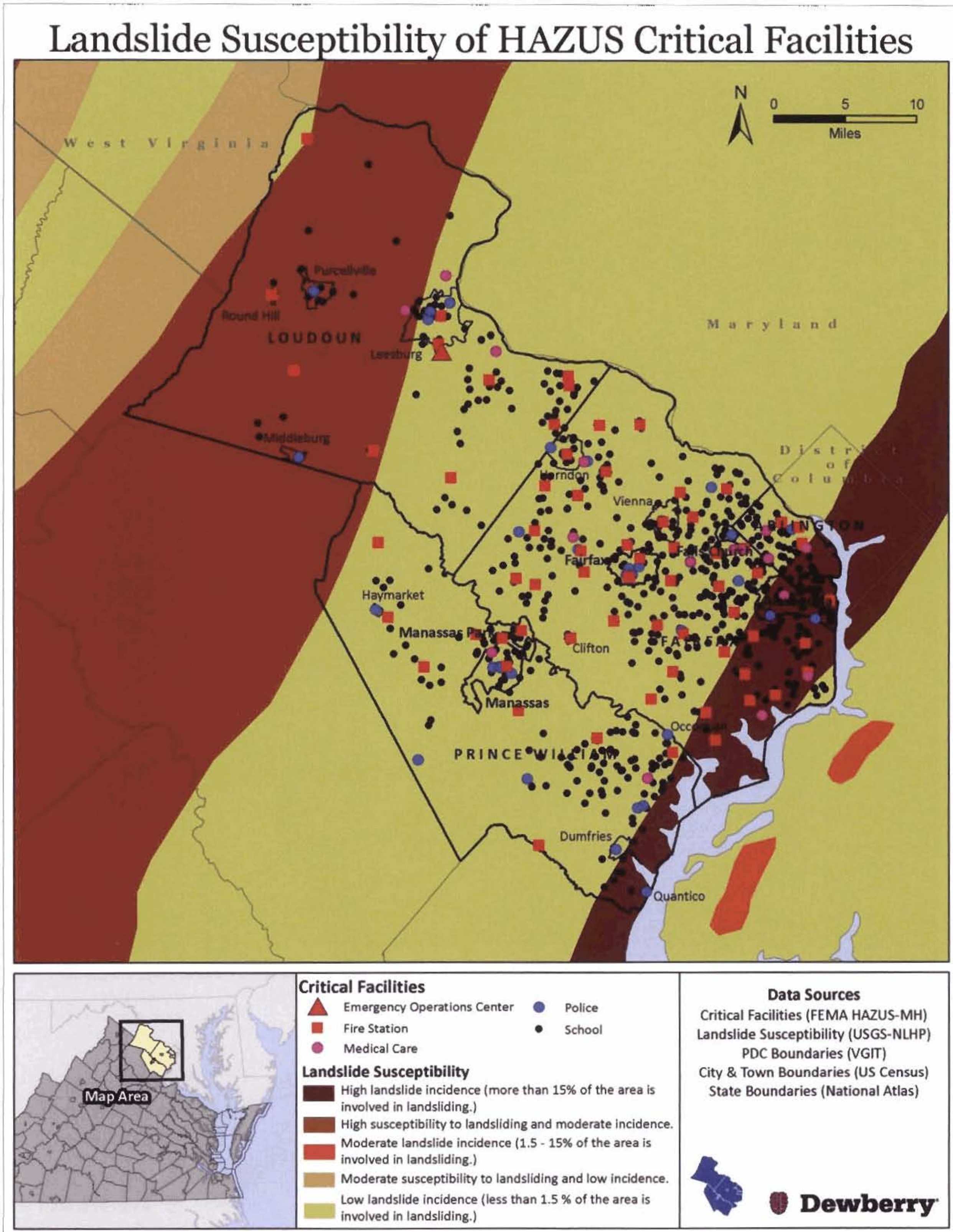


Figure 4.51. HAZUS^{MH} critical facility locations in relation to landslide susceptibility.

Existing Buildings and Infrastructure Risk

For the purposes of this risk assessment, potentially at-risk buildings for landslides were not considered due to the fact that the landslide incidence data is highly generalized, owing to the small scale and the scarcity of precise landslide information for much of the country, and is unsuitable for local planning or actual site selection. This precaution should be noted and is applicable to the analysis completed for critical facilities in the landslide zones.

Overall Loss Estimates and Ranking

Due to the lack of any historical landslide damage data and well established occurrence probabilities, damages caused by landslides and associated dollar losses could not be estimated for the 2006 plan creation or 2010 update.

The Commonwealth of Virginia's 2010 Hazard Mitigation Plan ranking was based on the NCDC database. The update to the Northern Virginia plan used this same framework to establish a common system for evaluating and ranking hazards. While this ranking methodology makes sense for the majority of the hazards in this plan, the data is limited/non-existent for landslides.

Inputs for landslide were very limited as a result of having no landslide events available in the NCDC database. To be able to include landslide in the ranking, some general assumptions were made; geographic extent was the primary basis for establishing risk and was calculated as what percent of the jurisdiction is in the high risk zone, as defined by USGS. In lieu of probability for future occurrence, areas with high landslide risk were assumed to be at greater risk. Since there are no recorded landslide events, the lowest ranking score (1) was assigned to the jurisdictions for events, damages, deaths, and injuries to be able to compare landslide to the other hazards.

Figure 4.52 summarizes each of the parameters used in the ranking and the overall relative ranking for landslides. The City of Alexandria and Loudoun County, in relation to the other jurisdictions in the planning region, have a higher risk for landslides. This can be attributed to population density and vulnerability and the geographic extent of USGS landslide mapping. The overall ranking for the City of Alexandria was modified to low based on feedback from city officials.

According to the 2006 qualitative assessment performed using the PRI tool, the landslide hazard scored a PRI value of 1.6 (on a scale of 0 to 4, with 4 being the highest risk level). Table 4.75 summarizes the risk levels assigned to each PRI category.

Table 4.72. 2006 Qualitative Assessment for Landslide

	Probability	Impact	Spatial Extent	Warning Time	Duration
Risk Level	Possible	Minor	Small	12 to 24 hours	Less than 6 hours

The 2006 PRI assessment is valid and supports the updated ranking and loss estimates.

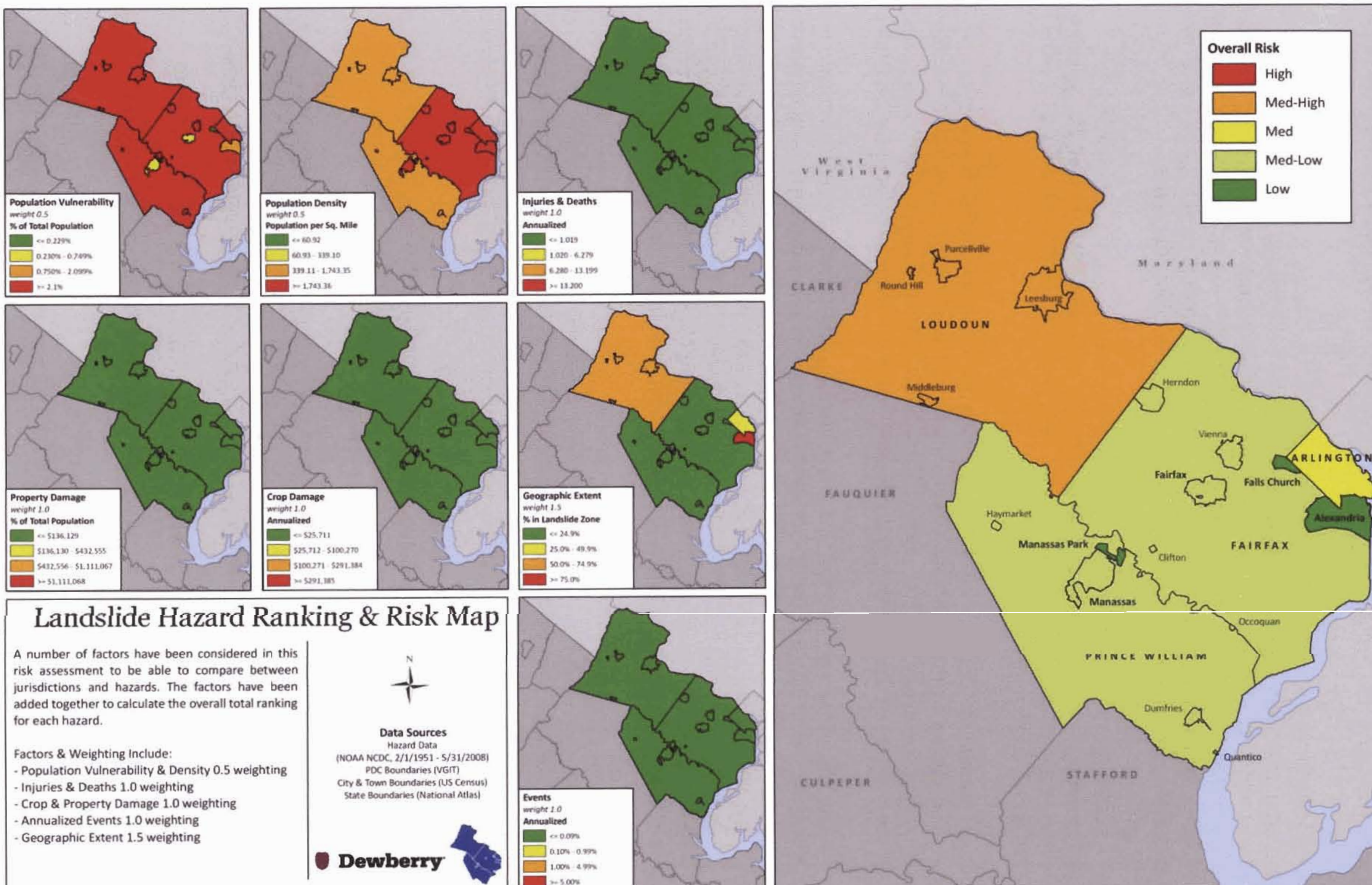


Figure 4.52. Landslide hazard ranking and risk.

XII. Wildfire

NOTE: As part of the 2010 plan update, the Wildfire hazard was reexamined and a new analysis performed. This new analysis included, but was not limited to: 1) refreshing the hazard profile; 2) updating the previous occurrences; 3) determining annualized number of hazard events and losses by jurisdiction using NCDC and other data sources where available; 4) updating the assessment of risk by jurisdiction based on new data; and 5) ranking of the hazard by jurisdiction using the methodology described in detail in Chapter 4, Section IV Ranking and Analysis Methodologies. Each section of the plan was also reformatted for improved clarity and new maps and imagery, when available and appropriate, were inserted.

A. Hazard Profile

1. Description

A wildfire is any fire occurring in a wildland area (i.e., grassland, forest, brush land) except for fire under prescription. Prescription burning, or "controlled burn," undertaken by land management agencies is the process of igniting fires under selected conditions, in accordance with strict parameters. Wildfires are part of the natural management of the Earth's ecosystems, but may also be caused by natural or human factors. More than 80% of forest fires are started by negligent human behavior such as smoking in wooded areas or improperly extinguishing campfires. The second most common cause for wildfire is lightning.

There are three classes of wildland fires: surface fire, ground fire, and crown fire. A surface fire is the most common of these three classes and burns along the floor of a forest, moving slowly and killing or damaging trees. A ground fire (muck fire) is usually started by lightning or human carelessness and burns on or below the forest floor. Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees. Wildland fires are usually signaled by dense smoke that fills the area for miles around.

State and local governments can impose fire safety regulations on home sites and developments to help curb wildfire. Land treatment measures such as fire access roads, water storage, helipads, safety zones, buffers, firebreaks, fuel breaks, and fuel management can be designed as part of an overall fire defense system to aid in fire control. Fuel management, prescribed burning, and cooperative land management planning can also be encouraged to reduce fire hazards.

Fire probability depends on local weather conditions; outdoor activities such as camping, debris burning, and construction; and the degree of public cooperation with fire prevention measures. Drought conditions and other natural disasters (tornadoes, hurricanes, etc.) increase the probability of wildfires by producing fuel in both urban and rural settings. Forest damage from hurricanes and tornadoes may block interior access roads and fire breaks, pull down overhead power lines, or damage pavement and underground utilities.

Many individual homes and cabins, subdivisions, resorts, recreational areas, organizational camps, businesses, and industries are located within high fire hazard areas. The increasing demand for outdoor recreation places more people in wildlands during holidays, weekends, and vacation periods. Unfortunately, wildland residents and visitors are rarely educated or prepared for the inferno that can sweep through brush and timber and destroy property in minutes.

2. Geographic Location/Extent

Wildfires commonly begin unnoticed and spread quickly through vegetative fuels. As discussed in the ranking methodology section, the VDOF risk assessment represents the geographic extent or locations throughout the Commonwealth that have a higher risk for wildfire. The geographic extent score for a given jurisdiction is based on the percent of the jurisdiction that falls within the "high" risk area as defined by VDOF. Fairfax and Loudoun Counties have the highest percent of their land area within the high risk classifications as compared to the other jurisdictions in the planning region. Table 4.73 and Figure 4.53 reflect the VDOF risk assessment and Figure 4.57 includes the geographic extent parameter used in the hazard ranking. Several areas in Northern Virginia are conducive to wildfires: the Conway-Robinson State Forest and Prince William Forests Park in Prince William County among them.

3. Magnitude or Severity

The Northern Virginia region is not considered as at-risk to wildfire as other areas of the State, but wildfire occurrence is certainly prevalent – particularly in Loudoun and Prince William counties. According to VDOF records, there were 120 wildfire events in the Northern Virginia region between 1995 and 2008. These fires burned a total of 368 acres and caused an estimated $180,895 in property damages, but fortunately caused no deaths or injuries. These fires were typically small in size, burning an average of approximately four acres before being suppressed (an estimated $7.5 million in damages were prevented by fire control efforts during this period). Of the 120 recorded historical incidents during this period, only six fires burned an area greater than 10 acres (all in Loudoun County). Table 4.74 lists the number of these fire events, acres burned, and estimated damages by jurisdiction for the Northern Virginia region.

4. Previous Occurrences

While the Commonwealth of Virginia rarely experiences the large, extensive wildfires typically seen in the western regions of the United States, wildfire risk remains a genuine concern. According to the VDOF, about 1,600 wildfires consume a total of 8,000 to 10,000 acres of forest and grassland in the State each year. During the fall drought of 2001, Virginia lost more than 13,000 acres to wildfires.

Virginia's wildfire season normally occurs in the spring (March and April) and then again in the fall (October and November). During these times, the relative humidity is usually lower, winds tend to be higher, and the fuels are cured to the point where they readily ignite. Also during these times hardwood leaves are on the ground providing more fuel and allowing sunlight to directly reach the forest floor, warming and drying the surface fuels.

Fire activity fluctuates during each month and also varies from year to year based on precipitation amounts. During years of adequate rain and snow, wildfire occurrence is typically low. Lack of moisture during other years means extended periods of warm, dry, windy days and therefore increased fire activity. The damage caused by Hurricane Isabel in 2003 increased the threat of wildfires in Virginia, and will be a major threat to lives and homes in the eastern half of Virginia for several years to come. The dead and downed timber caused by the storm has had time to cure and could produce wildfires that will be larger and much harder and dangerous to suppress.

Records indicate that most of Virginia's wildfires are caused by people. Virginia is growing more rapidly than many other States, and its population has doubled in the last 45 years. Further, people are moving into residential developments located within forested areas, and there is an increased use of the forests for recreational uses. All of these trends increase the risk of wildfires and require continued fire prevention and protection activities.

There have been 120 wildfire burning 368 acres during 1995 through 2008 totaling $180,895 in damages. Table 4.73 shows the total number of fires, acres burned, total damages, and total saved for jurisdictions that had recorded wildfire events by VDOF. Loudoun County wildfires make up the majority of damages in Northern Virginia during the period of record (1995-2008).

Table 4.73. Wildfire events in the Northern Virginia Region, 1995-2008

Jurisdiction	Number of Fires	Total Acres	Total Damages	Total Saved
Fairfax County	2	3	$0	$0
Loudoun County	90	287	$165,355	$17,778,450
Town of Leesburg	2	2	$200	0
Prince William County	25	70	$15,340	$3,374,600
Town of Dumfries	1	6	$0	$0
Total	**120**	**368**	**$180,895**	**$21,153,050**

Source: VDOF

The majority of the wildfire occurrences in the Northern Virginia region were caused by debris burning and other human activities. Table 4.74 shows the leading causes of wildfires in the region based on VDOF records for the 120 historical wildfires occurring between 1995 and 2008.

Table 4.74. Leading Causes of Wildfires in the Northern Virginia Region, 1995-2008

Cause	# of Fires	% of Wildfires
Debris Burning	35	29%
Children	24	20%
Miscellaneous	23	19%
Incendiary	14	12%
Smoking	12	10%
Equipment Use	8	7%
Campfire	2	2%
Lightning	1	1%
Railroad	1	1%

Source: VDOF

Based on the number of historical occurrences, wildfires are very prevalent events in the Northern Virginia region. These events, however, are usually contained to very small areas and have caused minimal damages to property due to strong fire response and suppression capabilities.

B. Risk Assessment

1. Probability of Future Events

Future wildfire incidents are difficult to predict, as the factors influencing wildfire generation vary greatly with changing weather conditions and human activities. There is currently no quantitative estimate of future wildfire probability for specific regions of the State.

While the VDOF Wildfire Risk Assessment does indicate the relative propensity for wildfires across the State, this assessment does not assign probabilities of occurrence or return intervals as is common with some of the other hazards. Based on available data from VDOF, during the years 1995 – 2008, Virginia experiences an average of 1,188 wildfires per year, affecting an average of 8,844 acres annually.

2. Impact & Vulnerability

Vulnerability to wildfire is influenced by a variety of factors, such as land cover, weather, and the effectiveness of land management techniques. Highly urbanized areas are less vulnerable to wildfire, but suburban neighborhoods located at the urban/wildland interface are very vulnerable to wildfire. The primary impacts of most wildfires are timber loss and environmental damage, although the threat to nearby buildings is always present. Secondary impacts may also include landslides and mudslides caused by the loss of groundcover which stabilizes the soil.

3. Risk

In 2002 and 2003, VDOF used GIS to develop a statewide spatial *Wildfire Risk Assessment* model that aims to: (1) identify areas where conditions are more conducive and favorable to wildfire occurrence and wildfire advancement; (2) identify areas that require closer scrutiny at larger scales; and (3) examine the spatial relationships between areas of relatively high risk and other geographic features of concern, such as woodland home communities, fire stations, and fire hydrants. This model incorporates data from several other State and Federal agencies including land cover, demographics, transportation corridors, and topography to illustrate the level of wildfire risk for all areas across the State of Virginia. The results of this model were merged and the wildfire risks were classified and scored as: 1 (low), 2 (moderate), and 3 (high).

Prince William County has over 15% of its acreage in the high risk category, with the Town of Round Hill having almost one-third of its acreage at high risk. Fairfax County has approximately 12% of its acreage in the high risk category, with over 16% of the Town of Clifton's area in high risk. The Northern Virginia region is mostly low (48.97%) and medium (41%) risk, with a tenth of the region in the high risk category. More information on VDOF's GIS-based Wildfire Risk Assessment is available at www.dof.virginia.gov.

Table 4.75. Wildfire Risk by Jurisdiction							
Jurisdiction	**Low (acres)**	**Low % Area**	**Medium (acres)**	**Medium % Area**	**High (acres)**	**High % Area**	**Total Acres**
Arlington County	16,064	**96.30%**	435	**2.61%**	183	**1.10%**	**16,682**
Fairfax County	143,682	**57.22%**	77,244	**30.76%**	30,174	**12.02%**	**251,100**
Town of Herndon	2,734	***99.93%***	1	***0.04%***	0	***0.00%***	**2,736**
Town of Vienna	2,795	***99.25%***	21	***0.75%***	0	***0.00%***	**2,816**
Town of Clifton	43	***26.06%***	95	***57.58%***	27	***16.36%***	**165**
Loudoun County	136,046	**42.16%**	166,511	**51.60%**	20,114	**6.23%**	**322,672**
Town of Leesburg	4,670	***58.46%***	2,635	***32.98%***	684	***8.56%***	**7,989**
Town of Purcellville	278	***13.69%***	1,738	***85.62%***	14	***0.69%***	**2,030**
Town of Middleburg	219	***33.08%***	389	***58.76%***	55	***8.31%***	**662**
Town of Round Hill		***0.00%***	165	***69.62%***	71	***29.96%***	**237**
Prince William County	87,118	**39.77%**	98,129	**44.79%**	33,828	**15.44%**	**219,076**
Town of Dumfries	745	***73.40%***	255	***25.12%***	14	***1.38%***	**1,015**
Town of Haymarket	240	***78.43%***	66	***21.57%***	0	***0.00%***	**306**
Town of Occoquan	83	***74.77%***	27	***24.32%***	0	***0.00%***	**111**
Town of Quantico	44	***93.62%***	3	***6.38%***	0	***0.00%***	**47**
City of Alexandria	9,644	**98.83%**	114	**1.17%**	0	**0.00%**	**9,758**
City of Fairfax	3,801	**94.65%**	215	**5.35%**	0	**0.00%**	**4,016**
City of Falls Church	1,275	**100.00%**	0	**0.00%**	0	**0.00%**	**1,275**
City of Manassas	6,130	**95.50%**	287	**4.47%**	2	**0.03%**	**6,419**
City of Manassas Park	741	**65.29%**	265	**23.35%**	129	**11.37%**	**1,135**
TOTAL	**416,352**	**48.97%**	**348,595**	**41.00%**	**85,295**	**10.03%**	**850,247**

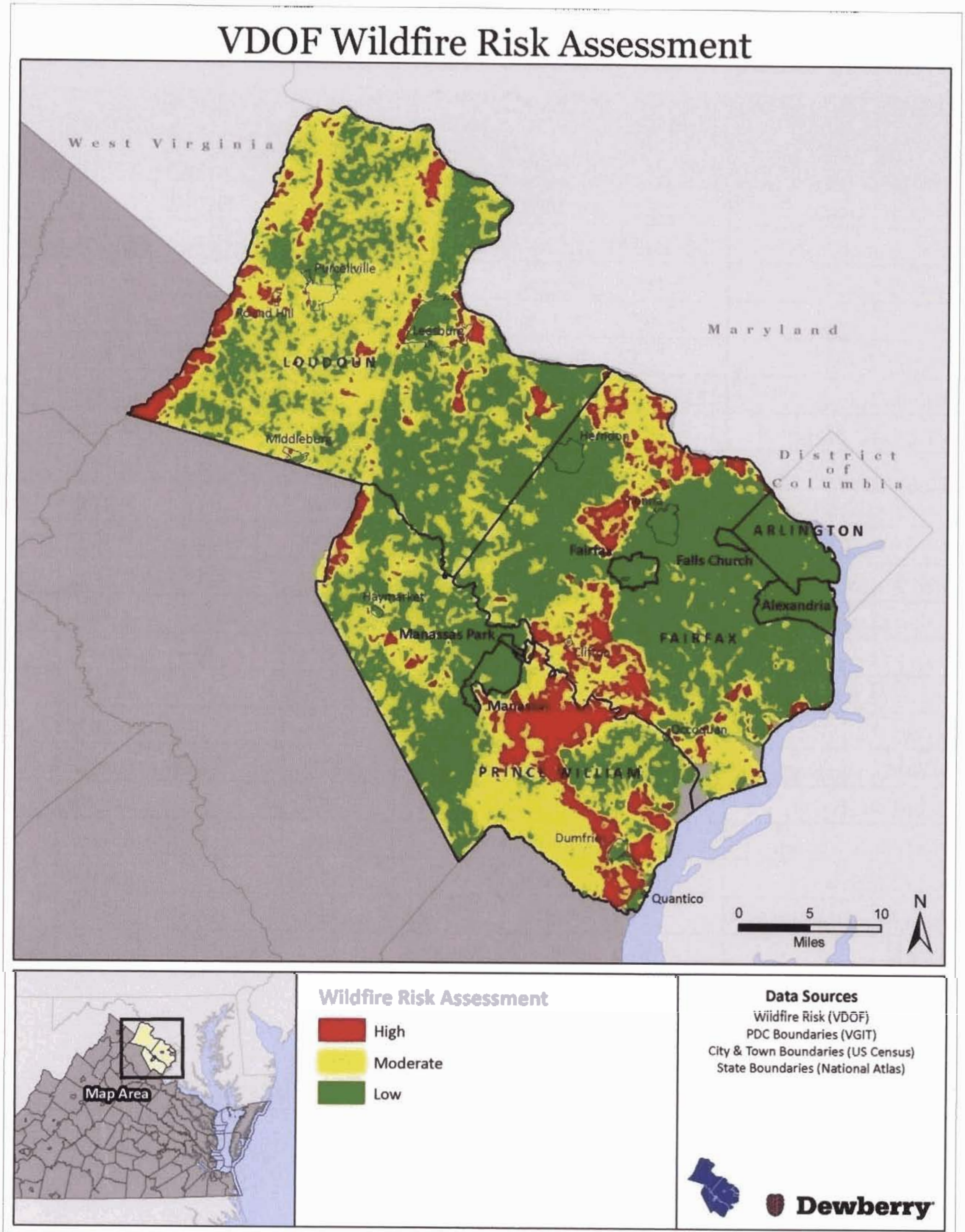


Figure 4.53. VDOF Wildfire Risk Assessment of Northern Virginia

Critical Facility Risk

The HAZUS^{MH} critical facilities data was intersected with the VDOF wildfire risk assessment to determine which facilities were at an increased risk for wildfire, or being in the urban/wildland interface. Table 4.76 shows the number of critical facilities, by locality, for the moderate and high VDOF risk zones. The results of this analysis indicate 22 critical facilities are located in high wildfire risk zones and 89 in moderate risk zones. Prince William County has the highest number of critical facilities in moderate (34) and high (15) risk zones. Schools represent the majority of critical facilities in the high wildfire risk zone. Only localities with critical facilities located in the moderate and high risk zones have been included in Table 4.76.

Risk for the locally supplied critical facilities data was calculated in the same fashion as described above for the HAZUS^{MH} facilities. Table 4.77 shows the number of critical facilities, by locality, for the moderate and high VDOF risk zones. Fairfax and Loudoun Counties were the only localities with critical facilities in moderate and high risk zones. Similar to the HAZUS^{MH} analysis, schools represent the majority of critical facilities in the high wildfire risk zone.

The names and information for the HAZUS^{MH} and local critical facilities in the wildfire risk zones are available in the Critical Facility-Risk Appendix D2.

The lack of wildfire probabilities and detailed infrastructure data led to the inability to calculate potential losses due to wildfire.

Table 4.76. Number of Local Government Critical Facilities Potentially At-Risk to Wildfire

Jurisdiction	**Wildfire Risk**		
Facility Type	*Moderate*	*High*	**Total**
Fairfax County	**25**	**2**	**27**
Fire Station	*3*	*0*	*3*
Hospital	*1*	*0*	*1*
Police	*2*	*0*	*2*
Schools	*19*	*2*	*21*
Loudoun County	**29**	**2**	**31**
Hospitals	*1*	*0*	*1*
Schools	*28*	*2*	*30*
Total	**54**	**4**	**58**

Table 4.77. Number of HAZUS^{MH} Critical Facilities Potentially At-Risk to Wildfire			
Jurisdiction	**Wildfire Risk**		**Total**
Facility Type	*Moderate*	*High*	
Fairfax County	**19**	**5**	**24**
Fire Station	2	1	3
School	17	4	21
Town of Clifton	**1**	**0**	**1**
Fire Station	1	0	1
Loudoun County	**24**	**2**	**26**
Fire Station	3	0	3
Medical Care	2	0	2
School	19	2	21
Town of Leesburg	**5**	**0**	**5**
Fire Station	1	0	1
School	4	0	4
Town of Purcellville	**4**	**0**	**4**
Police Station	1	0	1
School	3	0	3
Town of Round Hill	**1**	**0**	**1**
Fire Station	1	0	1
Prince William County	**34**	**15**	**49**
Fire Station	4	1	5
Medical Care	1	0	1
Police Station	2	1	3
School	27	13	40
City of Fairfax	**1**	**0**	**1**
School	1	0	1
Total	**89**	**22**	**111**

Existing Buildings and Infrastructure Risk

According to VDOF statistics collected in 2003, Virginia has more than 4,000 woodland home communities. These areas are defined by VDOF as "clusters of homes located along forested areas at the wildland-urban interface that could possibly be damaged during a nearby wildfire incident." In the Northern Virginia region, there are 91 woodland home communities, all of which are located in Loudoun (21) and Prince William (70) counties. Table 4.78 lists the number of woodland home communities by planning area for the Northern Virginia region that are located in areas identified as being either high or moderate risk for wildfires. Figure 5.54 shows the location of these woodland home communities in relation to the identified wildfire hazard areas. More information on these communities is readily available through the VDOF.

Table 4.78. At-Risk Woodland Communities in the Northern Virginia Region

County	Low Risk	Moderate Risk	High Risk
Prince William County	7	27	36
Loudoun County	1	13	7
Total	**8**	**40**	**43**

Source: VDOF

As demonstrated above and in the critical facility analysis, most of the wildfire risk in the Northern Virginia region is located in areas of Loudoun and Prince William counties. Historically, wildfires have been larger and caused more damages in these counties mainly due to not only increased vegetative fuel loads, but also because the areas are sparsely settled and have less rapid fire response capabilities. The most at-risk properties within these areas are considered to be those structures located along the wildland-urban interface, defined by the National Wildfire Coordinating Group[30] as "the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels." Structures with combustible roofs and less than 30 feet of cleared defensible space are particularly at risk.

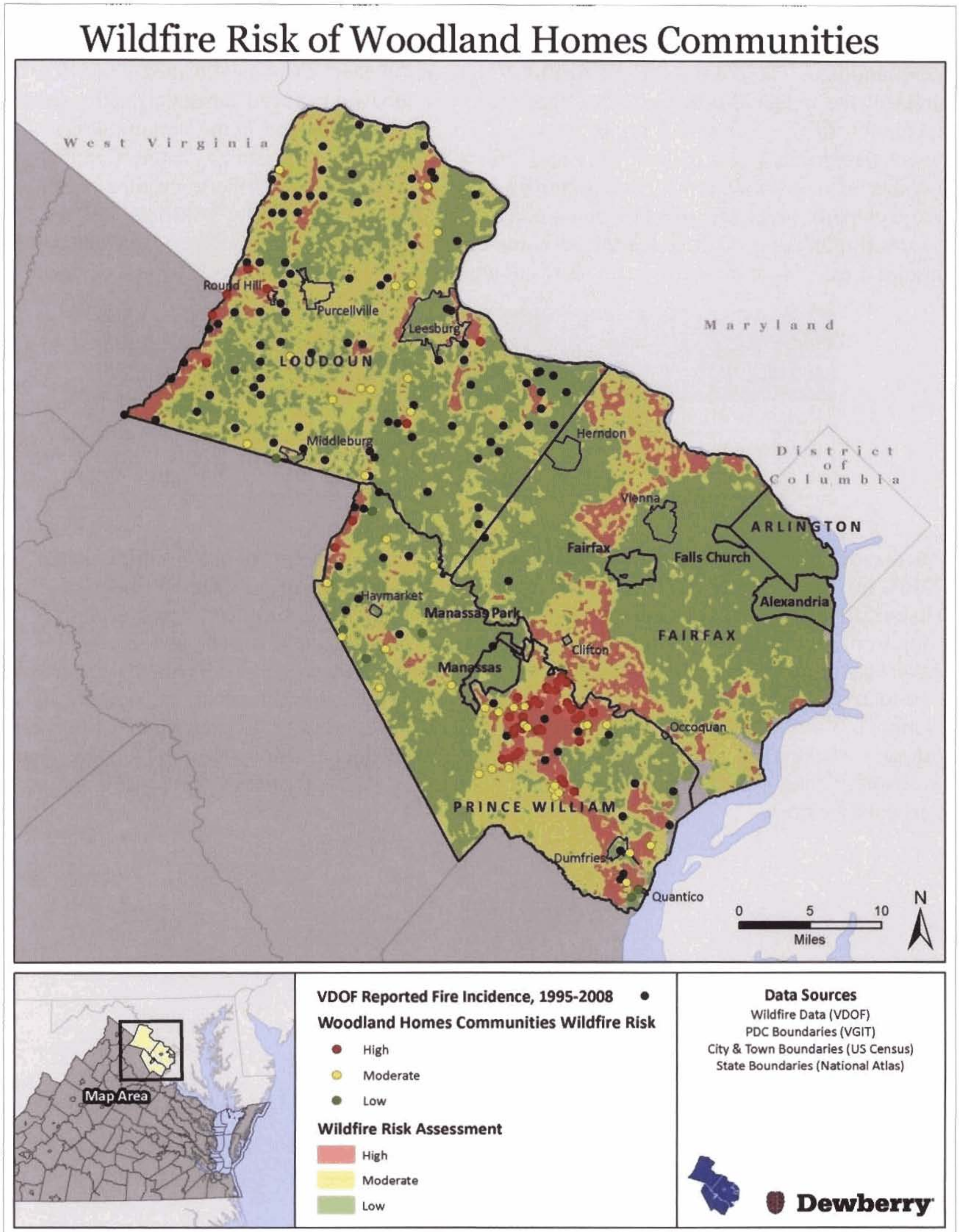


Figure 4.53. Wildfire Risk to Woodland Homes Communities

Wildfire Risk to Historic Buildings

Historic site data provided by Fairfax County and Arlington County was used to identify historical buildings and lands that are vulnerable to wildfire, shown in Figure 4.54. In Fairfax County, six historic sites are at moderate risk of wildfire. These sites include George Washington's House at Mt. Vernon, George Washington's Gristmill, Sully Plantation, Matildaville Ruins, Woodland Plantation, and The Old Schoolhouse at Great Falls Grange Park. In Arlington County, only one of 30 historic sites is vulnerable, The Glenmore House at 3440 North Roberts Lane.

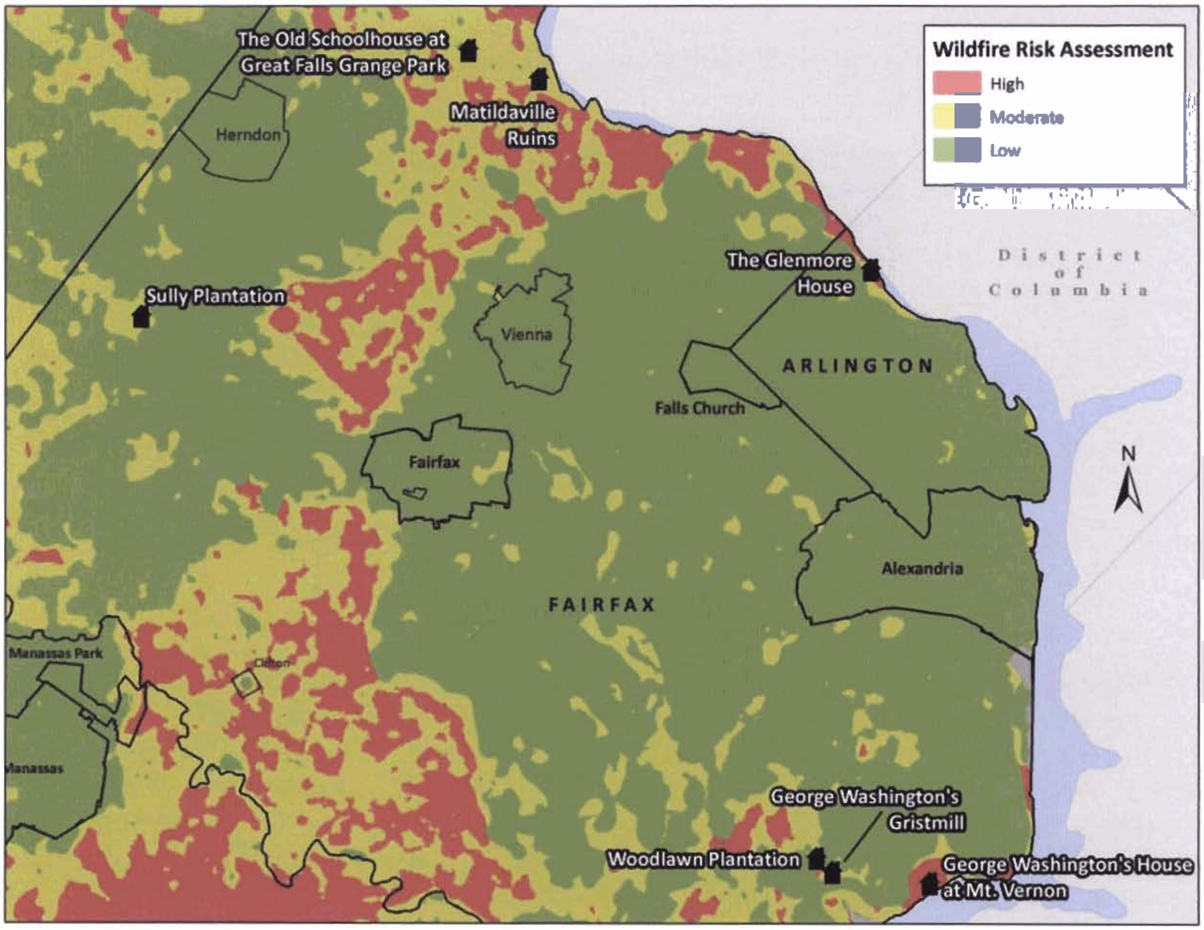


Figure 4.54. Wildfire Vulnerability of Historic Sites

Overall Loss Estimates and Ranking

During the 2006 plan creation, annualized loss for wildfire was estimated at $25,000 for the region. For the 2010 plan update, seven additional years of VDOF record were utilized to develop updated annualized loss estimates of $13,915.

Between 1995 and 2008, the VDOF recorded 120 wildfire events in the Northern Virginia region totaling approximately $180,895 in damages. Table 4.79 shows the specific annualized loss by jurisdiction. This is based on the total VDOF reported damages divided by the number of years of record. The regional annualized loss estimate for the wildfire hazard in the Northern Virginia region is $13,915. The annualized loss has decreased since the 2006 plan; this can be attributed to the longer length of record with 34 additional wildfires with a total of $5,895 in damages being added to the dataset.

Table 4.79. Wildfire Annualized Loss Estimate based on VDOF data, 1993 – 2008.

Jurisdiction	Annualized Loss
Fairfax County	$0
Loudoun County	$12,720
Town of Leesburg	$15
Prince William County	$1,180
Town of Dumfries	$0
Total	**$13,915**

No wildfire events were recorded in the NCDC database for the Northern Virginia region; as a result, no NCDC annualized loss estimate was calculated. The Commonwealth of Virginia's 2010 Hazard Mitigation Plan ranking was based on the NCDC database. The update to the Northern Virginia plan used this same framework to establish a common system for evaluating and ranking hazards. While this ranking methodology makes sense for the majority of the hazards in this plan, the data is limited and/or non-existent for wildfires. The geographic extent score for each jurisdiction is based on the percent of the jurisdiction that falls within the "high" risk zone, as defined by VDOF. Since there are no recorded wildfire events, the lowest ranking score (1) was assigned to the jurisdictions for events, damages, and deaths and injuries to compare wildfire to the other hazards.

Figure 4.55 shows the relative wildfire rankings for each jurisdiction. The majority of the region is located in Medium and Medium-Low risk zones. As shown, the population parameters and VDOF risk assessment drive the overall results of this ranking. Fairfax and Prince William counties have a Medium ranking, while Loudoun County, as a result of the other parameters, has an overall ranking of Medium-Low. Based on committee feedback, the City of Fairfax ranking parameters have been changed to mirror Fairfax County. This is only reflected in Figure 4.55 and on the overall ranking map (Figure 4.61) at the end of the Risk Assessment. NCDC values contained within the tables have not been adjusted and reflect what was available in the database.

According to the qualitative assessment performed in 2006 by the steering committee using the PRI tool, the wildfire hazard scored a PRI value of **2.6** (on a scale of 0 to 4, with 4 being the highest risk level). Table 4.80 summarizes the risk levels assigned to each PRI category.

Table 4.80. 2006 Qualitative Assessment for Wildfire

	Probability	Impact	Spatial Extent	Warning Time	Duration
Risk Level	Highly Likely	Minor	Small	Less than 6 hours	Less than one week

The 2006 PRI assessment remains valid and supports the updated ranking and loss estimates.

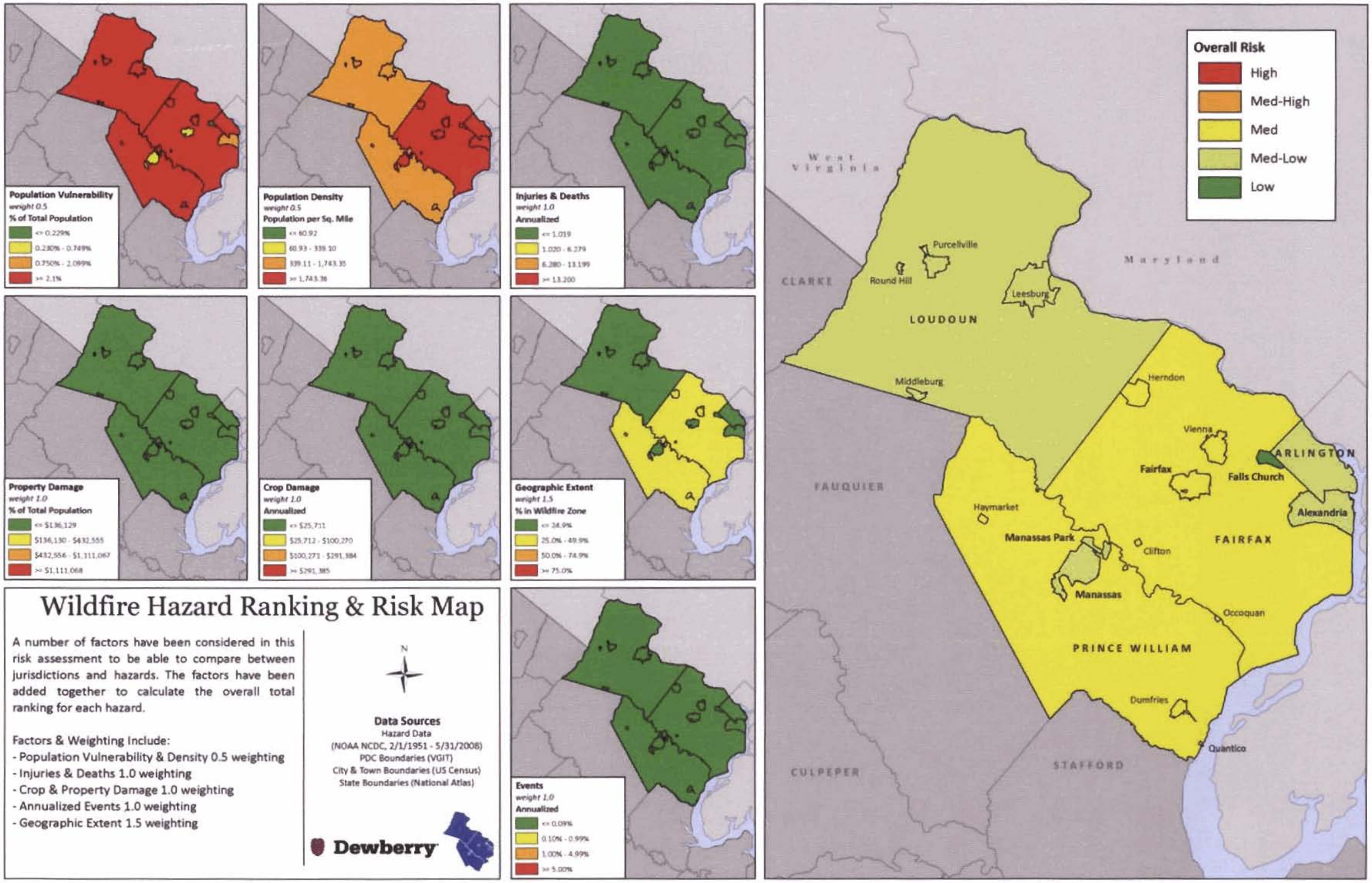


Figure 4.55. Wildfire ranking and overall risk.

C. Building Fires

In addition to those caused by wildfires, building fires may also be the result of arson or accidents. Accidental building fires are relatively unpredictable and could be caused by a variety of sources.

Potential ignition sources include:

- Heat from fuel-fired, fuel-powered object (e.g., heat, spark, ember, or flame from equipment);
- Heat from electrical equipment arcing, overloaded (e.g., short circuit arc, fluorescent light ballast);
- Heat from smoking material (e.g., cigarette);
- Heat from open flame (e.g., lighter, candle);
- Heat from a hot object (e.g., electric lamp, spark from friction);
- Heat from natural source (e.g., lightning);
- Heat spreading from another hostile fire (exposure) (e.g., radiated heat, direct flame); and
- Other[31].

Vulnerability of buildings to fire is in part related to existing fire protection, construction type (interior, exterior, roofing) and the building's contents. High-occupancy areas (high-rise buildings, dormitories, etc.) and areas containing flammable or incendiary materials (laboratories, chemical storage facilities, libraries, etc.) are of special concern and mitigation activities should be tailored accordingly.


On Sunday, December 31, 2006 a car smashed into a gas meter at an apartment complex in the Tysons Corner area resulting in a fire and explosion. Several apartments were damaged and residents were displaced. (Photo from Fairfax County, VA)

Buildings are also vulnerable to fires that result from criminal activity such as acts of vandalism, illicit substance use, malicious or intentional acts, and rioting.

Building fires also are inter-related to other hazards, as is mitigation of these hazards. For example, if fire suppression hydrants are unusable due to a severe winter cold snap (freeze) or if a blizzard makes them inaccessible due to snow plowing blocking access, building fire suppression is compromised.

XIII. Sinkholes / Karst / Land Subsidence

NOTE: As part of the 2010 plan update, the Sinkholes/Karst/Land Subsidence hazards were reexamined and a new analysis performed. This new analysis included, but was not limited to: 1) refreshing the hazard profile; 2) updating the previous occurrences; 3) determining annualized number of hazard events and losses by jurisdiction using NCDC and other data sources where available; 4) updating the assessment of risk by jurisdiction based on new data; and 5) ranking of the hazard by jurisdiction using the methodology described in detail in Chapter 4, Section IV Ranking and Analysis Methodologies. Each section of the plan was also reformatted for improved clarity, and new maps and imagery, when available and appropriate, were inserted.

A. Hazard Profile

1. Description

Sinkholes are a frequent occurrence in areas underlain by calcareous carbonate formations, especially limestone and dolomite. Groundwater flow through cracks, fissures, joints, and other discontinuities in the rock mass dissolves the carbonate minerals creating small voids. Over time continued water seepage and dissolution of minerals enlarges the void to form caves and caverns in the rock. As the void increases in size, so does the load supported by the void roof. If the strength of the roof layer becomes less than the weight of the material above it the roof fails and the overburden materials collapse into the void. If the collapse manifests itself at the surface, the resulting depression is referred to as a sinkhole. Other calcareous carbonate materials include partially-cemented to well-cemented shell formations found in coastal areas of the southeastern United States.

The process of sinkhole formation depends on a complex set of variables including geologic structure, geochemistry, hydrologic conditions, and development activity. If the roof above the void is sound rock and the water level falls below the roof level, future growth of the void may not reduce the roof thickness and collapse may not occur. However, if the roof rock is fractured or otherwise cracked, shallow groundwater from above can flow into the void bringing with it eroded overburden soil. The erosion of overburdened soil into the rock void creates a similar soil void that can migrate to the surface, resulting in a collapse of the soil roof even though the underlying rock has not collapsed.

Changes in hydrologic conditions, natural or man-made, can increase the occurrence of sinkholes. An increase in the volume and/or velocity of flow through the rock provides more fresh water to dissolve soluble minerals and more energy to erode solid particles, increasing existing voids or creating new ones. Water supply and open pit mining are common reasons for pumping large volumes of water through soluble calcareous formations.

Sink holes vary in size, ranging from a few feet to a mile or more in diameter. Sink holes can reach several hundred feet below the surface. Areas of abundant sinkholes are referred to as karst topography. Karst areas have few surface streams as drainage is primarily through underground solution channels.

Sinkholes can also occur due to the impacts of constructed facilities in most geologic environments, including those not underlain by calcareous carbonate rocks. Undetected leaks in underground utility lines can result in subsurface erosion of soil from around the pipe. Left undetected, the erosion creates a void that expands upward until the soil roof cannot support the overburden load and the roof collapses.

2. Geographic Location/Extent

Sinkholes are prevalent in the Great Valley region of central Virginia, including karst terrains in the Shenandoah Valley where voids are formed by the natural dissolution of soluble rock such as limestone and dolomite.

According to the Virginia Department of Mines, Minerals and Energy, sinkholes are very rare in the Northern Virginia region and do not pose a significant risk. However, a band of metamorphosed limestone, dolostone, and marble located in eastern Loudoun County and the Town of Leesburg has a history of sinkhole activity. Figure 4.56 shows the karst regions and areas of historical subsidence in the Commonwealth, based on the USGS Engineering Aspects of Karst. The karst regions in Northern Virginia are considered short karst type, which include fissured, tube, and caves generally less than 1,000 feet long; and 50 feet or less in vertical extent.

Loudoun County has a region of karst geology located in an area roughly one mile on either side of State Route 15 from just south of Leesburg, north to the Potomac River bridge. The region is bounded sharply to the west by the Bull Run Fault, which runs at the base of Catoctin Mountain through Loudoun County. Figure 4.57 shows the limestone district for Loudoun County. The Limestone Overlay District (LOD) is primarily comprised of the following geologic formations:

- Cf-Frederick Limestone;
- Ct-Tomstown Dolomite;
- JTRc-Catharpin Creek Formation;
  JTRcg-Catharpin Creek Formation Goose Creek Member;
- TRbl-Balls Bluff Siltstone Leesburg Member; and
- TRbs-Balls Bluff Siltsone Fluvial and Deltaic Sandstone Member.

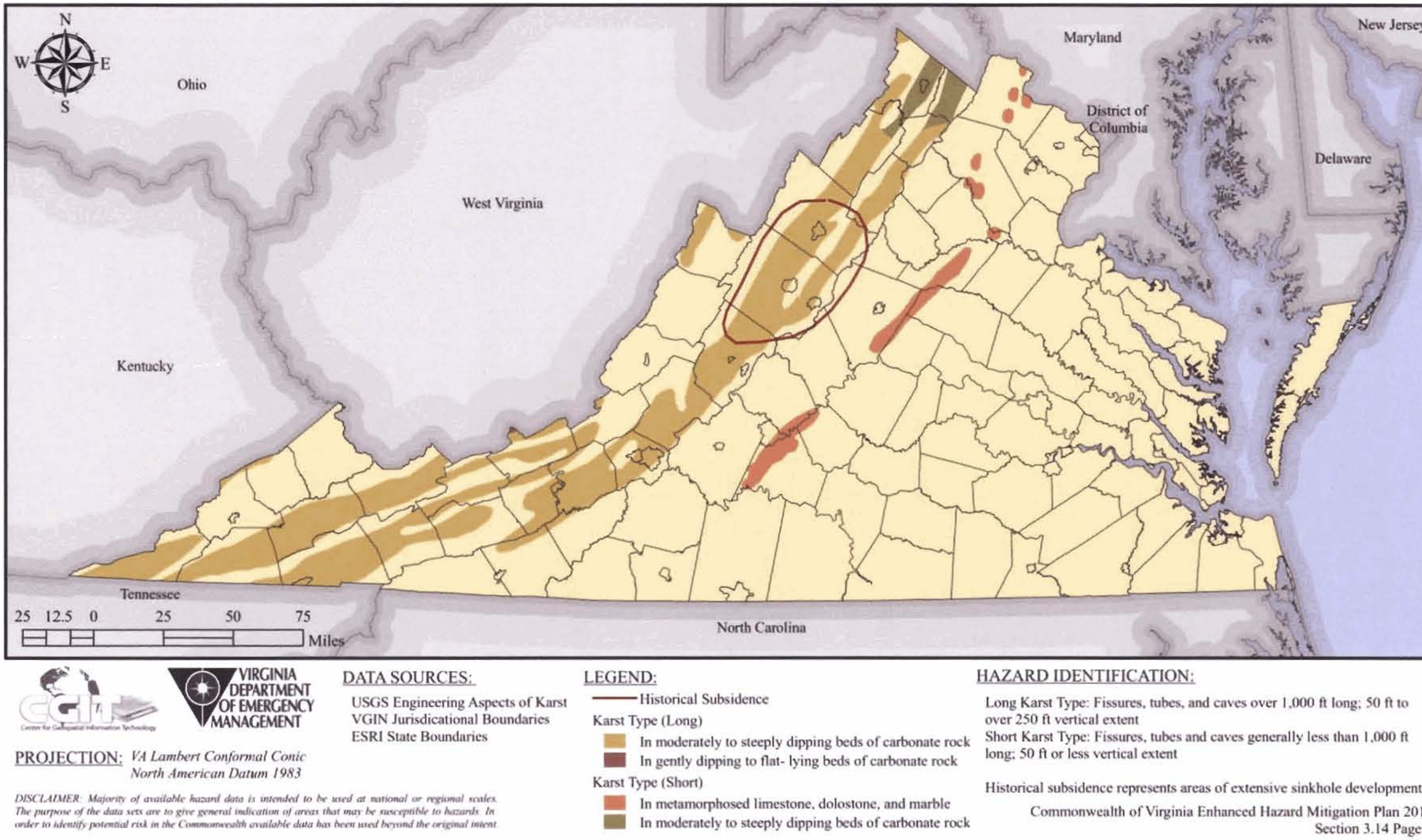


Figure 4.56. Karst Regions and Historical Subsidence in Virginia. *Source: Commonwealth of Virginia Emergency Operations Plan*

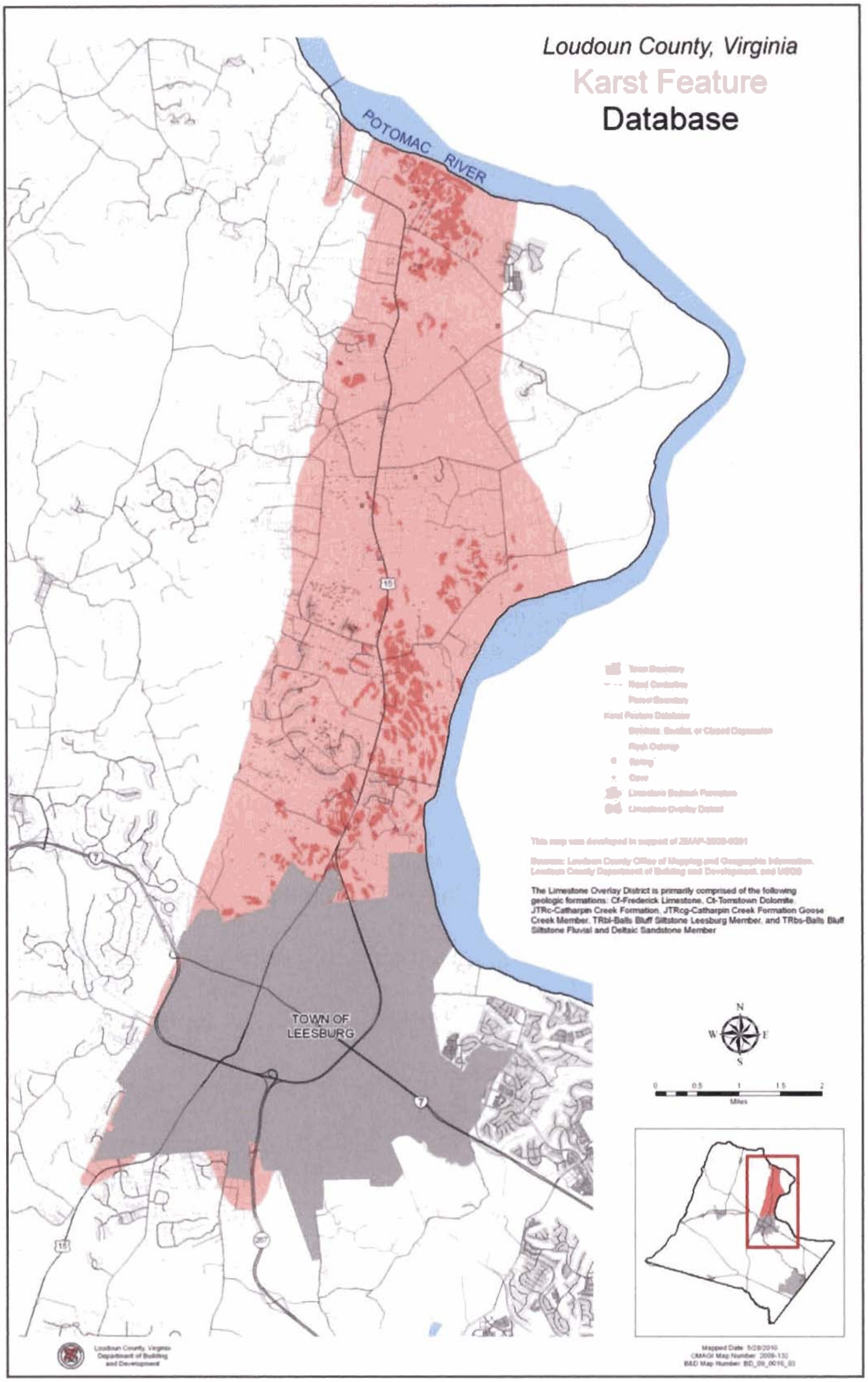


Figure 4.57. Loudoun County limestone district. Source: Loudoun County website http://www.loudoun.gov

3. Magnitude or Severity

Although sinkholes frequently occur without notice, there are warnings of potential sinkhole development including:

- Slumping or leaning fence posts, utility poles, trees, etc.;
- Discolored vegetation;
- Tension crack visible in the ground surface;
- Discolored well water;
- New cracks in building walls and/or; and
- Newly sagging floors or pavements.

Sinkhole formation is aggravated and accelerated by urbanization. Development increases water usage, alters drainage pathways, overloads the ground surface, and redistributes soil. According to FEMA, the number of human-induced sinkholes has doubled since 1930, costing nearly $100 million. The increasing frequency of sinkholes could be affected by reporting biases. A paper published by the USGS, Tampa, Florida shows a significant increase in sinkhole development that corresponds to a period of drought. Changes in ground water levels increase the overburden stress on the void roof increasing the potential for roof collapse. Thus using that period as indicating a larger trend may not be appropriate, especially given the context of the initial data. Additionally, Florida data suggests that the jump in sinkhole development in the 1987 to 1991 period was caused, at least in part, by natural events. Further, the reason for the jump in insurance payouts is likely the result of naturally caused sinkholes occurring under more expensively developed real estate[32].

4. Previous Occurrences

Water leaking from culverts or other drainage structures can create a void beneath the drainage structure by compaction or internal scour of the soil. This reduction in support can result in displacement of the leaking structure and an increase in leakage or breakage. The void may increase in size to the extent that the soil has insufficient strength to support itself with subsequent failure, leading to the formation of a steep sided, collapsed sinkhole.

Sinkholes remain a possible occurrence in localized areas of the Northern Virginia region. To date, there have been no Federal Declared Disasters or NCDC recorded events for karst related events. Land subsidence is very site-specific. Currently there is no comprehensive long-term record of past events in Virginia.

Known events, although not comprehensive, include:

- A sinkhole 20 feet deep and 25 feet wide closed down Dale Boulevard west of Mapledale Avenue, about four miles from Interstate 95 in Prince William County (2008).
- August 11, 2001, heavy rainfall washed out a culvert and created a sinkhole in Arlington County, though no damages were reported.

B. Risk Assessment

The Engineering Aspects of Karst data set shows areas of karst in the United States. This data set is a digital representation of USGS Open-File Report 2004-1352, which is a PDF version of the 1984 USGS Engineering Aspects of Karst map (scale 1:7,500,000). These maps depict areas containing distinctive surficial and subterranean features, developed by solution of carbonate and other rocks and characterized by closed depressions, sinking streams, and cavern openings. Loudoun County and the Town of Leesburg are the only areas in the planning region that have been included in the USGS Engineering Aspects of Karst.

David Hubbard, geologist with the Virginia Department of Mines, Minerals, and Energy developed 1:24,000 scale sinkhole boundary maps during 1980 and 1988 for the State. Sinkhole distribution is shown in three main regions along the Valley and Ridge province. A total of 48,807 sinkholes have been mapped over 254 standard (7.5 minute) topographic maps for an average of 192.1 sinkholes per map. The southern third of the project area represented more than half of the mapped location. There appears to be an increase in the relative degree of karstification from north to south across the State of Virginia[33]. These maps are not currently available in digital format. Additional analysis may be able to be completed in future versions of this plan as digital data becomes available.

In May 2010, Loudoun County re-adopted and re-enacted the LOD. In February 2010 the Board of Supervisors adopted amendments to the Zoning Ordinance Zoning Map, Facilities and Standards Manual, the land Subdivision & Development Ordinance, and other county ordinances to create the LOD. The amendments will implement the County's adopted Comprehensive Plan provisions concerning limestone areas by creating and mapping a new LOD and amending Section 6-407(A) of the Zoning Ordinance to add a LOD to the list of environmental overlay districts for which the Zoning Administrator is authorized to make cartographic interpretations, and amending Article 8, Definitions, of the Zoning Ordinance to add and/or revise definitions for uses and terminology used in the proposed amendments.

1. Probability of Future Occurrences

The exact time that land subsidence will occur cannot be predicted; it can occur suddenly without warning or over an extended period of several years. However, some factors that can cause a decrease in strength are wet conditions, vibrations, and increased surface loading. Land subsidence that occurs as a result of a drawdown of the groundwater table is likely to take place over a number of years. Procedures for predicting the occurrence of land subsidence have not yet been developed.

To be able to include karst in the risk assessment some general assumptions were made. Geographical Extent, using USGS Karst Topography maps, was the primary basis for establishing risk and was calculated as a percent of the jurisdictional area. In lieu of probability of future occurrence, areas with more karst were assumed to be at greater risk.

2. Impact & Vulnerability

The potential impacts of land subsidence depend on the type of subsidence that occurs (regional or localized, gradual or sudden) and the location that the subsidence occurs. The impacts of subsidence occurring in nonurban areas are likely to be less damaging than subsidence that occurs in heavily populated locations. The amount of structural damage depends on the type of construction, the structure location and orientation with respect to the subsidence location, and the characteristics of the subsidence event (sag or pit).

Potential impacts from land subsidence could include damage to residential, commercial, and industrial structures; damage to underground and above-ground utilities; damage to transportation infrastructure, including roads, bridges, and railroad tracks; as well as damage or loss of crops. The extent and value of the potential damage cannot be assessed because the nature of the damage is site- and event-specific.

3. Risk

As discussed above, sinkholes are relatively uncommon events in the Northern Virginia region. The existing soil types are not conducive to creating natural sinkholes, and those that do occur are related to soil piping or the dissolution of sparse carbonate rock and typically cause very little damage. There are no known sources of sinkhole probability data for the region and no record of historical incidences causing property damages.

As mentioned above, Loudoun County has adopted a LOD in their zoning ordinance that seeks to preserve and protect the unique geologic characteristics and the quality of the groundwater in its limestone area. The ordinance is intended to regulate land use and development in areas underlain by limestone and in areas with Karst features and Karst terrain in such a manner as to[34]:

- Protect the health, safety and welfare of the public;
- Protect groundwater and surface water resources from contamination; and
- Reduce potential for property damage resulting from subsidence or other earth movement.

Critical Facility Risk

The vulnerability of each identified critical facility was assessed using GIS analysis by comparing their physical location with the extent of known hazard areas that can be spatially defined through GIS technology. Of those critical facilities identified in the region, many were indeed determined to be in known hazard areas upon further GIS analysis and thereby determined to be "potentially at-risk."

There are approximately 22 HAZUS^{MH} critical facilities and 14 local critical facilities (some of which are most likely duplicates) located in or near mapped karst regions all located within Loudoun County (Table 4.81). Critical facilities provided by Loudoun County are shown in Table 4.82. Schools make up the majority of the critical facilities located within the hazard zones. Figure 4.58 shows the location of the mapped karst regions and the HAZUS^{MH} critical facilities.

The names and information for the HAZUS^{MH} and local critical facilities located in the karst regions are available in Critical Facility Risk, Appendix D2.

Table 4.81. HAZUS^{MH} critical facilities located in USGS karst zones.					
Jurisdiction	**Fire Station**	**Medical Care Facilities**	**Police Station**	**School**	**Total**
Loudoun County	1	2	0	4	**7**
Town of Leesburg	0	0	3	12	**15**
Total	**1**	**2**	**3**	**16**	**22**

Table 4.82. Local critical facilities located in USGS karst zones.					
Jurisdiction		**Medical Care Facilities**	**Police Station**	**School**	**Total**
Loudoun County	0	1	0	5	**0**
Town of Leesburg	0	1	0	9	**0**
Total	**0**	**2**	**0**	**14**	**0**

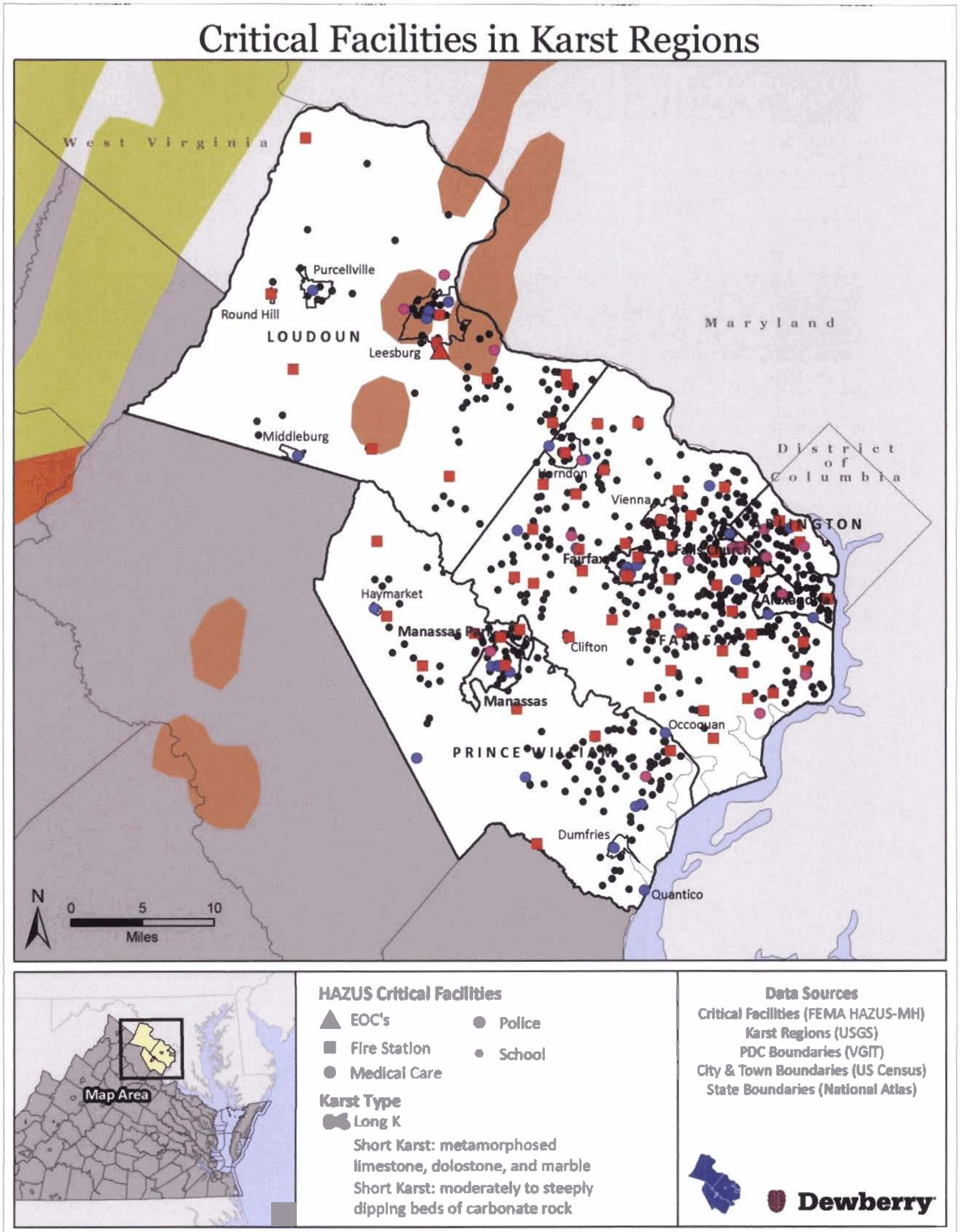


Figure 4.58. Karst regions and HAZUS^{MH} critical facilities.

Existing Buildings and Infrastructure Risk
Loss estimates could not be calculated for land subsidence events due to a lack of detailed and accurate information regarding structures and assets located in the previously determined hazard areas. In addition, due to the extremely localized and site specific nature of typical subsidence events, any inventory of potential at risk structures may grossly over-estimate potential losses.

Loudoun County maintains a karst feature database (the mapped karst features in the County are the developer's responsibility to provide necessary information to determine if all the requirements or ordinances and provisions have been met. For applications within the LOD, all documentation and studies are outlined in Section 4-1900 of the zoning ordinance. This organization allows Loudoun County to significantly reduce risk of sinkhole development to facilities, property, and people.

Overall Loss Estimates and Ranking
As stated above, loss estimates could not be calculated for land subsidence events due to a lack of historical data causing property damages and probability of future occurrences.

The hazard ranking for land subsidence is based on events reported in the NCDC Storm Events database and a generalized geographic extent. These parameters in the karst risk assessment are illustrated in Figure 4.59, along with the overall hazard ranking. The entire planning region for the 2010 hazard ranking was considered to be at a Medium-Low risk due to land subsidence (karst). As discussed above, Loudoun County and the Town of Leesburg has a slightly elevated risk due to the short karst features in the region. Loudoun County has ordinances in place to help mitigate their risk to this hazard.

There are currently no karst related records in NCDC; as a result, the lowest ranking score (1) was assigned to the annualized data for events, damages, and deaths and injuries to be able to compare karst to the other hazards, as described in Risk Assessment Methodology section.

Refer to the Risk Assessment Methodology section of the HIRA for a full description of the methodology and the limitations of the data used for ranking the hazards. NCDC data, although limited, provides a comprehensive historical record of natural hazard events and damages.

According to the 2006 qualitative assessment performed using the PRI tool, the sinkhole hazard scored a PRI value of 1.5 (on a scale of 0 to 4, with 4 being the highest risk level). Table 4.83 summarizes the risk levels assigned to each PRI category.

Table 4.83. 2006 Qualitative Assessment for Sinkholes					
	Probability	Impact	Spatial Extent	Warning Time	Duration
Risk Level	Possible	Minor	Negligible	6 to 12 hours	Less than 6 hours

The 2006 PRI assessment remains valid and supports the updated ranking and loss estimates.

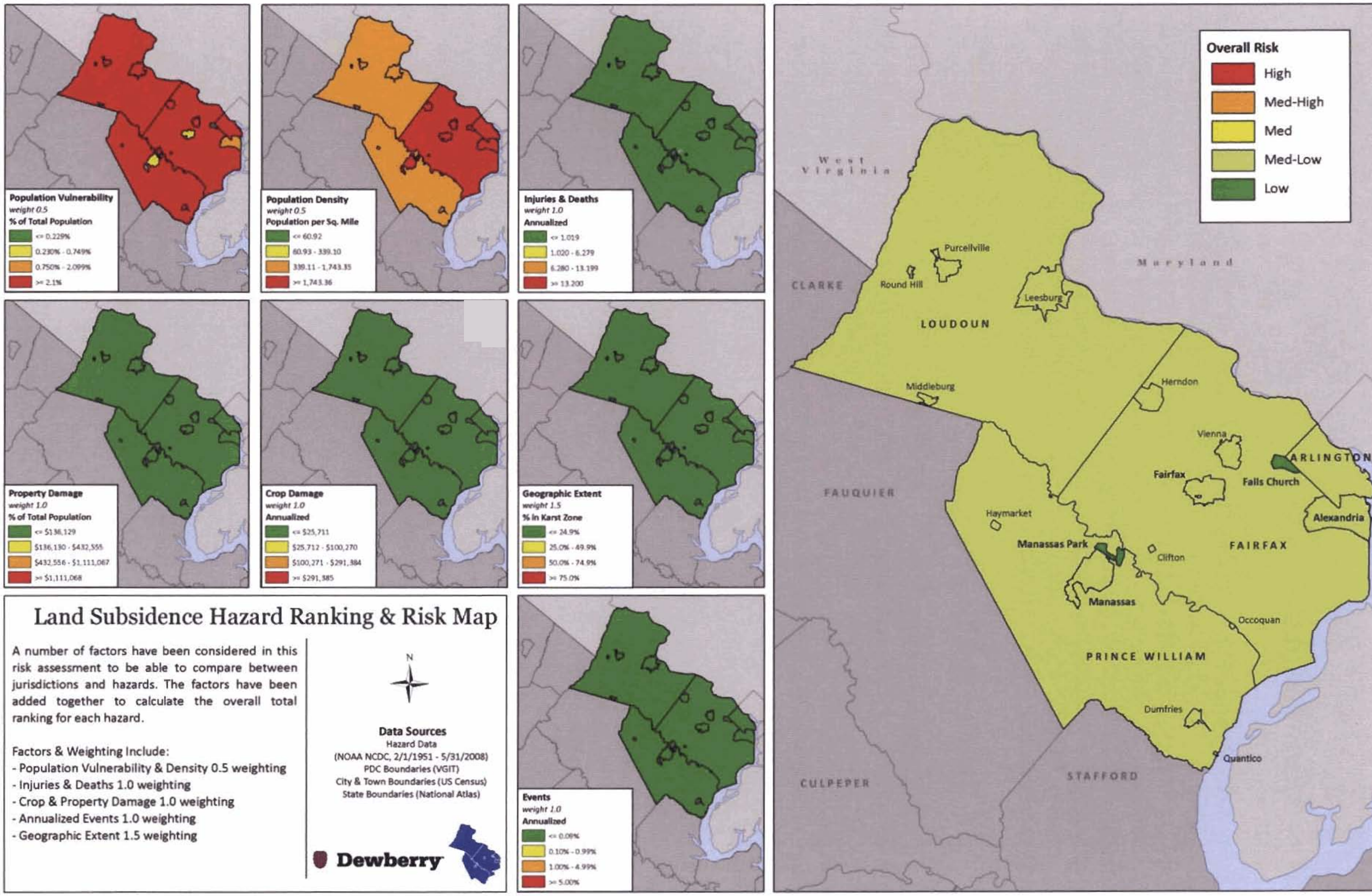


Figure 4.59. Land Subsidence (karst) hazard ranking and risk.

XIV. Dam Failure

NOTE: As part of the 2010 plan update, the Dam Failure hazard was reexamined and a new analysis performed. This new analysis included, but was not limited to: 1) refreshing the hazard profile; 2) updating the previous occurrences; 3) determining the annualized number of hazard events and losses by jurisdiction using NCDC and other data sources where available; 4) updating the assessment of risk by jurisdiction based on new data; and 5) ranking of the hazard by jurisdiction using the methodology described in detail in Chapter 4, Section IV Ranking and Analysis Methodologies. Each section of the plan was also reformatted for improved clarity, and new maps and imagery, when available and appropriate, were inserted.

A. Hazard Profile

1. Description

Worldwide interest in dam and levee safety has risen significantly in recent years. Aging infrastructure, new hydrologic information, and population growth in floodplain areas downstream from dams and near levees have resulted in an increased emphasis on safety, operation, and maintenance. The distinction between dams and levees is their purpose: dams are constructed to impound water behind them and levees are constructed to keep water out of the land behind them.

There are about 80,000 dams in the United States today, the majority of which are privately owned. Public owners include State and local authorities, and Federal agencies. The benefits of dams are numerous: they provide water for drinking, improved waterway navigation, hydroelectric power, flood control, and agricultural irrigation. Dams also provide enhanced recreation opportunities.

2. Geographic Location/Extent

The National Inventory of Dams (NID) was developed by the U.S. Army Corps of Engineers (USACE) in cooperation with FEMA's National Dam Safety Program. The full inventory contains over 75,000 dams, of which 7,700 are classified as major, and is used to track information on the country's water control infrastructure.

According to the NID, there are 12 major dams located in the Northern Virginia region and 73 non-major dams. Major dams are defined as dams being 50 feet or more in height, or with a normal storage capacity of 5,000 acre-feet or more, or with a maximum storage capacity of 25,000 acre-feet or more. The state regulatory agency for dams is the Virginia Department of Conservation and Recreation (DCR) through the Dam Safety and Floodplain Management Program. In addition to the 12 major dams discussed here, the DCR tracks and regulates a number of other smaller dams (e.g., farm pond impoundments, etc.) that present less severe hazard threats. The DCR maintains additional data on State-regulated dams in the Northern Virginia region, as well as information on the potential impact of failure. There are no major levees located in the Northern Virginia region.

Of the 12 major dams located in the region, six are classified as "high" hazards where failure or mis-operation of the dam may cause loss of human life. Another five major dams are classified as "significant" hazards, where failure or mis-operation results in no probable loss of human life, but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Only one of the 12 major dams is classified as a "low" hazard. It is important to note that these hazard classifications are not related to the physical condition or structural integrity of the dam (nor the probability of its failure), but strictly to the potential for adverse downstream effects if the dam were to fail.

Table 4.84 lists some of the descriptive information made available for each of the 12 major dams in the Northern Virginia region, while each of their general locations are illustrated in Figure 4.60.

Table 4.84. Major Dams in the Northern Virginia Region. *Source Army Corp of Engineers.*

Dam Name	Hazard Class	Drainage Area (Sq. Mi.)	Primary Purpose	Owner
Upper Occoquan	High	595	Hydroelectric	Fairfax County Water Authority
T. Nelson Elliott	High	74	Hydroelectric	City of Manassas
Barcroft	High	15	Recreation	Lake Barcroft Watershed Improv. Dist.
Lake Montclair	High	11	Recreation	Montclair Property Owners Association
Pohick Creek #1	High	6	Flood Control	Fairfax County Board of Supervisors
Lake Thoreau	High	1	Recreation	Reston Home Owners Association
Sleeter Lake	Significant	10	Irrigation	Round Hill Associates
Beaverdam Creek	Significant	6	Water Supply	City of Fairfax
Kingstowne Lake	Significant	1	Recreation	Kingstowne Limited Partnership
Possum Point Ash	Significant	< 1	Debris Control	Virginia Power
Breckinridge	Significant	< 1	Water Supply	U.S. Department of Defense (USMC)
Horsepen	Low	23	Other	Metro-Washington Airport Authority

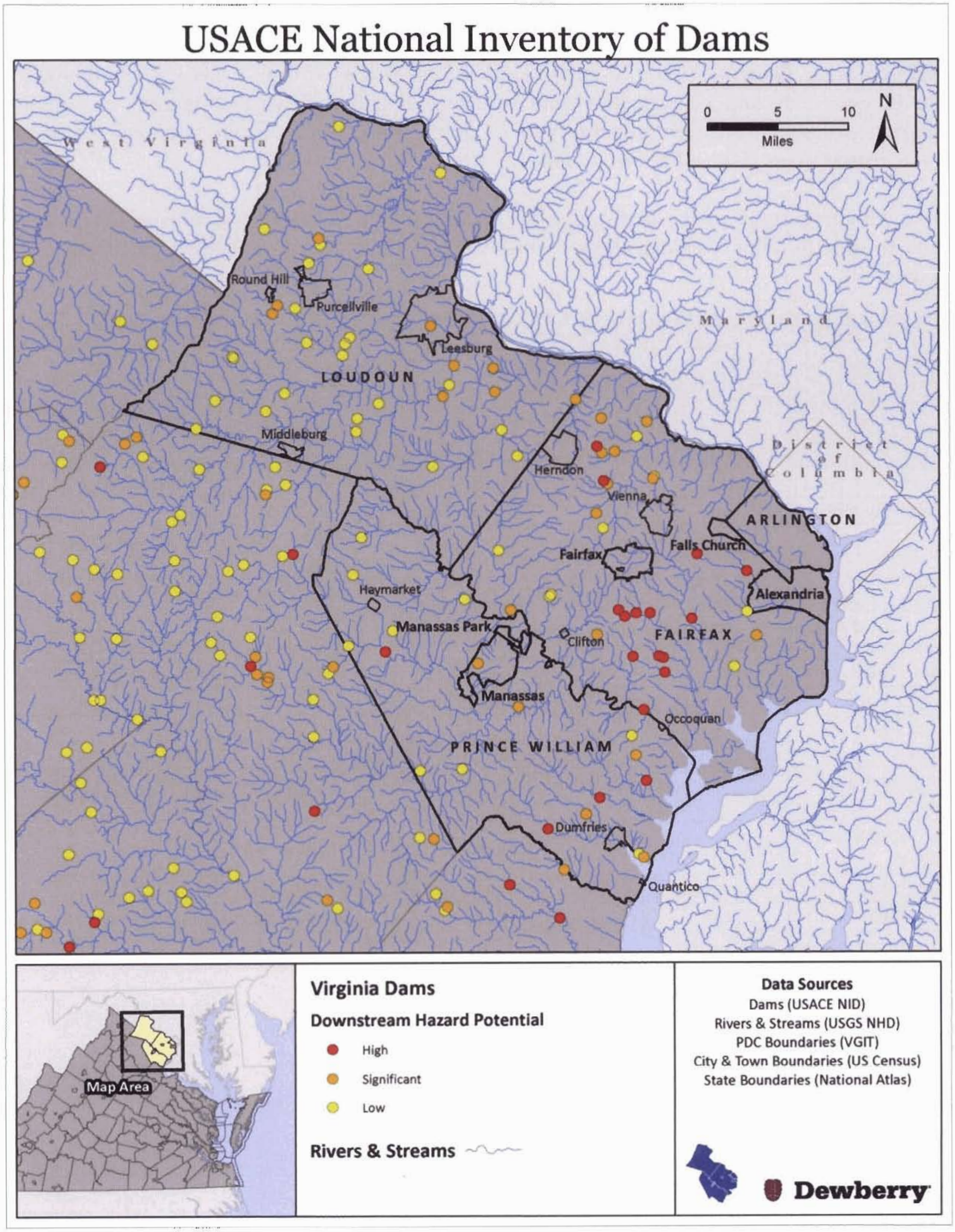


Figure 4.60. Dam downstream hazard potential. *Source: USACE*

3. Magnitude or Severity

Though dams have many benefits, they also can pose a risk to communities if not designed, operated, and maintained properly. In the event of a dam failure, the energy of the water stored behind even a small dam is capable of causing loss of life and great property damage if development exists downstream of the dam. If a levee breaks, scores of properties are quickly submerged in floodwaters and residents may become trapped by this rapidly rising water. The failure of dams and levees has the potential to place large numbers of people and great amounts of property in harm's way.

4. Previous Occurrences

While dam failures are not common occurrences, there have been some notable recent events throughout Virginia. Most failures occur due to lack of maintenance of the dam in combination with major rainfall, such as hurricanes and thunderstorms. In 1995, torrential rains burst the Timberlake Dam in Campbell County, killing two people downstream in the flooding. Following Hurricane Floyd in 1999, 13 dam failures were reported across the eastern portion of the State causing significant damages.

The Barcroft dam in Fairfax County failed during heavy rains associated with Hurricane Agnes (June 1972). Although it caused no loss of life, the dam failure resulted in damage to the Holmes Run area, most notably the destruction of an overpass at Van Dorn Street and Holmes Run ($300,000 plus an additional $200,000 to clear away 29 acres of trees and debris from the stream). The dam, which had originally been built in 1913, also suffered major damage and had to be rebuilt in order to restore Lake Barcroft, a recreational area for community residents.

B. Risk Assessment

1. Probability of Future Occurrences

Predicting the probability of flooding due to dam failure requires a detailed, site-specific engineering analysis for each dam in question. Failure may result from hydrologic and hydraulic design limitations, or from geotechnical or operational factors.[35]

Dam failure remains an unlikely occurrence for all major and non-regulated dams in the Northern Virginia region. The DCR is tasked with monitoring the routine inspection and maintenance of those dams that present the greatest risk or are in need of structural repair.

2. Impact & Vulnerability

Failure of dams may result in catastrophic localized damages. Vulnerability to dam failure is dependent on dam operations planning and the nature of downstream development. Depending on the elevation and storage volume of the impoundment, the impact of flooding due to dam failure may include loss of human life, economic losses such as property damage and infrastructure disruption, and environmental impacts such as destruction of habitat. Evaluation of vulnerability and impact is highly dependent on site-specific conditions.

3. Risk

Dam failure is considered unlikely in the Northern Virginia region due to existing safety measures and rigorous inspection reporting programs. The DCR requires specific operation and maintenance procedures, as well as routine inspections and regularly updated emergency action plans for each of the major and State-regulated dams in the Northern Virginia region. Therefore, future damages caused by dam failure and associated dollar losses are expected to be negligible – though the danger remains real and will continue to receive critical attention through the DCR's Dam Safety and Floodplain Management Program.

Due to the lack of specific data on dam failure probability or inundation zones, the potential risk to critical facilities and existing buildings and infrastructure was not estimated for this revision of the Plan. Virginia's new Impounding Structure Regulations require dam break inundation zone mapping and additional information is available from the DCR Dam Safety Program.

There are 19 dams in the region classified as "high" hazard; all located in Fairfax and Prince William counties. These dams are summarized in Table 4.85. Again, these hazard classifications are not related to the physical condition or structural integrity of the dam (nor the probability of its failure), but strictly to the potential for adverse downstream effects from failure or mis-operation of the dam or facilities. While there are no dam failure inundation maps available for the Northern Virginia region, the distribution of dams throughout the region is shown in Figure 4.60.

Only two of the major dams classified as high hazard have a drainage area of more than 20 square miles (the Upper Occoquan dam in Fairfax County and the T. Nelson Elliot dam in Prince William County), making the possibility of a catastrophic dam failure event elsewhere highly unlikely in the region. The Northern Virginia region is likely more prone to intentional water releases by dam operators immediately prior to or during major rainfall events, though in such cases the releases are coordinated with local emergency management officials to minimize potential risks to people and property.

Table 4.85: NID Downstream Hazard Potential for Dams

Jurisdiction	Low	Significant	High	Total
Arlington County	0	0	0	**0**
Fairfax County	8	10	15	**33**
Town of Herndon	0	0	0	**0**
Town of Vienna	0	0	0	**0**
Town of Clifton	0	0	0	**0**
Loudoun County	24	8	0	**32**
Town of Leesburg	0	1	0	**1**
Town of Purcellville	0	0	0	**0**
Town of Middleburg	0	0	0	**0**
Town of Round Hill	0	0	0	**0**

Table 4.85: NID Downstream Hazard Potential for Dams				
Jurisdiction	**Low**	**Significant**	**High**	**Total**
Prince William County	9	5	4	**18**
Town of Dumfries	0	0	0	**0**
Town of Haymarket	0	0	0	**0**
Town of Occoquan	0	0	0	**0**
Town of Quantico	0	0	0	**0**
City of Alexandria	0	0	0	**0**
City of Fairfax	0	0	0	**0**
City of Falls Church	0	0	0	**0**
City of Manassas	0	1	0	**1**
City of Manassas Park	0	0	0	**0**
Total	**41**	**25**	**19**	**85**

Overall Loss Estimates and Ranking

Dam failure was not ranked with the hazards as a result of limited data available for analysis. As discussed regarding critical facilities, loss estimates were not developed due to the lack of specific data on dam failure probability or inundation zones. Fairfax County has the highest percentage of dams in the high and significant downstream hazard potentials in relation to the rest of the planning region.

According to the 2006 qualitative assessment performed using the PRI tool; the dam failure hazard scored a PRI value of 2.3 (on a scale of 0 to 4, with 4 being the highest risk level). Table 4.86 summarizes the risk levels assigned to each PRI category.

Table 4.86. 2006 Qualitative Assessment for Dam Failure					
	Probability	**Impact**	**Spatial Extent**	**Warning Time**	**Duration**
Risk Level	Unlikely	Critical	Small	Less than 6 hours	Less than one week

Future updates to this Plan will attempt to address dam failure vulnerability in greater detail, if warranted. This may include a detailed analysis of properties directly downstream of the high hazard dams in order to better determine the amount of people and value of properties located in potential inundation zones and thereby vulnerable to dam failure.

XV. Overall Hazard Results

The preceding sub-sections discuss the probability, impacts, vulnerability, and risks for each of the natural hazards that have been determined to have a significant impact on the Northern Virginia planning region. The final section of the HIRA provides an overall assessment, summary, and comparison of the overall hazard ranking and estimated losses. Risk to critical facilities has been discussed, to the extent possible, in each of the hazard sub-sections. These sections highlight the results of the analysis completed during the 2006 plan creation and 2010 plan update. Refer to the tables in these sections to determine what facilities or facility types are at greater risk for each hazard. This information is ideal for determining structural mitigation strategies. The names and information for the $HAZUS^{MH}$ and local critical facilities in the wildfire risk zones are available in the Critical Facility Risk, Appendix D2.

Hazard Ranking

For the 2006 plan creation, the qualitative and quantitative assessments, combined with final determinations from the MAC, were fit into three categories for a final summary of hazard risk for the Northern Virginia region based on High, Moderate, or Low designations. During the 2010 plan update, the NCDC ranking, 2006 qualitative assessments, and feedback from the MAC helped to reposition the ranking into five categories of High, Medium-High, Medium, Medium-Low, and Low. The reclassification of the hazards allows for a clearer distinction of the hazards that pose the greatest risk in the Northern Virginia region. Table 4.87 summarizes the jurisdiction specific and overall region ranking.

The ranking methodology used in the 2010 update to the HIRA was originally developed for the VDEM by CGIT at Virginia Tech for the Commonwealth of Virginia Hazard Mitigation Plan 2010 Update. During the Northern Virginia HIRA kick-off meeting it the MAC agreed to use the scoring and ranking framework that was developed by the State, with modifications as deemed necessary.

To determine the overall hazard risk, the total hazard ranking values for each of the hazards were separately averaged to determine what hazards should be considered the most significant in the region. Through this analysis, it was determined that Flood, High Wind, Tornado, and Winter Weather pose the highest risk for communities in the Northern Virginia planning region. Figure 4.61 illustrates the jurisdictional rankings for these significant hazards.

It should be noted that although some hazards are classified as posing Low risk, their occurrence at varying or unprecedented magnitudes is still possible and should continue to be re-evaluated during future updates of this Plan. Hazards that were considered low risk or negligible were included as textual descriptions in the major hazard sections. This includes erosion, sea-level rise, lightning, hail, extreme heat, and extreme cold.

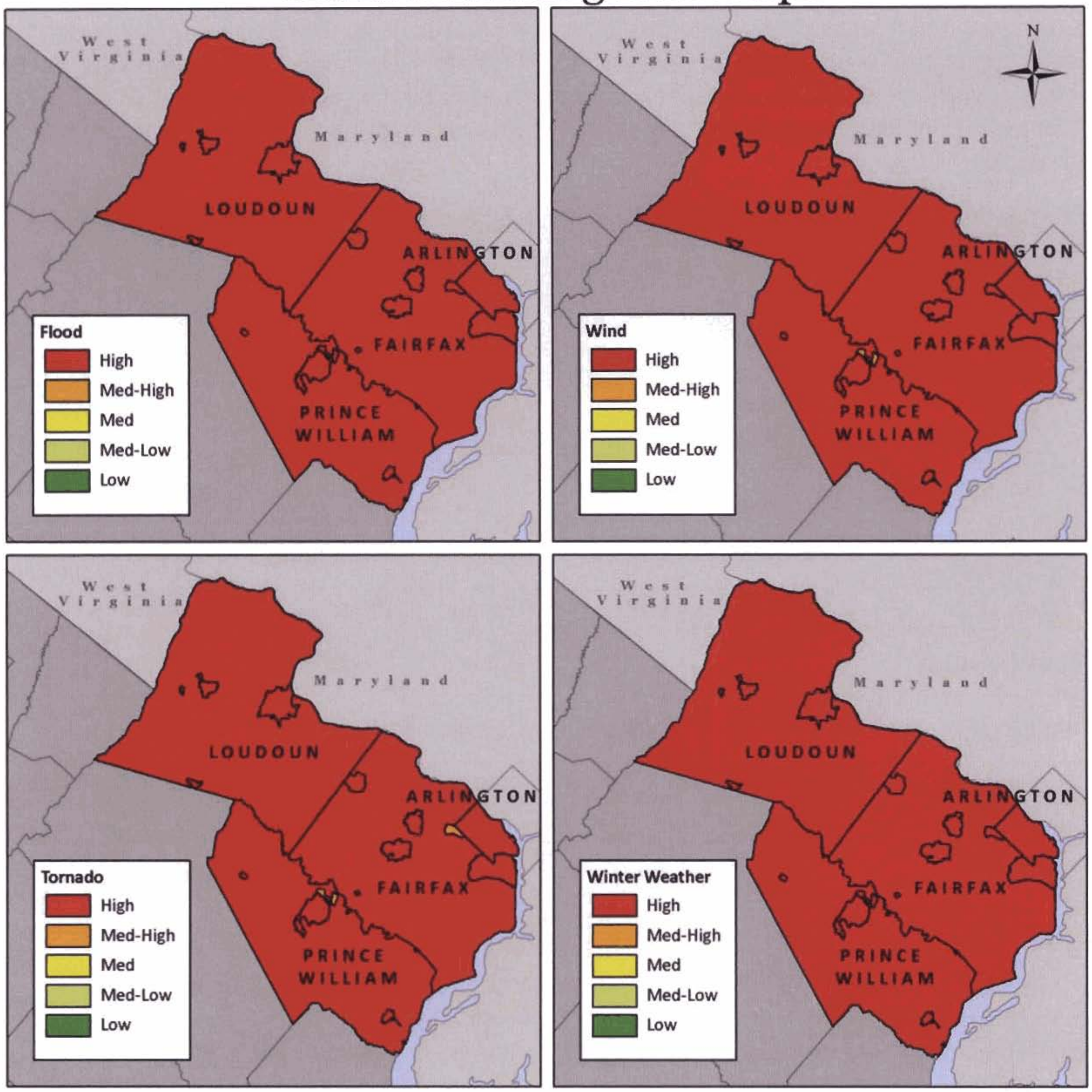
It should also be noted that the overall rankings for Flooding, Drought, Wind, Wildfire, and Winter Weather have been slightly altered to reflect the MAC's feedback for the Cities of Fairfax and Manassas Park. Based solely on the ranking parameter data, these two cities received slightly lower scores as compared to the rest of the region. For the hazards mentioned above, the City of Fairfax was updated to mirror Fairfax County.

It should also be noted that the overall rankings for Landslide was changed for the City of Alexandria from high to low based on the city's feedback.

Limitations of the data, specifically NCDC storm events data, are discussed in detail in the Risk Assessment and Methodology section of the HIRA.

<table>
<tr><th colspan="10">Table 4.87. Overall Hazard Ranking by Jurisdiction</th></tr>
<tr><th>Jurisdiction</th><th>Flood</th><th>Wind</th><th>Tornado</th><th>Winter Weather</th><th>Drought</th><th>Earthquake</th><th>Landslide</th><th>Wildfire</th><th>Karst</th></tr>
<tr><td>Arlington County</td><td>High</td><td>High</td><td>High</td><td>High</td><td>Med-High</td><td>Med</td><td>Med</td><td>Med-Low</td><td>Med-Low</td></tr>
<tr><td>Fairfax County</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">Med-High</td><td rowspan="5">Med</td><td rowspan="5">Med-Low</td><td rowspan="5">Med</td><td rowspan="5">Med-Low</td></tr>
<tr><td>Town of Herndon</td></tr>
<tr><td>Town of Vienna</td></tr>
<tr><td>Town of Clifton</td></tr>
<tr><td></td></tr>
<tr><td>Loudoun County</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">Med</td><td rowspan="5">Med-High</td><td rowspan="5">Med-Low</td><td rowspan="5">Med-Low</td></tr>
<tr><td>Town of Leesburg</td></tr>
<tr><td>Town of Purcellville</td></tr>
<tr><td>Town of Middleburg</td></tr>
<tr><td>Town of Round Hill</td></tr>
<tr><td>Prince William County</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">Med</td><td rowspan="5">Med-Low</td><td rowspan="5">Med</td><td rowspan="5">Med-Low</td></tr>
<tr><td>Town of Dumfries</td></tr>
<tr><td>Town of Haymarket</td></tr>
<tr><td>Town of Occoquan</td></tr>
<tr><td>Town of Quantico</td></tr>
<tr><td>City of Alexandria</td><td>High</td><td>High</td><td>High</td><td>High</td><td>Med-High</td><td>Med</td><td>Low</td><td>Med-Low</td><td>Med-Low</td></tr>
<tr><td>City of Fairfax</td><td>High</td><td>High</td><td>High</td><td>High</td><td>Med-High</td><td>Med</td><td>Med-Low</td><td>Med</td><td>Med-Low</td></tr>
<tr><td>City of Falls Church</td><td>High</td><td>High</td><td>Med-High</td><td>High</td><td>Med</td><td>Med-Low</td><td>Low</td><td>Low</td><td>Low</td></tr>
<tr><td>City of Manassas</td><td>High</td><td>High</td><td>High</td><td>High</td><td>Med-High</td><td>Med</td><td>Med-Low</td><td>Med-Low</td><td>Med-Low</td></tr>
<tr><td>City of Manassas Park</td><td>High</td><td>High</td><td>Med-High</td><td>High</td><td>Low</td><td>Med-Low</td><td>Low</td><td>Med-Low</td><td>Low</td></tr>
<tr><td>Overall Risk</td><td>High</td><td>High</td><td>High</td><td>High</td><td>Med-High</td><td>Medium</td><td>Medium</td><td>Med-Low</td><td>Med-Low</td></tr>
</table>

Hazard Ranking Risk Maps



Hazard Identification & Risk Assessment

A number of factors have been considered in this risk assessment to be able to compare between jurisdictions and hazards. The factors have been added together to calculate the overall total ranking for each hazard.

Factors & Weighting include:

- Population Vulnerability & Density 0.5 weighting
- Injuries & Deaths 1.0 weighting
- Crop & Property Damage 1.0 weighting
- Annualized Events 1.0 weighting
- Geographic Extent 1.5 weighting

Data Sources
Hazard Data (NOAA NCDC, 2/1/1951 - 5/31/2008)
Demography (US Census Bureau)

Dewberry

Figure 4.61. Overall Hazard Ranking for High Ranking Hazards

As mentioned above, during the 2006 plan creation, the MAC reviewed the results of quantitative and qualitative assessments shown in Table 4.88. This table summarizes the degree of risk assigned to each category for all identified hazards in the Northern Virginia region based on the application of the PRI tool (discussed in the Risk Assessment and Methodology section). Assigned risk levels were based on historical and anecdotal data, as well as input from the MAC. The results were then used in calculating PRI values and making conclusions for the qualitative assessment.

Table 4.88 Summary of Qualitative Assessment (2006)

Hazard	Category / Degree of Risk				
	Probability	Impact	Spatial Extent	Warning Time	Duration
Flood	Highly Likely	Critical	Moderate	6 to 12 hours	Less than one week
Severe Thunderstorms	Highly Likely	Limited	Small	Less than 6 hours	Less than 6 hours
Hurricanes and Tropical Storms	Possible	Critical	Large	More than 24 hours	Less than 24 hours
Tornadoes	Likely	Critical	Small	Less than 6 hours	Less than 6 hours
Winter Storms	Likely	Limited	Large	More than 24 hours	Less than one week
Drought	Possible	Limited	Moderate	More than 24 hours	More than one week
Earthquakes	Unlikely	Minor	Large	Less than 6 hours	Less than 6 hours
Landslides	Possible	Minor	Small	12 to 24 hours	Less than 6 hours
Wildfire	Highly Likely	Minor	Small	Less than 6 hours	Less than one week
Sinkholes	Possible	Minor	Negligible	6 to 12 hours	Less than 6 hours
Erosion	Likely	Minor	Negligible	More than 24 hours	More than one week
Extreme Temperatures	Likely	Minor	Large	More than 24 hours	Less than one week
Dam Failure	Unlikely	Critical	Small	Less than 6 hours	Less than one week

Loss Estimation

The Northern Virginia planning region can expect over $8.5 million in annualized damages due to natural hazards impacting the region. These totals have been based on the available records from the NCDC storm events database, adjusted for inflation. Fairfax County makes up 45% of the overall total estimated losses, followed by Prince William County (14.6%). Table 4.89 below includes the total of all the hazards available in the NCDC storm events database.

Table 4.89. Total NCDC storm events data and annualized loss estimates.

Jurisdiction	Total Events	Total Crop Damage	Total Property Damage	Annualized Crop Damage	Annualized Property Damage	Total Annualized Loss
Arlington County	279	$2,860,525	$10,502,359	$157,315	$521,113	**$678,428**
Fairfax County	475	$2,620,475	$160,083,383	$146,300	$3,684,398	**$3,830,698**
Loudoun County	518	$7,317,346	$13,658,281	$418,180	$478,184	**$896,364**
Prince William County	364	$3,080,631	$26,141,962	$173,094	$1,069,445	**$1,242,539**
City of Alexandria	239	$2,860,525	$4,759,845	$157,315	$244,942	**$402,257**
City of Fairfax	25	$0	$94,131	$0	$4,482	**$4,482**
City of Falls Church	216	$2,860,525	$10,005,946	$157,315	$334,823	**$492,138**
City of Manassas	246	$3,014,556	$16,055,674	$169,207	$789,182	**$958,390**
City of Manassas Park	4	$0	$12,041	$0	$573	**$573**
Total	**2,366**	**$24,614,583**	**$241,313,623**	**$1,378,727**	**$7,127,143**	**$8,505,869**

Supplemental annualized loss estimates for flooding, hurricane winds, and earthquake have also been derived from the other sources as described in each of the individual hazard sections. NCDC did not include any historical information about damages due to land subsidence (karst/sinkholes), landslides, or wildfires, and as a result, these are not included in the loss estimates. Dam failure was not included as part of the hazard ranking (see the Dam Failure section for more details).

Based on the information from the NCDC storm events database, the Northern Virginia region can expect approximately $8,505,869 in annualized damages due to all the hazards that impact the region. As discussed, this data has limitations due to the amount of historical data available, and reporting of events. By substituting the supplemental annualized loss values for flood, hurricane wind, earthquake, and wildfire, the region could expect $110,217,797 in annualized damages due to all the hazards that impact the region.

Table 4.90 compares the 2006 and 2010 annualized loss estimates for each of the hazards. Differences in the values can be attributed to a wide range of factors, including significantly different methodologies for calculating losses that are further discussed in the individual hazard sections. The estimates provided for the 2010 update account for inflation.

High wind and winter weather each make up about one-third of the NCDC loss estimates for the region. Even so, these estimates are believed to be an underrepresentation of the actual losses experienced due to both hazards as losses from events that go unreported or that are difficult to quantify are not likely to appear in the NCDC database. Additionally, the HAZUS^{MH} loss estimates for flooding appear high in comparison to the other hazards. It should be kept in mind that the HAZUS^{MH} results take into account many additional factors that are not represented in the NCDC values, which only account for property and crop damages. The factors considered in the flood module are further explained in the flood section of this report.

Tornados have resulted in 59 injuries and two deaths in the region, followed by high wind events that resulted in 25 injuries and two deaths. Lightning, not included in the ranking, is responsible for 13 injuries and two deaths. There has been one injury and one death related to flooding in Arlington County as recorded in the NCDC storm events database. It is known that winter weather can cause significant injuries and related deaths (i.e., heart attack while shoveling; accidents due to icy roadways and sidewalks, etc.). At this time, no injury and death totals are available in the database.

Refer to the Risk Assessment Methodology section of the HIRA for a full description of the methodology and the limitations of the data used for ranking the hazards and loss estimation. For most natural hazards, the NCDC data, although somewhat limited, provides the most comprehensive historical record of events and damages available. This analysis is only representative of the NCDC data that was used. It is known that the time period of this data is small in comparison to the known historical events. The data does not fully represent geological hazards, but in the absence of better data, NCDC was used to represent the risk.

Table 4.90. Hazard Ranking and Loss Estimate Comparison.

Ranking	Hazard Classification 2010	Hazard Classification 2006	PRI Value	2006 Annualized Loss	2010 Annualized Loss from NCDC	Annualized Loss from Other Sources	Data Source
High	Flood*	Flood	3.3	$3,912,000	$1,652,650	$99,049,000	FEMA HAZUS^{MH}
		Erosion	1.9	Negligible			
High	High Wind	Severe Thunderstorms	2.7	$1,110,000	$2,902,973	$4,795,691	FEMA HAZUS^{MH}
		Hurricanes and Tropical Storms	2.6	$33,723,000			
High	Tornadoes	Tornadoes	2.7	$731,000	$2,612,298		
High	Winter Storms**	Winter Storms	3	$109,000	$394,977		
		Extreme Temps	2.4	Negligible			
Med-High	Drought***	Drought	2.3	$2,207,000	$942,971		
		Extreme Temps	2.4	Negligible			
Medium	Earthquakes	Earthquakes	1.9	$341,000	None Recorded	$2,408,945	FEMA HAZUS^{MH}
Medium	Landslides	Landslides	1.6	Negligible	None Recorded		
Medium	Wildfire	Wildfire	2.6	$25,000	None Recorded	$13,915	VDOF 1993-2008 wildfire statistics
Med-Low	Sinkholes	Sinkholes	1.5	Negligible	None Recorded		
Med-Low	Dam Failure	Dam Failure	2.3	Negligible	None Recorded		
				$42,158,000	**$8,505,869**	**$106,267,551**	
					$110,217,797		

Table notes:

**Erosion included but not ranked or annualized*

*** Extreme cold included but not ranked or annualized*

****Extreme heat included but not ranked or annualized*

Unique Risks for Local Jurisdictions

During the 2006 plan creation, officials from each of the participating local jurisdictions were asked to provide information on any unique hazard risks that were omitted or not satisfactorily addressed during the drafting stage of the Plan and through a survey instrument distributed at the Mitigation Strategies Meeting.

In response to that request, officials from three jurisdictions responded with specific concerns. These responses are summarized in Table 4.91. No other local jurisdiction identified unique hazards of concern beyond those already covered under this Plan.

Table 4.91. Unique Risks and Hazard Concerns

Jurisdiction	Unique Risk / Hazard Concern
City of Fairfax	A large petroleum tank farm facility located in the city, and potentially vulnerable to manmade and natural hazards including lightning, high winds, and flooding.
City of Manassas	The airport (and particularly areas around Broad Run) is prone to frequent flooding. A nearby mobile home park (approximately 200 units) is identified as presenting a unique risk, in addition to approximately 10 commercial buildings and the air traffic control tower.
Prince William County	Pipeline rupture and train derailment identified as unique risks.

Limitations of Data

It should be noted that the data sources used in the hazard ranking and loss estimation are varied in their degree of completeness, accuracy, and precision as the ability to accurately prioritize some of the hazards would be improved by better information (e.g., landslide, karst, etc.). Further discussion on the data limitations and how the data was adapted for analysis is available in the Risk Assessment and Methodology section.

Chapter 5: Capability Assessment

I. Introduction

This portion of the plan assesses the current capacity of the communities of Northern Virginia to mitigate the effects of the natural hazards identified in Chapter 4 of the plan. As part of the 2010 update, the capability assessment section includes an update to the capability matrices found in Chapter 7 of the 2006 plan, as well as section reformatting. Perhaps the biggest change in the 2010 capability assessment section is the addition of the capabilities of the Towns that participated in this plan update. This assessment includes a comprehensive examination of the following local government capabilities:

- Administrative Capability;
- Technical Capability;
- Planning and Regulatory Capability; and
- Fiscal Capability.

The purpose of conducting a capability assessment is to determine the ability of a local jurisdiction to implement a comprehensive mitigation strategy, and to identify potential opportunities for establishing or enhancing specific mitigation policies, programs or projects.[1] As in any planning process, it is important to try to establish which goals, objectives, and/or actions are feasible, based on an understanding of the organizational capacity of those agencies or departments tasked with their implementation. A capability assessment helps to determine which mitigation actions are practical and likely to be implemented over time given a local government's planning and regulatory framework, level of administrative and technical support, amount of fiscal resources, and current political climate.

A capability assessment has two primary components: an inventory of a local jurisdiction's relevant plans, ordinances, or programs already in place; and an analysis of its capacity to carry them out. Careful examination of local capabilities will detect any existing gaps, shortfalls, or weaknesses with ongoing government activities that could hinder proposed mitigation activities and possibly exacerbate community hazard vulnerability. A capability assessment also highlights the positive mitigation measures already in place or being implemented at the local government level, which should continue to be supported and enhanced through future mitigation efforts.

For the 2010 update, each participating jurisdiction was given an opportunity to update their capability assessment information presented in the original 2006 plan. This effort included updating a Plans, Ordinances, and Programs table, Relevant Fiscal Resources table, and Relevant Staff and Personnel Resources table. Additionally, updates to the information presented below were conducted to better reflect the capabilities within the region as of 2010.

---

[1] While the Interim Final Rule for implementing the Disaster Mitigation Act of 2000 does not require a local capability assessment to be completed for local hazard mitigation plans, it is a critical step in developing a mitigation strategy that meets the needs of each jurisdiction while taking into account their own unique abilities. The Rule does state that a community's mitigation strategy should be "based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools" (44 CFR, Part 201.6(c)(3)).

II. Conducting the Capability Assessment

In order to facilitate an update of the 2006 inventory and analysis of local government capabilities throughout the Northern Virginia region, specific tables and components of the previous plan were distributed to the communities. These tables, which were completed by appropriate local government officials, requested information on a variety of "capability indicators" such as existing local plans, policies, programs, or ordinances that contribute to or hinder the community's ability to implement hazard mitigation actions. Other indicators included information related to each jurisdiction's fiscal, administrative, and technical capabilities, such as access to local budgetary and personnel resources for mitigation purposes.

At a minimum, the updates to the 2006 information provided an extensive inventory of existing local plans, ordinances, programs, and resources in place or under development, in addition to their overall effect on hazard loss reduction. The update thereby not only helps to accurately assess each jurisdiction's degree of local capability, but also serves as a good source of introspection for those jurisdictions that want to improve their capabilities as identified gaps, weaknesses, or conflicts can be recast as opportunities for specific actions to be proposed as part of the community's mitigation strategy.

III. Capability Assessment Findings

The findings of the capability assessment are summarized in this Plan to provide insight into the relevant capacity of participating jurisdictions to implement hazard mitigation activities. All information is based upon the input provided by local government officials through the Capability Assessment Survey and during meetings of the Mitigation Advisory Committee. All completed survey questionnaires are available from the NVRC upon request.

A. Administrative and Technical Capability

1. Administrative

The ability of a local government to develop and implement mitigation projects, policies, and programs is directly tied to its ability to direct staff time and resources for that purpose. Administrative capability can be evaluated by determining how mitigation-related activities are assigned to local departments and if there are adequate personnel resources to complete these activities. The degree of intergovernmental coordination among departments will also affect administrative capability for the implementation and success of proposed mitigation activities.

The following table, originally developed under the 2006 Northern Virginia Hazard Mitigation plan, was updated as part of the 2010 planning process. A (Y) indicates that the given local staff member(s) is maintained through each particular jurisdiction's local government resources. A (Y*) indicates that this capability is new as of the 2010 update. The Towns of Dumfries, Occoquan, and Quantico did not provide an update to the capability assessment.

Table 5.1. Administrative and Technical Capabilities

Jurisdiction	Planners with knowledge of land development and land management practices	Engineers or professionals trained in construction practices related to buildings and/or infrastructure	Planners or engineers with an understanding of natural and/or human-caused hazards	Emergency manager	Floodplain manager	Land surveyors	Scientist familiar with the hazards of the community	Staff with education or expertise to assess the community's vulnerability to hazards	Personnel skilled in Geographic Information Systems (GIS) and/or HAZUS^{MH}	Resource development staff or grant writers
Alexandria, City of	Y	Y	Y	Y	Y	Y		Y	Y	Y
Arlington County	Y	Y	Y*	Y		Y	Y	Y	Y	
Clifton, Town of	Y*	Y*	Y*	Y*	Y*	Y*		Y*	Y*	Y*
Dumfries, Town of	Y	Y	Y	Y						Y
Fairfax County	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fairfax, City of	Y	Y	Y	Y*	Y	Y*		Y	Y	
Falls Church, City of	Y	Y	Y	Y	Y			Y	Y	Y
Haymarket, Town of	Y*	Y*								
Herndon, Town of	Y	Y	Y	Y	Y	Y*		Y*	Y	Y
Leesburg, Town of	Y	Y	Y*	Y*	Y*	Y*		Y*	Y*	Y*
Loudoun County	Y	Y	Y	Y	Y*	Y*	Y*	Y	Y	Y*
Manassas Park, City of	Y	Y	Y	Y	Y	Y		Y	Y	Y
Manassas, City of	Y	Y	Y		Y	Y		Y	Y	
Middleburg, Town of	Y*	Y*	Y*		Y*				Y*	
Occoquan, Town of										
Prince William County	Y	Y	Y	Y	Y	Y		Y	Y	Y
Purcellville, Town of	Y	Y	Y	Y	Y	Y		Y	Y	Y
Quantico, Town of										
Round Hill, Town of	Y*		Y*							
Vienna, Town of	Y	Y	Y	Y	Y	Y*		Y*	Y	Y*

As described previously, the planning area is comprised of four counties, five cities, and 11 towns. All of the counties in the planning area, Arlington County, Fairfax County, Loudoun County, and Prince William County, operate under a Board of Supervisors - County Administrator/Executive system. In this form of government, the elected board of supervisors appoints a county administrator who oversees daily operations of the county.

The Cities of Alexandria, Falls Church, Fairfax, Manassas, and Manassas Park operate under the City Council – City Manager system. The City Council is elected and it, in turn, appoints a City Manager who acts as the chief administrative officer and oversees daily business operations of the City.

The Towns of Clifton, Dumfries, Haymarket, Occoquan, and Round Hill operate under the Town Council – Mayor system; and the Towns of Herndon, Leesburg, Middleburg, Purcellville, and Vienna operate under a Town Council – Town Manager system, where the council appoints the Town Manager to act as the administrative officer.

Under the County Administrator, City, and Town Manager systems, each jurisdiction (with the exception of the Town of Quantico) has departments, councils, and boards that are responsible for the various functions of local government. The following table created for the 2010 update, highlights the departments in each jurisdiction that could facilitate the implementation of this hazard mitigation plan.

Table 5.2. Departments that could facilitate mitigation action implementation

Jurisdiction	Departments
Alexandria, City of	Building and Fire Code Administration Fire Planning and Zoning Transportation and Environmental Services
Arlington County	Community Planning, Housing and Development Fire Department Environmental Services Office of Emergency Management
Clifton, Town of	Planning Commission
Dumfries, Town of	Town Council
Fairfax County	Office of Emergency Management Fire and Rescue Planning and Zoning Public Works and Environmental Services Water Authority
Fairfax, City of	Community Development and Planning Fire Department Public Works Police Department Utilities

Table 5.2. Departments that could facilitate mitigation action implementation

Jurisdiction	Departments
Falls Church, City of	Development Services Environmental Services Public Safety
Haymarket, Town of	Planning Commission
Herndon, Town of	Public Safety Planning/Zoning
Leesburg, Town of	Planning and Zoning Police Department
Loudoun County	Fire, Rescue and Emergency Management Planning
Manassas Park, City of	Fire and Rescue Planning and Zoning Police Public Works
Manassas, City of	Emergency Preparedness Fire and Rescue Police Department Public Works Community Development
Middleburg, Town of	Zoning and Planning Police Department Engineering
Occoquan, Town of	Town Council
Prince William County	Fire and Rescue Planning Office Police Department Public Works
Purcellville, Town of	Planning Department Police Department Public Works
Quantico, Town of	None
Round Hill, Town of	Planning Commission
Vienna, Town of	Planning and Zoning Public Works Police

While exact responsibilities differ from jurisdiction to jurisdiction, the general duties of the departments highlighted in the table are described below.

The OEM is responsible for the mitigation, preparedness, response, and recovery operations that deal with both natural and man-made disaster events. Fire/EMS departments provide medical aid and fire suppression at the scene of accidents and emergencies. These departments are often responsible for responding to hazardous materials incidents.

The Planning Department addresses land use planning. This department, depending on the jurisdiction, may enforce the NFIP requirements and other applicable local codes. Zoning also may be managed by the Planning Department or it may be a separate office.

In some jurisdictions, the Utilities Department oversees community water facilities or natural gas provisions. In others, the Public Works Department oversees the maintenance of infrastructure including roadways, sewer and stormwater facilities and the community's water treatment facilities. This department also may review new development plans, ensure compliance with environmental regulations, and work with the Virginia Department of Transportation on road issues. Depending on the jurisdiction, the Department of Public Works may enforce the NFIP requirements.

2. Technical Capability

Mitigation cuts across many disciplines. For a successful mitigation program, it is necessary to have a broad range of people involved with diverse backgrounds. These people include planners, engineers, building inspectors, emergency managers, floodplain managers, people familiar with GIS, and grant writers. Technical capability can generally be evaluated by assessing the level of knowledge and technical expertise of local government employees, such as personnel skilled in using GIS to analyze and assess community hazard vulnerability.

GIS systems can best be described as a set of tools (hardware, software, and people) used to collect, manage, analyze, and display spatially-referenced data. Many local governments are now incorporating GIS systems into their existing planning and management operations. GIS is invaluable in identifying areas vulnerable to hazards. Access to the Internet can facilitate plan development, public outreach, and project implementation.

The table below summarizes the technical capabilities of the jurisdictions. When provided, the specific department that has the technical capability is identified.

5.3. Technical Capabilities of each Jurisdiction								
Jurisdiction	**Land Use Planners**	**Civil or Building Engineers**	**Emergency manager**	**Floodplain manager**	**Staff familiar with hazards**	**GIS staff**	**Grant writers**	**Internet access?**
Alexandria, City of	Planning & Zoning	Transportation & Environmental Services	Fire Department - Emergency Management	Transportation & Environmental Services	Fire Department - Emergency Management	Planning & Zoning	Planning & Zoning, City Administration	**Yes**
Arlington County	Community Planning	Environmental Services	Office of Emergency Management	Community Planning	Office of Emergency Management	Information Technology	County Administration, Police Department	**Yes**
Clifton, Town of	Planning Commission	Planning Commission	Public Safety	Planning Commission	Public Safety	Planning Commission	Planning Commission	**Yes**
Dumfries, Town of	Town Council	Town Council	Town Council	Town Council	Town Council	Town Council	Town Council	**Yes**
Fairfax County	Planning & Zoning	Public Works	Emergency Management	Planning and Zoning	Emergency Management	Information Technology	County Administration	**Yes**
Fairfax, City of	Community Development & Planning	Public Works	Public Safety - Emergency Management	Community Development & Planning	Community Development & Planning, Public Safety	Information Technology	City Administration	**Yes**
Falls Church, City of	Development Services	Environmental Services	Public Safety	Development Services	Development Services, Public Safety	Public Safety	Development Services	**Yes**
Haymarket, Town of	Planning Commission	Planning Commission	Planning Commission	Planning Commission	Planning Commission	Planning Commission	Town Council	**Yes**
Herndon, Town of	Planning Zoning	Planning & Zoning	Public Safety	Planning & Zoning	Public Safety	Public Safety	Town Council	**Yes**
Leesburg, Town of	Planning & Zoning	Planning & Zoning	Police Department	Planning & Zoning	Police Department	Police Department	Town Council	**Yes**
Loudoun County	Planning	Public Works	Fire, Rescue & Emergency Management	Planning	Fire, Rescue & Emergency Management	Fire, Rescue & Emergency Management	Planning	**Yes**

5.3. Technical Capabilities of each Jurisdiction								
Jurisdiction	**Land Use Planners**	**Civil or Building Engineers**	**Emergency manager**	**Floodplain manager**	**Staff familiar with hazards**	**GIS staff**	**Grant writers**	**Internet access?**
Manassas Park, City of	Planning & Zoning	Public Works	Police Department	Planning & Zoning	Police, Fire & Rescue	Police, Fire & Rescue	Planning & Zoning, City Administration	**Yes**
Manassas, City of	Community Development	Public Works	Emergency Preparedness	Community Development, Emergency Preparedness	Public Safety	Emergency Preparedness	Community Development	**Yes**
Middleburg, Town of	Zoning & Planning	Engineering	Police Department	Zoning & Planning	Police Department	Police Department	Zoning & Planning	**Yes**
Occoquan, Town of	Town Council	Town Council	Town Council	Town Council	Town Council	Town Council	Town Council	**Yes**
Prince William County	Planning Office	Public Works	Fire & Rescue, Police Department	Planning Office	Fire & Rescue, Police Department	Fire & Rescue, Police Department	Planning Office	**Yes**
Purcellville, Town of	Planning Office	Public Works	Police Department	Planning Office	Police Department	Police Department	Planning Office	**Yes**
Quantico, Town of	Town Council	Town Council	Town Council	Town Council	Town Council	Town Council	Town Council	**Yes**
Round Hill, Town of	Planning and Zoning	Utility Department	Community Policing	Planning and Zoning	Town Council	Planning and Zoning	Planning and Zoning	**Yes**
Vienna, Town of	Planning & Zoning	Public Works	Police	Planning & Zoning	Police	Police	Planning & Zoning	**Yes**

B. Planning and Regulatory Capability

Planning and regulatory capability is based on the implementation of plans, ordinances, and programs that demonstrate a jurisdiction's commitment to guiding and managing growth, development, and redevelopment in a responsible manner, while maintaining the general welfare of the community. It includes emergency operations and mitigation planning, comprehensive land use planning, and transportation planning, in addition to the enforcement of zoning or subdivision ordinances and building codes that regulate how land is developed and structures are built, as well as protecting environmental, historic, and cultural resources in the community. Although some conflicts can arise, these planning initiatives generally present significant opportunities to integrate hazard mitigation principles and practices into the local decision making process.

The Planning and Regulatory capability assessment is designed to provide a general overview of the key planning and regulatory tools or programs in place or under development, along with their potential effect on loss reduction. This information helps identify opportunities to address existing planning and programmatic gaps, weaknesses, or conflicts with other initiatives, in addition to integrating the implementation of this plan with existing planning mechanisms where appropriate.

The table below provides an update to the 2006 Northern Virginia Hazard Mitigation Plan. It summarizes relevant local plans, ordinances, and programs already in place or under development for participating jurisdictions. A (Y) indicates that the given item is currently in place and being implemented by the local jurisdiction (or in some cases by the County on behalf of that jurisdiction), or that it is currently being developed for future implementation. A (Y*) indicates that capability is new as of the 2010 update.

Table 5.4. Local plans, ordinances and programs												
Jurisdiction	Hazard Mitigation Plan	Comprehensive Land Use Plan	Floodplain Management Plan	Open Space Management Plan	Stormwater Management Plan	Flood Response Plan	Emergency Operations Plan	SARA Title III Plan	Radiological Emergency Plan	Continuity of Operations Plan	Evac Plan	Disaster Recovery Plan
Alexandria, City of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Arlington County	Y	Y	Y*	Y	Y	Y*	Y	Y	Y	Y	Y	Y
Clifton, Town of	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*
Dumfries, Town of	Y	Y		Y	Y		Y				Y	
Fairfax County	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fairfax, City of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Falls Church, City of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Haymarket, Town of		Y*	Y*	Y*	Y*							
Herndon, Town of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Leesburg, Town of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loudoun County	Y	Y	Y*	Y	Y	Y	Y	Y	Y*	Y	Y	Y
Manassas Park, City of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Manassas, City of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Middleburg, Town of	Y*	Y*	Y*	Y*	Y*	Y*		Y*	Y*	Y*		Y*
Occoquan, Town of												
Prince William County	Y	Y	Y				Y	Y	Y	Y	Y	
Purcellville, Town of	Y	Y	Y	Y	Y	Y	Y	Y	Y*	Y*	Y	Y
Quantico, Town of												
Round Hill, Town of		Y*			Y*							
Vienna, Town of	Y	Y	Y*	Y	Y	Y*	Y	Y	Y	Y	Y	Y*

Table 5.4. Local plans, ordinances and programs

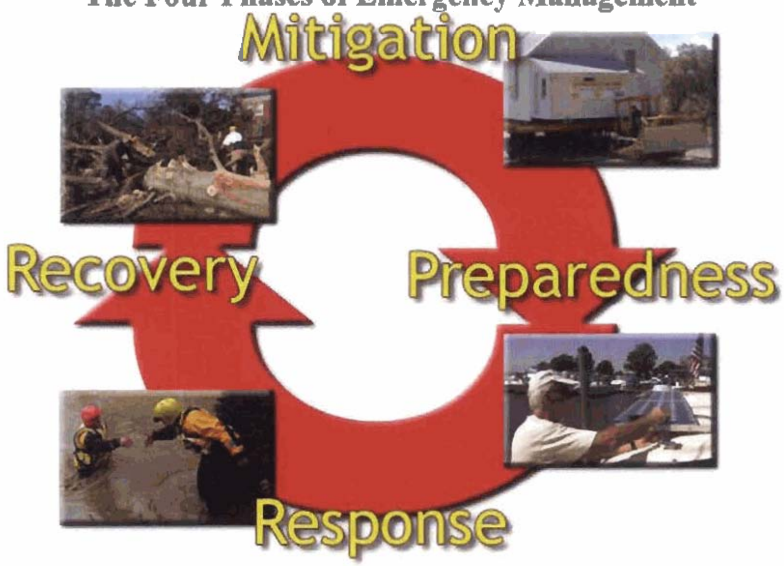
Jurisdiction	Capital Improvements Plan	Economic Development Plan	Historic Preservation Plan	Flood Damage Prevention Ordinance	Zoning Ordinance	Subdivision Ordinance	Post-disaster Red/Rec. Ordinance	Building Code	Fire Code	National Flood Insurance Program	NFIP Community Rating System
Alexandria, City of	Y			Y	Y	Y		Y	Y	Y	Y
Arlington County	Y	Y	Y*	Y	Y	Y*		Y	Y	Y	Y
Clifton, Town of	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*
Dumfries, Town of	Y	Y		Y	Y	Y		Y	Y	Y	
Fairfax County	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fairfax, City of	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y*
Falls Church, City of	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y*
Haymarket, Town of	Y*				Y*	Y*				Y*	
Herndon, Town of	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y*
Leesburg, Town of	Y	Y	Y	Y	Y	Y		Y	Y	Y	
Loudoun County	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
Manassas Park, City of	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Manassas, City of	Y	Y	Y	Y	Y	Y		Y	Y	Y	
Middleburg, Town of										Y	
Occoquan, Town of										Y	
Prince William County	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
Purcellville, Town of	Y	Y	Y	Y	Y	Y		Y	Y	Y	
Quantico, Town of										Y	
Round Hill, Town of	Y*				Y*	Y*			Y*	Y*	
Vienna, Town of	Y	Y*	Y*	Y	Y	Y	Y*	Y	Y	Y	Y

A more detailed discussion on each jurisdiction's planning and regulatory capability follows, along with the incorporation of additional information based on the narrative comments provided by local officials in response to the survey questionnaire. Copies of the completed surveys provide more detailed information on local capability, and can be obtained from the NVRC.

Emergency Management

Hazard mitigation is widely recognized as one of the four primary phases of emergency management. The three other phases include preparedness, response, and recovery. In reality each phase is interconnected with hazard mitigation as Figure 5.1 suggests. Opportunities to reduce potential losses through mitigation practices are most often implemented before disaster strikes, such as elevation of flood prone structures or through the continuous enforcement of policies that prevent and regulate development that is vulnerable to hazards because of its location, design, or other characteristics. Mitigation opportunities will also be presented during immediate preparedness or response activities (such as installing storm shutters in advance of a hurricane), and certainly during the long-term recovery and redevelopment process following a hazard event.

Figure 5.1
The Four Phases of Emergency Management



Planning for each phase is a critical part of a comprehensive emergency management program and a key to the successful implementation of hazard mitigation actions. As a result, the *Capability Assessment Survey* asked several questions across a range of emergency management plans in order to assess each jurisdiction's willingness to plan and their level of technical planning proficiency.

Hazard Mitigation Plan: A hazard mitigation plan represents a community's blueprint for how it intends to reduce the impact of natural and human-caused hazards on people and the built environment. The essential elements of a hazard mitigation plan include a risk assessment, capability assessment, and mitigation strategy.

Disaster Recovery Plan: A disaster recovery plan serves to guide the physical, social, environmental, and economic recovery and reconstruction process following a disaster. In many instances, hazard mitigation principles and practices are incorporated into local disaster recovery plans with the intent of capitalizing on opportunities to break the cycle of repetitive disaster losses. Disaster recovery plans can also lead to the preparation of disaster redevelopment policies and ordinances to be enacted following a hazard event.

- Eleven out of 20 jurisdictions have or are developing Disaster Recovery Plans, although some jurisdictions indicate that other plans include this topic, e.g., an emergency operations plan, and there is no separate disaster recovery plan that addresses long-term recovery issues.

Emergency Operations Plan: An emergency operations plan outlines responsibilities and the means by which resources are deployed during and following an emergency or disaster.

- Fifteen out of 20 jurisdictions have their own local emergency operations plans.

Continuity of Operation Plan: A continuity of operations plan establishes a chain of command, line of succession, and plans for backup or alternate emergency facilities in case of an extreme emergency or disaster event.

- Survey results indicate that seven jurisdictions do not have continuity of operations plans in place.

Radiological Emergency Plan: A radiological emergency plan delineates roles and responsibilities for assigned personnel and the means to deploy resources in the event of a radiological accident.

- Twelve jurisdictions have a plan to address radiological emergencies.

SARA Title III Emergency Response Plan: A Superfund Amendments and Re-authorization Act (SARA) Title III Emergency Response Plan outlines the procedures to be followed in the event of a chemical emergency such as the accidental release of toxic substances. These plans are required by federal law under Title III of the SARA, also known as the Emergency Planning and Community Right-to-Know Act.

- Fourteen jurisdictions have an Emergency Response Plan for chemical emergencies.

General Planning

The implementation of hazard mitigation activities often involves agencies and individuals beyond the emergency management profession. Stakeholders may include local planners, public works officials, economic development specialists, and others. In many instances, concurrent local planning efforts will help to achieve or complement hazard mitigation goals even though they are not designed as such. Therefore, the *Capability Assessment Survey* also asked questions regarding each jurisdiction's general planning capabilities and the degree to which hazard mitigation is integrated into other on-going planning efforts.

Comprehensive Land Use Plan: A comprehensive land use plan establishes the overall vision for what a community wants to be and serves as a guide to future governmental decision making. Typically a comprehensive plan contains sections on demographic conditions, land use, transportation elements, and community facilities. Given the broad nature of the plan and its regulatory standing in many communities, the integration of hazard mitigation measures into the comprehensive plan can enhance the likelihood of achieving risk reduction goals, objectives, and actions.

- Survey results indicate that 16 jurisdictions have a comprehensive land use plan. All the jurisdictions indicated that their land use plans either strongly support or help facilitate hazard loss reduction. Some jurisdictions indicated that although hazard mitigation is not specifically addressed in the plan, some elements of the plan might be relevant to hazard mitigation (e.g., environmental protection).

Capital Improvements Plan: A capital improvement plan guides the scheduling of spending on public improvements. A capital improvements plan can serve as an important mechanism for guiding future development away from identified hazard areas. Limiting public spending in hazardous areas is one of the most effective long-term mitigation actions available to local governments.

- Survey results indicate that all jurisdictions have a capital improvements plan in place or under development. Most of these are five-year plans that are updated annually, and all survey respondents indicated they either support or facilitate loss reduction efforts in their community.

Historic Preservation Plan: A historic preservation plan is intended to preserve historic structures or districts within a community. An often overlooked aspect of the historic preservation plan is the assessment of buildings and sites located in areas subject to natural hazards, and the identification of ways to reduce future damages.[36] This may involve retrofitting or relocation techniques that account for the need to protect buildings that do not meet current building standards, or are within a historic district that cannot easily be relocated out of harm's way.

- In 2006, survey results indicate that 10 out of 14 jurisdictions have a historic preservation plan for their communities. Arlington County, the Town of Dumfries, and the Town of Vienna indicated that they do not have any plans that address historic preservation. In 2010, this information was not changed.

Zoning Ordinances: Zoning represents the primary means by which land use is controlled by local governments. As part of a community's police power, zoning is used to protect the health, safety, and welfare of those in a given jurisdiction that maintains zoning authority. A zoning ordinance is the mechanism through which zoning is typically implemented. Since zoning regulations enable municipal governments to limit the type and density of development, it can serve as a powerful tool when applied in identified hazard areas.

Survey results indicate that all jurisdictions in the Northern Virginia region have adopted and enforce a zoning ordinance. All jurisdictions indicated that their zoning ordinance either strongly supports or helps facilitate hazard loss reduction.

Subdivision Ordinances: A subdivision ordinance is intended to regulate the development of housing, commercial, industrial, or other uses, including associated public infrastructure, as land is subdivided into buildable lots for sale or future development. Subdivision design that accounts for natural hazards can dramatically reduce the exposure of future development.[2]

[2] For additional information regarding the use of subdivision regulations in reducing flood hazard risk, see

- Survey results indicate that all jurisdictions in the Northern Virginia region, except Arlington County, have adopted and enforce a subdivision ordinance. The jurisdictions indicated that their ordinance either strongly supports or helps facilitate hazard loss reduction.

Building Codes, Permitting and Inspections: Building Codes regulate construction standards. In many communities permits are issued for, and inspections of work take place on, new construction. Decisions regarding the adoption of building codes (that account for hazard risk), the type of permitting process required both before and after a disaster, and the enforcement of inspection protocols all affect the level of hazard risk faced by a community.

- The Virginia Uniform Statewide Building Code (USBC) is a State regulation promulgated by the Virginia Board of Housing and Community Development for the purpose of establishing minimum regulations to govern the construction and maintenance of buildings and structures. As of October 1, 2003, the 2000 version of the International Building Code and International Fire Code were adopted by the Commonwealth of Virginia.
- As provided in the USBC Law, the USBC supersedes the building codes and regulations of the counties, municipalities, and other political subdivisions and state agencies.

The adoption and enforcement of building codes by local jurisdictions is routinely assessed through the Building Code Effectiveness Grading Schedule (BCEGS) program developed by the Insurance Services Office, Inc. (ISO).[3] Under the BCEGS program, ISO assesses the building codes in effect in a particular community and how the community enforces its building codes, *with special emphasis on mitigation of losses from natural hazards*. The results of BCEGS assessments are routinely provided to ISO's member private insurance companies, which in turn may offer ratings credits for new buildings constructed in communities with strong BCEGS classifications. The concept is that communities with well-enforced, up-to-date codes should experience fewer disaster-related losses, and as a result should have lower insurance rates.

In conducting the assessment, ISO collects information related to personnel qualification and continuing education, as well as number of inspections performed per day. This type of information combined with local building codes is used to determine a grade for that jurisdiction. Table 5.5 shows the BCEGS rating for the jurisdictions in the Northern Virginia region. The grades range from 1 to 10, with the lower grade being better. A BCEGS grade of 1 represents exemplary commitment to building code enforcement, and a grade of 10 indicates less than minimum recognized protection.

Subdivision Design in Flood Hazard Areas. 1997. Morris, Marya. Planning Advisory Service Report Number 473. American Planning Association: Washington, D.C.

[3] Participation in BCEGS is voluntary and may be declined by local governments if they do not wish to have their local building codes evaluated.

Table 5.5. BCEGS Rating for the Northern Virginia Region		
Jurisdiction	Year of Evaluation	BCEGS Rating
Arlington Co	2000	3
Fairfax County	1997	3
Loudoun County	1997	3
Prince William County	1997	4
Alexandria, City of	1998	3
Fairfax, City of	1998	4
Falls Church, City of	1999	5
Manassas, City of	1997	4
Manassas Park, City of	2000	3
Dumfries, Town of	1997	5
Herndon, Town of	1997	3
Leesburg, Town of	1997	3
Purcellville, Town of	1997	3
Vienna, Town of	N/A	N/A

Source: Insurance Services Office, Inc. (ISO)

1. NFIP participation

Communities that regulate development in floodplains are able to participate in the NFIP. In return, the NFIP makes federally-backed flood insurance policies available for eligible properties in the community. All of the participating jurisdictions included in this planning initiative participate in the NFIP. The table below shows when each of the jurisdictions began participating in the NFIP. The table also provides the date of the FIRM in effect in each community. These maps were developed by FEMA or its predecessor and show the boundaries of the 100-year and 500-year floods. As the table shows, 13 of the maps are over 15 years old. Parts of the planning area have experienced dramatic growth over the past decade that is not reflected in the FIRM. This difference may mean that the actual floodplain varies from that depicted on the map.

Table 5.6. Communities participating in the NFIP.					
Community Name	Init FHBM Identified	Init FIRM Identified	Current Effective Map Date	Reg-Emer Date	DFIRM/Q3
Arlington County		10/1/1969	5/3/1982	12/31/1976	DFIRM
Fairfax County	5/5/1970	3/5/1990	3/5/1990	1/7/1972	DFIRM
Town of Herndon	6/14/1974	8/1/1979	8/1/1979	8/1/1979	
Town of Vienna	8/2/1974	2/3/1982	2/3/1982	2/3/1982	
Town of Clifton	3/28/1975	5/2/1977		5/2/1977	
Loudoun County	4/25/1975	1/5/1978	7/5/2001	1/5/1978	DFIRM
Town of Leesburg	8/3/1974	9/30/1982	7/5/2001	9/30/1982	
Town of Purcellville	7/11/1975	11/15/1989	7/5/2001	11/15/1989	
Town of		7/5/2001	7/5/2001	7/31/2001	

Table 5.6. Communities participating in the NFIP.					
Community Name	Init FHBM Identified	Init FIRM	Current Effective Map Date	Reg-Emer Date	DFIRM/Q3
Middleburg					
Town of Round Hill	5/13/1977	7/5/2001	7/5/2001	1/10/2006	
Prince William County	1/10/1976	12/1/1981	1/5/1995	12/1/1981	DFIRM
Town of Dumfries	6/18/1976	5/15/1980	1/5/1995	5/15/1980	
Town of Haymarket	8/9/1974	1/17/1990	1/5/1995	1/31/1990	
Town of Occoquan	7/19/1974	9/1/1978	1/5/1995	9/1/1978	
Town of Quantico	11/1/1974	8/15/1978	1/5/1995	8/15/1978	
City of Alexandria	8/22/1969	8/22/1969	5/15/1991	5/8/1970	Q3
City of Fairfax	5/5/1970	12/23/1971	6/2/2006	12/17/1971	DFIRM
City of Falls Church	9/6/1974	2/3/1982	7/16/2004	2/3/1982	DFIRM
City of Manassas	5/31/1974	1/3/1979	1/5/1995	1/3/1979	DFIRM
City of Manassas Park	3/11/1977	9/29/1978	1/5/1995	9/29/1978	DFIRM

as of 7/6/2010 *http://www.fema.gov/cis/VA.html*

C. Fiscal Capability

For Fiscal Year 2010, the budgets of the participating jurisdictions range from $1.3 Million (Town of Middleburg) to $1.2 Billion (Fairfax County). The table below shows the total budget amounts for each jurisdiction in addition to the amount budgeted for public safety, public works and their respective planning and zoning departments. The Towns of Clifton, Quantico, and Occoquan and the City of Manassas Park did not have fiscal year 2010 budgetary information available for review.

Table 5.7. 2010 budgets by jurisdiction				
Jurisdiction	FY 2010 Budget ($)	Public Works Budget ($)	Public Safety Budget ($)	Planning Budget ($)
Alexandria, City of	530M	27.2M	33M	5.3M
Arlington County	946.8M	70.2M	104M	9.2M
Clifton, Town of	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*
Dumfries, Town of	4M	0.25M	1.3M	0.215M
Fairfax County	1.21B	421M	62.8M	10.6M

Table 5.7. 2010 budgets by jurisdiction				
Jurisdiction	FY 2010 Budget ($)	Public Works Budget ($)	Public Safety Budget ($)	Planning Budget ($)
Fairfax, City of	126M	10.9M	19.1M	2M
Falls Church, City of	66.9M	0.671M	9.4M	0.746M
Haymarket, Town of	1.2M	0.116M	0.352M	.0038M
Herndon, Town of	41.1M	8.8M	8.5M	1.3M
Leesburg, Town of	45.1M	10.9M	10.9M	1.58M
Loudoun Coun		*Not Available for Review*	131M	0.607M
Manassas Park, City of	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*
Manassas. Citv of	100M	7.5M	19M	.462M
Middleburg, Town of	1.3M	*Not Available for Review*	0.48M	0.142M
Occoquan, Town of	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*
Prince William County	845M	1.9M	13M	0.93M
Purcellville, Town of	13.5M	2.8M	1.5M	0.564M
Quantico, Town of	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*	*Not Available for Review*
Round Hill, Town of	2.7 M	1.4 M	*Not Available for Review*	*Not Available for Review*
Vienna, Town of	20.8M	6.7M	5.6M	.746M

The counties, cities, and towns receive most of their revenue through State and local sales tax, local services, and through restricted intergovernmental contributions (Federal and State pass through dollars). It is unlikely that any of the counties, cities, or towns could easily afford to provide the local match for the existing hazard mitigation grant programs. Considering the current budget deficits at both the State and local government level in Virginia, combined with the apparent increased reliance on local accountability by the Federal government, this is a significant and growing concern.

The following table is an update to the 2006 Northern Virginia Hazard Mitigation Plan. The table highlights each jurisdiction's fiscal capability through the identification of locally available financial resources. A (Y) indicates that the given fiscal resource is locally available for hazard mitigation purposes (including match funds for State and Federal mitigation grant funds). A (Y*) indicates that capability is new as of the 2010 update.

5.8. Fiscal capabilities by jurisdiction									
Jurisdiction	Capital Improvement Programming	Community Development Block Grants	Special Purpose Taxes	Gas / Electric Utility Fees	Water / Sewer Fees	Stormwater Utility Fees	Development Impact Fees	General Obligation Bonds / Revenue Bonds / Special Tax Bonds	Partnering Arrangements or Intergovernmental Agreements
Alexandria, City of	Y	Y	Y		Y		Y	Y	Y
Arlington County	Y	Y	Y*	Y*	Y*	Y*		Y	Y
Clifton, Town of	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*
Dumfries, Town of	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fairfax County	Y	Y	Y	Y	Y	Y*	Y*	Y	Y
Fairfax, City of	Y		Y		Y				
Falls Church, City of	Y	Y			Y	Y	Y	Y	Y
Haymarket, Town of	Y*							Y*	
Herndon, Town of	Y	Y	Y	Y*	Y	Y*	Y*	Y	Y
Leesburg, Town of	Y		Y*	Y	Y			Y	Y
Loudoun County	Y	Y	Y					Y	Y*
Manassas Park, City of	Y	Y			Y	Y		Y	Y
Manassas, City of	Y	Y	Y	Y	Y	Y		Y	Y
Middleburg, Town of	Y*	Y*			Y*			Y*	Y*
Occoquan, Town of									
Prince William County	Y	Y	Y		Y	Y	Y	Y	Y
Purcellville, Town of	Y	Y			Y			Y	Y
Quantico, Town of									
Round Hill, Town of	Y*			Y*	Y*			Y*	Y*
Vienna, Town of	Y	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*

Chapter 6: Mitigation Strategies

This section of the Plan describes the most challenging part of any such planning effort – the development of a Mitigation Strategy. It is a process of:

1. Setting mitigation goals;
2. Considering mitigation alternatives;
3. Identifying objectives and strategies; and
4. Developing a mitigation action plan.

In being comprehensive, the development of the strategy included a thorough review of all natural hazards and identified far-reaching policies and projects intended to not only reduce the future impacts of hazards, but also to assist counties and municipalities to achieve compatible economic, environmental, and social goals. In being strategic, the development of the strategy ensures that all policies and projects are linked to established priorities and assigned to specific departments or individuals responsible for their implementation with target completion deadlines. When necessary, funding sources are identified that can be used to assist in project implementation.

For the 2010 update, the regional goals, objectives, and strategies were re-examined by the committee and jurisdictions and new goals and strategies were included in this section of the plan update. Local jurisdiction strategies are included in Chapter 7.

I. Planning Process for Setting Mitigation Goals

The hazard mitigation planning process conducted by the MAC is a typical problem-solving methodology:

- Describe the problem (Hazard Identification);
- Estimate the impacts the problem could cause (Vulnerability Assessment);
- Assess what safeguards exist that might already or could potentially lessen those impacts (Capability Assessment); and
- Using this information, determine what, if anything, can be done, and select those actions that are appropriate for the community in question (Develop an Action Plan).

When a community decides that certain risks are unacceptable and that certain mitigation actions may be achievable, the development of *goals* and *objectives* takes place. Goals and objectives help to describe what actions should occur, using increasingly narrow descriptors. Initially, long-term and general statements known as broad-based goals are developed. Goals then are accomplished by meeting objectives, which are specific and achievable in a finite time period. In most cases there is a third level, called *strategies,* which are detailed and specific methods to meet the objectives.

The MAC discussed regional goals and objectives for this plan at two points in the planning process. First, they attended a workshop on July 12, 2010, to discuss the results of the HIRAs and to begin developing the mitigation strategy by discussing the 2006 mitigation goals. These original goals were broad and applicable to the region and the committee felt that in general, they still were applicable to the 2010 plan update. Then, during the final hazard identification and risk assessment presentation on October 18, 2010, the committee finalized the regional goals and developed one regional strategy per goal. This process was completed by looking at the jurisdiction-specific actions and the regional goals, and determining from there the type of objectives that would be the most logical extension.

Following the development of the regional goals, jurisdictional meetings were conducted during the months of September and early October 2010. During these separate jurisdictional meetings, the HIRA was presented to the attendees, and then strategies, or actions, were developed specific to each jurisdiction. Most of these actions are dynamic and can change and have been organized into a Mitigation Action Plan for the Region and its member jurisdictions.

Data collection supports the goals and recommended actions in two ways. First, the HIRA data identifies areas exposed to hazards, at-risk critical facilities, and future development at risk. Second, the Capability Assessment data identifies areas for integration of hazard mitigation into existing polices and plans.

The MAC members used the results of the data collection efforts to develop goals and prioritize actions for the region and their jurisdiction. The priorities differ somewhat from jurisdiction to jurisdiction. Each jurisdiction's priorities were developed based on past damages, existing exposure to risk, other community goals, and weaknesses identified by the local government capability assessments.

II. Considering Mitigation Alternatives

During the separate jurisdictional meetings that occurred between September and early October 2010, members of each jurisdiction were presented with the HIRA findings. Discussions held during the meeting resulted in the generation of a range of potential mitigation goals and actions to address the hazards. A range of alternatives were then identified and prioritized by each jurisdiction. These alternatives are presented in Chapter 7.

A. Identification and Analysis of Mitigation Techniques

In formulating Northern Virginia's mitigation strategy, a wide range of activities were considered in order to help achieve the general regional goals in addition to the specific hazard concerns of each participating jurisdiction. This includes the following activities as recommended by the Emergency Management Accreditation Program[37] (EMAP):

1) The use of applicable building construction standards;
2) Hazard avoidance through appropriate land-use practices;
3) Relocation, retrofitting, or removal of structures at risk;
4) Removal or elimination of the hazard;
5) Reduction or limitation of the amount or size of the hazard;
6) Segregation of the hazard from that which is to be protected;
7) Modification of the basic characteristics of the hazard;
8) Control of the rate of release of the hazard;
9) Provision of protective systems or equipment for both cyber or physical risks;
10) Establishment of hazard warning and communication procedures; and

11) Redundancy or duplication of essential personnel, critical systems, equipment, and information materials.

All activities considered by the MAC can be classified under one of the following six (6) broad categories of mitigation techniques:

Prevention

Preventative activities are intended to keep hazard problems from getting worse, and are typically administered through government programs or regulatory actions that influence the way land is developed and buildings are built. They are particularly effective in reducing a community's future vulnerability, especially in areas where development has not occurred or capital improvements have not been substantial. Examples of preventative activities include:

- Planning and zoning;
- Building codes;
- Open space preservation;
- Floodplain regulations;
- Stormwater management regulations;
- Drainage system maintenance;
- Capital improvements programming; and
- Shoreline / riverine / fault zone setbacks.

Property Protection

Property protection measures involve the modification of existing buildings and structures to help them better withstand the forces of a hazard, or removal of the structures from hazardous locations. Examples include:

- Acquisition;
- Relocation;
- Building elevation;
- Critical facilities protection;
- Retrofitting (e.g., windproofing, floodproofing, seismic design techniques, etc.);
- Safe rooms, shutters, shatter-resistant glass; and
- Insurance.

Natural Resource Protection

Natural resource protection activities reduce the impact of natural hazards by preserving or restoring natural areas and their protective functions. Such areas include floodplains, wetlands, steep slopes, and sand dunes. Parks, recreation, or conservation agencies and organizations often implement these protective measures. Examples include:

Floodplain protection;

- Watershed management;
- Beach and dune preservation;
- Riparian buffers;
- Forest/vegetation management (e.g., fire resistant landscaping, fuel breaks, etc.);
- Erosion and sediment control;
- Wetland preservation and restoration;
- Habitat preservation; and

- Slope stabilization,

Structural Projects

Structural mitigation projects are intended to lessen the impact of a hazard by modifying the environmental natural progression of the hazard event through construction. They are usually designed by engineers and managed or maintained by public works staff. Examples include:

- Reservoirs;
- Dams / levees / dikes / floodwalls / seawalls;
- Diversions / detention / retention;
- Channel modification;
- Beach nourishment; and
- Storm sewers.

Emergency Services

Although not typically considered a "mitigation" technique, emergency service measures do minimize the impact of a hazard event on people and property. These commonly are actions taken immediately prior to, during, or in response to a hazard event. Examples include:

- Warning systems;
- Evacuation planning and management;
- Emergency response training and exercises;
- Sandbagging for flood protection; and
- Installing temporary shutters for wind protection.

Public Education and Awareness

Public education and awareness activities are used to advise residents, elected officials, business owners, potential property buyers, and visitors about hazards, hazardous areas, and mitigation techniques they can use to protect themselves and their property. Examples of measures to educate and inform the public include:

- Outreach projects;
- Speaker series / demonstration events;
- Hazard map information;
- Real estate disclosure;
- Library materials;
- School children educational programs; and
- Hazard expositions.

B. Prioritizing Alternatives

Through discussion and self analysis, each jurisdiction used the STAPLE/E (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) Criteria when considering and prioritizing the most appropriate mitigation alternatives for the Region's communities. This methodology requires that social, technical, administrative, political, legal, economic, and environmental considerations be taken into account when reviewing potential actions for the area's jurisdictions to undertake. This process was used to help ensure that the most equitable and feasible actions would be undertaken based on a jurisdiction's capabilities.

Table 6.1, below, provides information regarding the review and selection criteria for alternatives.

Table 6.1. STAPLE/E Review and Selection Criteria for Alternatives
Social
▪ Is the proposed action socially acceptable to the community(s)? ▪ Are there equity issues involved that would mean that one segment of a community is treated unfairly? ▪ Will the action cause social disruption?
Technical
▪ Will the proposed action work? ▪ Will it create more problems than it solves? ▪ Does it solve a problem or only a symptom? ▪ Is it the most useful action in light of other community(s) goals?
Administrative
▪ Can the community(s) implement the action? ▪ Is there someone to coordinate and lead the effort? ▪ Is there sufficient funding, staff, and technical support available? ▪ Are there ongoing administrative requirements that need to be met?
Political
▪ Is the action politically acceptable? ▪ Is there public support both to implement and to maintain the project?
Legal
▪ Is the community(s) authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? ▪ Are there legal side effects? Could the activity be construed as a taking? ▪ Is the proposed action allowed by a comprehensive plan, or must a comprehensive plan be amended to allow the proposed action? ▪ Will the community(s) be liable for action or lack of action? ▪ Will the activity be challenged?
Economic
▪ What are the costs and benefits of this action? ▪ Do the benefits exceed the costs? Are initial, maintenance, and administrative costs taken into account? ▪ Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? ▪ How will this action affect the fiscal capability of the community(s)? ▪ What burden will this action place on the tax base or local economy? ▪ What are the budget and revenue effects of this activity? ▪ Does the action contribute to other community goals, such as capital improvements or economic development? ▪ What benefits will the action provide?
Environmental
▪ How will the action affect the environment? • Will the action need environmental regulatory approvals? • Will it meet local and state regulatory requirements?

Table 6.1. STAPLE/E Review and Selection Criteria for Alternatives
• Are endangered or threatened species likely to be affected?

Ranking was completed in order of relative priority based on the STAPLE/E criteria, as well as the strategy's potential to reduce vulnerability to natural hazards.

III. Identifying Objectives and Strategies

A. Goals and Strategies

Through a series of jurisdictional meetings, the following goals and strategies for the region were accepted by the MAC. The goals and strategies form the basis for the development of a Mitigation Action Plan and specific mitigation projects to be considered for the Region. The process consisted of 1) setting goals, 2) considering mitigation alternatives, 3) identifying strategies, and 4) developing an action plan resulting in a mitigation strategy.

Community officials should consider the goals that follow before making community policies, public investment programs, economic development programs, or community development decisions for their communities. In addition, Regional strategies have been developed for each goal. These strategies state a more specific outcome that the jurisdictions of the Northern Virginia region expect to accomplish over the next five years. The strategies will outline the specific steps necessary to achieve that end.

Regional Goals and Strategies

- Goal 1: Improve the quality and utilization of best available data for conducting detailed hazard risk assessments and preparing meaningful mitigation action plans.
- Goal 2: Increase the capability of the Northern Virginia jurisdictions to successfully mitigate hazards to include participation in grant programs, revision of codes, expansion of programs such as the Community Rating System, and continuation or expansion of outreach programs.
- Goal 3: Develop and maintain specific plans to minimize the effects of known hazards in the region.
- Goal 4: Improve existing local policies, codes, and regulations to reduce or eliminate the impacts of known hazards. This includes maintaining continued compliance with the NFIP for all participating jurisdictions.
- Goal 5: Investigate and implement a range of structural projects that will reduce the effects of natural and human-caused hazards on public and private property throughout the region.
- Goal 6: Increase the public's awareness of natural and human-caused hazard risks in the Northern Virginia region, while also educating residents and businesses on the mitigation measures available to minimize those risks.

The previous regional strategy from the 2006 plan stated: Coordinate with participating local jurisdictions on the acquisition and/or development of improved GIS data layers for use in conducting enhanced risk assessment studies for future updates to the Northern Virginia Regional Hazard Mitigation Plan, in a continuing effort within the region. The region has successfully increased is GIS capacity over the last five years and each community has coordinated with each other to ensure dataset synergies where appropriate.

Agency/Department: Mitigation Action	Lead Agency Department Organization	Flood	Winter Weather	Thunderstorm	Tornado	Hurricane	Drought	Wildfire	Earthquake	Extreme Temps	Dam Failure	Erosion	Landslides	Karst	Human-Caused	Funding Source	Target Completion Date	Interim Measure of Success	Priority
Develop an improved critical facility dataset to use in emergency planning efforts and the 2016 mitigation plan update.	Northern Virginia Emergency Managers Committee	X	X	X	X	X	X	X	X	X	X	X	X	X	X	EMPG Funds HMGP 7% PDM Planning Other DHS funds.	June 2016	Define critical facility and identify which DHS category will be included in dataset by June 2012	Critical
Coordinate with VDEM on obtaining funding opportunities to implement jurisdiction strategies.	Northern Virginia Emergency Managers Committee	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	June 2016	Identify at least two funding sources by June 2011	High
Conduct a regional commodity flow study and develop recommendations from these studies to implement effective mitigation actions.	Fairfax County Office of Emergency Management														X	EMPG DHS SARA Title II (EPA)	January 2014	Secure funding by June 2011	High
Educate elected officials and residents on the importance of the NFIP.	Jurisdictional Offices of Emergency Management	X		X		X										HMGP 5% Initiative Projects	June 2016	Develop informational memorandums to disseminate by June 2012	High
Acquire, elevate, retrofit properties located in the floodplain per local jurisdiction plans.	Jurisdictional Offices of Emergency Management	X		X		X										FEMA HMA Programs	June 2016	Acquire, elevate, and/or retrofit at least 3 properties per year in the region.	High
Update, print and distribute "NOVA EM Prep Guide" and include mitigation.	Loudoun County Office of Emergency Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	EMPG HMGP 5% Initiative Projects	January 2012	Update the guide by June 2011	High

Local Mitigation Strategies

In formulating a mitigation strategy, a wide range of activities was considered in order to help achieve the goals and to lessen the vulnerability of the Northern Virginia area to the effects of natural hazards. Through a series of jurisdictional meetings, conference calls, and e-mail exchanges from August through December 2010, all of the jurisdictions (county, cities, and towns) participated in the development and review of the local mitigation strategy.

Strategies were ranked by each community. Ranking was completed in order of relative priority based on the STAPLE/E criteria, as well as the strategy's potential to reduce vulnerability to natural hazards. Actions were given a ranking of high, medium, or low, with the following meanings:

- High (H) – actions should be implemented in the short-term
- Medium (M) – actions should be implemented in the long-term
- Low (L) – actions should be implemented only as funding becomes available

When deciding on which strategies should receive priority in implementation, the communities considered:

- Time – Can the strategy be implemented quickly?
- Ease to implement – How easy is the strategy to implement? Will it require many financial or staff resources?
- Effectiveness – Will the strategy be highly effective in reducing risk?
- Lifespan – How long will the effects of the strategy be in place?
- Hazards – Does the strategy address a high priority hazard or does it address multiple hazards?
- Post-disaster implementation – Is this strategy easier to implement in a post-disaster environment?

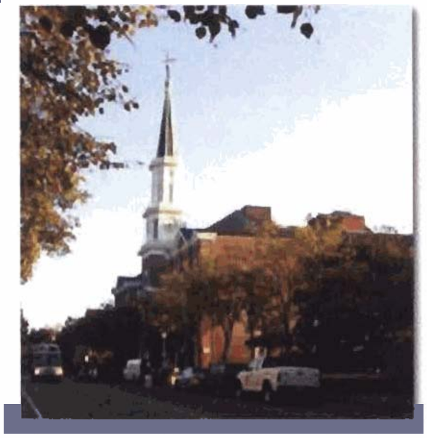
In addition, the anticipated level of cost effectiveness of each measure was a primary consideration when developing mitigation actions. Because mitigation is an investment to reduce future damages, it is important to select measures for which the reduced damages over the life of the measure are likely to be greater than the project cost. For structural measures, the level of cost effectiveness is primarily based on the likelihood of damages occurring in the future, the severity of the damages when they occur, and the level of effectiveness of the selected measure. Although detailed analysis was not conducted during the mitigation action development process, these factors were of primary concern when selecting measures. For those measures that do not result in a quantifiable reduction of damages, such as public education and outreach, the relationship of the probable future benefits and the cost of each measure was considered when developing the mitigation actions. Each jurisdiction's mitigation strategy can be found in Chapter 7 and the status of the 2006 mitigation strategies can be found in Appendix E. Where a strategy's status is blank, updates were unable to be retrieved from the jurisdiction's representative.

Each of the strategies are numbered in the action plans below and listed in order of their prioritization (High, Medium, or Low). The strategies that were brought forward from the 2006 plan are listed first in the table under their original strategy number, which is a simple numeric value. The new strategies for this new planning cycle start at 1 again. The second column denotes which year the strategy was developed in. Where there are no 2006 strategies listed, either this was the first time that jurisdiction participated in a mitigation plan, or none of the strategies from the previous plan were brought forward.

Chapter 7: Jurisdiction Executive Summaries

Chapter 7 is a new chapter for the 2010 plan update. It was reviewed and approved by the Northern Virginia MAC.

I. Alexandria



What is now the City of Alexandria was first settled as part of the British Colony of Virginia in the late 1690s. In 1791, George Washington included portions of the City of Alexandria in what was to become the District of Columbia. That portion was given back to Virginia in 1846 and the City of Alexandria was re-chartered in 1852. In 1870, the City of Alexandria became independent of Alexandria County, with the remainder of the county changing its name to Arlington County in 1920. The population of the city was 128,283 as of the 2000 Census and was estimated to be 141,738 in 2009.

Alexandria has a moderate climate. The average annual temperature is approximately 58 degrees. Temperatures generally range from January lows in the mid-20s to July highs in the upper-80s and lower-90s. Annual precipitation averages above 40 inches and approximately 14 - 16 inches of snow falls in any given year. Recent history proves that weather events well outside of these averages can and do occur. Climate change is expected to continue the trend of the past 40 to 50 years of an increased frequency of extreme weather events.

Alexandria's high population density and its location along the banks of the Potomac River increase the city's vulnerability to a variety of hazards, most notably flooding. In addition to snow melt and rain-related river flooding episodes, Alexandria is also subjected to tidal and storm surge flooding. As sea levels rise, permanent inundation of low lying areas along and near the river shoreline is also a concern. Winter weather and high wind events also pose a significant threat to the city as the 2009 – 2010 winter and summer seasons have proven.

To a large extent, historical records are used to identify the level of risk within the Northern Virginia region, including Alexandria, with the assumption that the data sources cited are reliable and accurate. Unless otherwise cited, data on historical weather-related events is based on information made available through the Storm Event Database by NOAA's NCDC[38]. Hazards were ranked using a semi-quantitative scoring system that involved grouping the data values (normalized to account for inflation) based on statistical methods. This method prioritizes hazard risk based on a blend of quantitative factors extracted from NCDC and other available data sources. The parameters considered include:

- Historical occurrence;
- Vulnerability of population in the hazard area; and
- Historical impact, in terms of human lives and property and crop damage.

The hazard scores were assigned a category of 'Low'; 'Medium-Low'; 'Medium'; 'Medium-High'; or 'High'. Based on this methodology, Flood, Wind, Tornado, Winter Weather, and Landslide hazards were ranked as 'High' for Alexandria. See Table 7.1 for a summary of hazard rankings.

Table 7.1: Hazard Ranking for Alexandria

Hazard	Flood	Wind	Tornado	Winter Weather	Drought	Earthquake	Landslide	Wildfire	Karst
	High	High	High	High	Med-High	Med	Low	Med-Low	Med-Low

Annualized loss statistics for Alexandria based on NCDC historical data as the result of Flood, High Wind, Tornado and Winter Storm are summarized in Table 7.2. It should be noted that while the NCDC storm events data is the most comprehensive database available for which to compare most natural hazards, its considerable limitations include spotty property and crop damage data that are considered to significantly under-estimate actual losses.

Table 7.2: NCDC Annualized Loss by Hazard for Alexandria

Annualized Loss as determine through NCDC data *(based on property and crop damages an years of record)*

County	Flood	High Wind	Tornado	Winter Storm	Total Annualized Loss
Years of Record	17	21	59	17	(for all hazards)
City of Alexandria	$57,033	$193,936	$149	$60,484	$311,602

HAZUS^{MH} provides another method for estimating annualized loss that uses science and engineering principals in addition to historical data to analyze potential damage and economic loss. Annualized loss statistic for Alexandria based on HAZUS^{MH} runs for flood, hurricane and earthquake are found in Tables 7.3, 7.4 and 7.5 below.

Table 7.3: HAZUS^{MH} - Annualized Loss Due to Flood for Alexandria

Jurisdiction	Building Loss	Content Loss	Inventory Loss	Relocation Loss	Income Loss	Rental Loss	Wage Loss	Total ualized Loss
City of Alexandria	$6,460,000	$5,306,000	$54,000	$10,000	$1,000	$12,000	$7,000	**$11,850,000**

Table 7.4: HAZUS^{MH} - Annualized Loss Due to Hurricane for Alexandria								
Jurisdiction	Building -	Content Loss	Inventory Loss	Relocation Loss	Income Loss	Rental Loss	Wage Loss	Total Annualized Loss
City of Alexandria	$387,234	$57,628	$427	$30,477	$4,701	$17,598	$6,277	**$504,342**

Table 7.5: HAZUS^{MH} - Annualized Loss Due to Earthquake for Alexandria	
Jurisdiction	Annualized Loss
City of Alexandria	**$198,495**

As seen in the HAZUS^{MH} analysis, the potential annual loss to property, contents, inventory, and related effects is extremely high at more than $11.8 million for flooding and $504,342 for hurricane. The earthquake annualized loss estimate is relatively low, but earthquakes occur only occasionally in the region. That was the case July 16, 2010, when a 3.6 magnitude quake centered near Gaithersburg, Maryland, shook the area.

A. Alexandria Mitigation Actions and Action Plan

#	Year	Agency/Department: Mitigation Action	Lead Agency Department Organization	Flood	Winter Weather	Thunderstorm	Tornado	Hurricane	Drought	Wildfire	Earthquake	Extreme Temps	Dam Failure	Erosion	Landslides	Karst	Human-Caused	Funding Source	Target Completion Date	Interim Measure of Success	Priority	Keep Action Redacted (Yes/No)
1	2006	Adopt revised FIRM.	Transportation and Environmental Services	X		X		X										Internal funding	May 2011	Complete final adoption public review as prescribed by NFIP.	Critical	No
1	2010	Excavate sediment from channel bed of Cameron Run-Hunting Creek to Potomac River.	Regional project with Fairfax County and VDOT and Transportation and Environmental Services	X										X				FEMA Unified Hazard Mitigation Assistance funding, United States Army Corp of Engineers, Virginia Department of Transportation, Fairfax County, City of Alexandria	Ongoing	Secure funding for project by March 2011	High	No
2	2010	Identify and exploit the most effective tools for communications with the public during emergencies, including leveraging emerging technologies.	Emergency Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Internal funding	Ongoing	3,000 new subscribers to e-News for receipt of emergency alerts by end of 2012.	High	No

#	Year	Agency/Department: Mitigation Action	Lead Agency Department Organization	Flood	Winter Weather	Thunderstorm	Tornado	Hurricane	Drought	Wildfire	Earthquake	Extreme Temps	Dam Failure	Erosion	Landslides	Karst	Human-Caused	Funding Source	Target Completion Date	Interim Measure of Success	Priority	Keep Action Redacted (Yes/No)
3	2010	Conduct annual outreach to each FEMA-listed repetitive loss and severe repetitive loss property owner, providing information on mitigation programs (grant assistance, mitigation measures, flood insurance information) that can assist them in reducing their flood risk.	Transportation and Environmental Services	X		X		X										Internal funding	Ongoing	Develop outreach materials, or identify appropriate outreach materials for dissemination by June 2011.	Medium	No
6	2006	Support mitigation of priority flood-prone structures through promotion of acquisition/ demolition, elevation, flood proofing, minor localized flood control projects, mitigation reconstruction and where feasible using FEMA HMA programs where appropriate.	Transportation and Environmental Services	X		X		X										FEMA Unified Hazard Mitigation Assistance funding,	Ongoing	Identify all priority flood-prone structures by December 2011.	Medium	No
4	2010	Promote structural mitigation to assure redundancy of critical facilities, to include but not limited to roof structure improvement, to meet or exceed building code standards, upgrade of electrical panels to accept generators, etc.	Emergency Management	X		X		X										FEMA Unified Hazard Mitigation Assistance funding,	Ongoing	Query local government building services staffs as to effectiveness of provided information regarding the structural review.	Medium	No
5	2010	Review locality's compliance with the National Flood Insurance Program with an annual review of the Floodplain Ordinances and any newly permitted activities in the 100-year floodplain. Additionally, Conduct annual review of repetitive loss and severe repetitive loss property list	Transportation and Environmental Services	X		X		X										Local program	Ongoing	Establish a schedule of review and review committee (if	Medium	No

#	Year		Lead Agency Department Organization	Flood	Winter Weather	Thunderstorm	Tornado	Hurricane	Drought	Wildfire	Earthquake	Extreme Temps	Dam Failure	Erosion	Landslides	Karst	Human-Caused	Funding Source	Target Compl etion Date	Interim Measure of Success	Priorit y	Keep Action Redacte d (Yes/No)
		requested of VDEM to ensure accuracy. Review will include verification of the geographic location of each repetitive loss property and determination if that property has been mitigated and by what means. Provide corrections if needed by filing form FEMA AW-501.																		necessary) by June 2011.		
6	2010	Install warning signs in park areas subject to flooding.	Recreation, Parks & Cultural Activities	X		X		X										Internal funding	2011	Develop prioritized list of sites requiring signage.	Mediu m	No
7	2010	Re-grade section of lower King Street, Union Street and The Strand to improve drainage and minimize flooding.	Transportation and Environmental Services	X		X		X										Alexandria Capital Improvement Project funding	2015	Integrate into capital improveme nt budgets; complete design and permitting.	Low	No
8	2010	Construct an elevated walkway along Potomac riverfront to elevation 6.0 feet (NAVD88) to mitigate flooding.	Transportation and Environmental Services	X		X		X										Alexandria Capital Improvement Project funding and developer contributions	2020	Integrate into capital improveme nt budgets; complete design and permitting.	Low	No