Commonwealth of Virginia Emergency Operations Plan
Standard Hazard Mitigation Support Annex 3
(Volume II)

CHAPTER 3

Hazard Identification and Risk Assessment (HIRA)

Section 3.7
Flooding

2010

SECTION 3.7

TABLE OF CONTENTS

Section 3.7: Flooding 2
Description 2
Coastal Flood Hazards 3
Coastal Erosion Hazards 3
Sea Level Rise 3
Riverine Flood Hazards 4
Flash Flooding Hazards 4
Tsunami Flooding Hazards 4
Historic Occurrence 5
Flood Mapping Efforts 10
FEMA Repetitive Flood Claims Program 13
Repetitive Loss Properties 13
Local Plan Comparison 13
Severe Repetitive Loss Properties 16
Risk Assessment 19
Probability 19
Impact & Vulnerability 19
Risk 20
State Facility Risk 20
Critical Facility Risk 22
Comparison with Local Plan Critical Facility Risk 22
Jurisdictional Risk 23
Local Plan Risk Assessment 31
Comparison with Local Ranking 34
Local Plan Changes in Development 34
Storm Surge Description 35
Risk Assessment 38
State Facility Risk 41
Critical Facility Risk 44
Jurisdictional Risk 44
Local Plan Risk Assessment 45
Comparison with Local Ranking 45
Changes in Development 45
Discrepancies between Storm Surge and Flood Insurance Rate Maps 46

TABLES, FIGURES AND GRAPHS

Table 3.7- 1: Historical Flood Events from 1862 through 2008. 6
Table 3.7- 2: Annual probability based on flood recurrence intervals. 10
Table 3.7- 3: NFIP insurance claims of over $1 million paid on RL. 14
Table 3.7- 4: NFIP insurance claims paid on severe SRL. 17

Table 3.7- 5: FEMA Special Flood Hazard Area designations and probabilities. 19
Table 3.7- 6: State facilities in FEMA flood zones. 21
Table 3.7- 7: State agencies in an AE floodway zone. 21
Table 3.7- 2: Critical facilities in FEMA flood zones. 22
Table 3.7- 9: Federal Insurance Administration (FIA) Depth-Damage data as used in the FEMA Benefit Cost Analysis (BCA) tools 24
Table 3.7- 10: Parameters for annualized loss calculations. Assumptions based on one story building without basement. 24
Table 3.7- 11: Jurisdictional annualized loss based on modeled floodplains and zonal parameters. 26
Table 3.7- 12: Comparison of local and statewide annualized loss. 32
Table 3.7- 13: Number and value of structures at risk due to flooding from local hazard mitigation plans. 33
Table 3.7- 14: SLOSH storm surge categories. 36
Table 3.7- 15: Selected Hurricane Evacuation Data (excerpt EOP Hurricane Plan) .39
Table 3.7- 16:: Cumulative total of number of state facilities and building value at risk by storm surge zone. 41
Table 3.7- 17: State facilities located within mapped storm surge categories. 42
Table 3.7- 18: Cumulative total of critical facilities located in mapped surge zones.44
Table 3.7-19: EMAP Analysis.....49

Figure 3.7- 1: Digital Flood Data Status 12
Figure 3.7- 2: Non-Mitigated Repetitive Loss Structures 15
Figure 3.7- 3: Severe Repetitive Loss Structures 18
Figure 3.7- 4: Flood Annualized Loss 29
Figure 3.7- 5: Flood Hazard Ranking Parameters and Risk Map 30
Figure 3.7- 6: Storm Surge Categories 37
Figure 3.7- 7: Comparison of FIRM and storm surge mapping (City of Virginia Beach) 47
Figure 3.7- 8: Comparison of FIRM and Storm surge mapping (Accomack County) 48

Graph 3.7- 1: Federal Insurance Administration (FIA) Depth-Damage data as shown in Table 3.7-9. 25

Section 3.7: Flooding

Description

Southwest Virginia, Flooding
2002
Source: Wade Collins, Technological Hazards Division, VDEM

A flood occurs when an area that is normally dry becomes inundated with water. Flooding may occur as an overflow of streams or rivers, an overflow of inland and tidal waters, mudflows, or due to the failure of engineered structures like dams or levees. Flooding can occur at any time of the year. Rapid snowmelt can cause flooding in the winter. Torrential rains from hurricanes, tropical systems, and seasonal rain patterns can cause flooding in the spring, summer and fall.

Flooding is typically characterized in terms of severity and frequency of occurrence. Small floods happen frequently, and large floods happen less frequently. A certain intensity of flood, as measured in terms of flood depth or inundated area, is typically described by its frequency of occurrence; for example, a “1%-annual chance flood”. As the name indicates, such a flood has a 1% probability of occurrence (or exceedance) in any given year. A 1% annual chance flood is interchangeably called the “100-year flood”, although the annual chance terminology is less misleading. For most regulatory and hazard identification purposes, the 1%-percent annual chance flood is a common baseline flood. The Federal Emergency Management Agency’s (FEMA) National Flood Insurance Program (NFIP) is aimed at producing and updating flood maps throughout the United States.

Flooding is one of the most common hazards that occur in the United States and in Virginia. During 35 years of federal disaster programs, 15 of the 23 major disasters in Virginia have been caused by floods (or hurricanes resulting in floods). Riverine and coastal flooding poses significant risk to Virginia. Virginia’s most urbanized areas are located in broad, flat coastal plains, prone to both coastal and riverine flooding. In the mountains of the western part of the state, most urban development occurs along the relatively flat river valleys, which are at risk for riverine flooding, and occasional flash flooding. Due to the prevalence of flood-prone areas throughout the state, flooding is Virginia’s most significant hazard.

Coastal Flood Hazards

Coastal flooding occurs when strong onshore winds push water from an ocean, bay or inlet onto the land. In addition, coastal areas experience flooding from overland flow, ponding and inadequate storm water drainage. Coastal flooding may arise from tropical cyclones (hurricanes and tropical storms) or Nor'easters (extratropical storms). In Virginia, the Tidewater region is particularly susceptible to coastal storms, and much of the Eastern Shore is less than 6 feet above mean sea level (MSL). The highest historical storm surge recorded at Norfolk was 8 feet above mean sea level during the 1933 hurricane.

Coastal Erosion Hazards

Although coastal erosion is a continual process, it is accelerated by flooding and storm-related wave action. Tidal surges cause continual small levels of erosion. When hurricanes produce large storm surges, tidal areas with insufficient protection (dunes, armoring, jetties) are impacted by major acceleration of erosion. Storm-induced erosion is rapid and can be the equivalent of decades of long-term erosion processes. Through loss of land and undercutting, infrastructure such as pipelines, piers, roadways, and other structures can be significantly damaged or destroyed.

The majority of the coastal communities considered erosion in their local hazard mitigation plans. Accomack-Northampton PDC ranked coastal erosion a high hazard; Northern Neck PDC and Middle Peninsula PDC as medium. Seven local plans considered this a low risk hazard while 17 plans did not address coastal erosion. The HIRA sub-committee decided that it would be best to limit the state-wide analysis to defining coastal erosion. Most of the coastal communities and agencies have done, and continue to do, detailed coastal analysis that is not within the scope of this plan.

Sea Level Rise

Sea level rise is a concern for coastal communities as sea level increases so does the impacts of coastal flooding and storm surge. "Just as water levels rise and fall, the earth's crust in many regions also moves up or down, adding or subtracting from the apparent sea level trend".[1] The Virginia Institute for Marine Sciences has indicated that in Virginia's lower Chesapeake Bay area, sea level rise averages 3.6 to 7.0 mm per year, which is equivalent to 1.18 to 2.3 feet per century. The correlation between sea level rise and storm surge has been documented as Hurricane Isabel produced a comparable storm surge to the more intense 1933 Chesapeake-Potomac Hurricane 70 years later.

[1]William and Mary Virginia Institute of Marine Science Initiative for Coastal Climate Change Research. Planning for Sea Level Rise and Coastal Flooding. http://www.vims.edu/research/units/programs/icccr/_docs/coastal_sea_level.pdf

Riverine Flood Hazards

Riverine flooding occurs primarily as a result of prolonged periods of heavy rainfall. Groundwater levels rise, and excess surface runoff flows into surface streams and rivers. The frequency and severity of these floods is modeled using statistical, hydrologic, and hydraulic models. Riverine flooding is prevalent throughout the state with 51,016 miles of free-flowing streams and rivers in the Commonwealth[2].

Flash Flooding Hazards

Flash flooding is a form of riverine flooding caused by heavy rainfall occurring in a short period of time. When such rainfall occurs at a time when the ground is already saturated from previous rain events, a higher fraction of the new rainfall will be converted directly to runoff. Urbanized and developed areas could experience an increase in flash flooding due to the increased impermeable surfaces. Flash flooding is particularly dangerous in steep mountain valleys or other confined areas where there is little floodplain storage to attenuate the flood wave. Areas prone to flash flooding are similar to the areas prone to other types of riverine flooding, although small streams and drainage ways not studied as part of the NFIP may experience noticeable effects from flash floods. Virginia partners with the National Weather Service and adjacent states to manage the Integrated Flood Observing and Warning System (IFLOWS), a wide area monitoring and communications network designed to improve local flash flood warnings. In Virginia, IFLOWS is installed in 35 jurisdictions in the western part of the state in the Blue Ridge Mountains and westward - from Lee County in southwestern Virginia to Warren County in the northwestern area of the state. There are a total of 282 rain sensors and 80 stream sensors scattered over this area that are maintained by VDEM. Also in these 35 jurisdictions is an IFLOWS communications system that utilizes VHF radio/microwave communications technology to carry a voice network. This network consists of the 35 localities, the Virginia Operations Center (VEOC), and the NWS offices in Virginia. Dual and party line service is available[3].

Tsunami Flooding Hazards

The National Weather Service (NWS) defines a tsunami, or seismic sea waves, as a series of traveling ocean waves of extremely long length generated by disturbance associated primarily with earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis. Tsunamis are typically considered a threat to the Pacific Coast but it should not be overlooked that they can occur in the Atlantic Ocean. These would most likely be caused by landslides or slumping near the continental shelf. Tsunami hazards are a very low

[2]Virginia Department of Environmental Quality (DEQ) 2008 305(b)/303(d) Water Quality Assessment Integrated Report, approved by EPA 12/18/2008
[3] VDEM Programs and Services, Integrated Flood Observing and Warning System. http://www.vdem.state.va.us/programs/iflows/index.cfm

probability event, but a very high impact event if they were to occur. The National Weather Service in Wakefield has been a part of a team that is developing criteria and policies for tsunami advisories and warnings along the US East Coast. The focus is on distant source and near shore tsunamis.

"Distant source" tsunami (e.g. Puerto Rican Trench earthquake, Canary Island event, etc.) would result in a Tsunami Advisory to be issued. These events would only constitute the need for immediate clearing of the beaches to be at a safe, elevate location. No large scale evacuation of coastal areas would be necessary. The advisory will not activate EAS, and therefore, communication of the advisory will be necessary for the beach clearing to take place in a timely fashion. If the tsunami observations indicate a wave of sufficient magnitude (8-10 feet or greater), the advisory would be upgraded to a warning. This would activate EAS, and potentially necessitate a larger scale evacuation of some near-shore areas. Ocean front hotels would still be considered adequate shelters, provided people are on the second floor or higher.

"Near shore" tsunami (e.g. slumping of the continental shelf) would result in the issuance of a Tsunami Warning, as time of arrival to the beach front would be one hour or less, and there would be no way of knowing the magnitude of the tsunami ahead of time.

Norfolk is currently a "TsunamiReady" community, certified by the National Weather Service (NWS) and in coordination with state emergency management agencies. The main purpose of this program is to increase public safety during tsunami emergencies. Only a handful of communities on the eastern seaboard have obtained this certification.

Historic Occurrence

Flooding occurs almost every year in almost every part of the state. Historical occurrences of flooding have been extensively recorded by local, state and federal agencies. Table 3.7-1 of significant flood events is based on available records from VDEM, National Weather Service, and local plan historical narratives. VDEM currently maintains a narrative inventory of historical weather events, including flooding and hurricanes on their website. Federally declared disasters related to flooding are available in Section 3.3 of this plan.

Table 3.7- 1: Historical Flood Events from 1862 through 2008.

Period of Occurrence	Description
February 22, 1862	The Clinch River crested at nearly 23 feet above gauge level at Cleveland. (Cumberland Plateau)
March, 1826	"Greatest known" flood on Clinch River in Tennessee and far Southwest Virginia (Cumberland Plateau PDC)
March 1867	A large flood was reported in the Town of Dungannon, but no specific records exist other than word of mouth. (Cumberland Plateau PDC)
September 1870	There was flooding in the Shenandoah River. A storm produced heavy rains causing 12 fatalities and washing away at least 23 buildings in Page and Clarke Counties. The town of Castleman's Ferry was completely wiped out and never rebuilt. (North Shenandoah RC)
May 1871	A massive flood caused the third floor of the Capitol building in Richmond to collapse, killing 60 people and causing injury to 250.
September 30, 1896	A period of heavy rainfall hit the Shenandoah region, especially affecting the City of Staunton. In Staunton, many homes and structures were swept away by floodwaters and three deaths occurred.
June 22, 1901	Far Southwest Virginia was affected as the Clinch River flooded due to storms in the headwater regions. The floods caused a great deal of damage and several deaths. (Cumberland Plateau)
March 1, 1902	As the Clinch River flooded, it caused landslides and washouts along railways running through the region. (Cumberland Plateau)
April 1905	Franklin County was affected. There were large floods that caused heavy damage to croplands and structures in the floodplains. (West Piedmont PDC).
April 27, 1905	Largest Flood on record recorded on the Banister River. (West Piedmont PDC).
August 1906	Highland County experienced extensive crop and property damage and one loss of life due to stream flooding after a prolonged wet period. (CSPDC)
June 14, 1907	The Clinch River reached 20 feet above gauge level and caused extensive crop damage (Cumberland Plateau)
January 29, 1918	Clinch River "Ice Tide". Major flooding occurred when a storm hit while the ground was covered with snow. (Cumberland Plateau)
May 12, 1924	Heavy rains over a period of several days caused the Shenandoah river to rise 34 feet in some locations, causing several boat rescues of stranded flood victims. Total damages to roads alone were over $500,000. (Northern Shenandoah)
August 23, 1933	Flooding occurred due to tidal surges in the Hampton Roads area, with surges of over 9 feet recorded in Portsmouth. (Chesapeake)
March 18-19, 1936	"The Great Spring Flood" The Potomac, Shenandoah, Rappahannock, James and York Rivers flooded. The months prior to the flood were marked with low temperatures and heavy snowfalls. Warmer temperatures and rainfall in March resulted in melting snow and rising rivers.
April 26-27, 1937	Heavy rains caused widespread flooding. Damages to roads and bridges approached half a million dollars and agricultural losses exceeded one million dollars

Period of Occurrence	Description
October 13, 1937	The largest flood on record in the City of Martinsville and Town of Bassett. Hundreds of homes in the county were inundated with floodwaters (West Piedmont PDC)
August 13-18, 1940	As a result of four rain events, the Blackwater River crested approximately 10 feet above flood stage. The Meherrin River crested 31.5 feet above flood stage in Emporia. (City of Franklin)
October 15-17, 1942	This flood is considered the worst river flood in Virginia. Damages to the Rappahannock neared $2.5 million and $4.5 million on the Potomac River. More than 1,300 people were left without homes in Albemarle, Spotsylvania, Stafford and Warren Counties. Transportation was disrupted for three days and severe damages and losses occurred to Virginia agriculture
August 18-20, 1955	"Diane" Heavy rains resulted in flash flooding along the Piedmont and in the Shenandoah Valley
January 30, 1957	Clinch River - The "highest known" flood in its time, this flood caused over $24,000 in damages in Russell County. (Cumberland Plateau PDC)
October 1957	A Nor'easter brought extremely high tides to the Town of Wachapreague on the Eastern Shore up to four feet above normal. (Eastern Shore PDC)
March 12, 1963	Clinch River - A major flood along the Clinch River forced over 100 families to evacuate their homes and washed away two bridges. Two homes were completely washed away by floodwaters. (Cumberland Plateau PDC).
August 20, 1969	Camille entered Virginia as a tropical depression, and had picked up enough moisture from the warm Gulf Stream that when she slowed over the Commonwealth, her thunderstorms "trained" for 12 hours. Nearly 31 inches of rain fell with devastating results. The ensuing flash flood and mudslide killed 153 people, mostly in Nelson County where 113 bridges washed out. Flooding cut off all communications between Richmond and the Shenandoah Valley. The City of Waynesboro on the South River saw eight feet of water downtown and Buena Vista had more than five feet. Damage was estimated at $113 million.
June 21, 1972	Remnants of Hurricane Agnes dropped heavy rains across the region. Sixteen inches of rain was recorded in Chantilly in Fairfax County, and both the Potomac and James rivers experienced flooding. The Richmond City water supply, sewage treatment, electric and gas plants were inundated. Only one of the five bridges crossing the James survived; the downtown section was closed for several days. More than 60 counties and 23 cities in the Commonwealth qualified for federal disaster relief. Sixteen people died in Virginia and damage was estimated at $222 million.
June 23, 1972	Flooding caused over $1 million in damages in the City of Danville. In the surrounding counties the damage was primarily agricultural. (West Piedmont PDC).
October 10, 1972	A storm produced up to 10 inches of rain in some locations causing the Shenandoah River to rise over 30 feet above flood stage in Northern Shenandoah. (North Shenandoah Valley RC)
November 1977	A flood along the Middle Fork Holston River caused over $8.6 Million in estimated damages in Smyth County. Many buildings had several feet of floodwaters in them. (Mt Rogers PDC)

Period of Occurrence	Description
November 4-7, 1985	"Election Day Flood" described earlier in the discussion on federally declared disasters (section 3.3).
September 7, 1987	Henry County. Severe flooding primarily in the Bassett, Stanleytown, Collinsville, and Fieldale areas. Approx. 500 residents were evacuated with over 150 housed in public shelters. The damage total $6.1 million with $4.6 million not covered by insurance. This estimate does not include damage to the 36 state roads in the county that suffered damage. (West Piedmont PDC).
June 6, 1992	A significant flood occurred in Giles County as the result of 6" of rainfall. (NRV)
June 1995	A period of sustained rainfall caused flash flooding and several landslides. In Madison County, 30 inches of rain were recorded over 16 hours. In other locations 25 inches of rain were recorded in a period as short as five hours. Flooding also occurred further to the southwest in Augusta County, which received 12 inches of rain in 11 hours, and in Glasgow, VA, where river flooding became a problem. (Central Shenandoah) In Albemarle County, over $2 million in damages were reported. (Thomas Jefferson PDC).
January 19-22, 1996	"The Great Melt Down" described earlier in the discussion on federally declared disasters (section 3.3).
September 5-6, 1996	Hurricane Fran caused all rivers in the central part of the state to experience major flooding, record level flooding occurred on the Dan River in South Boston, and on the Shenandoah River in Page County. Page County, Rockingham County, Warren County, and the City of Alexandria all experienced major flooding.
June 26, 1997	Frederick County. A strong downburst produced winds up to 100 mph, which uprooted many trees and damaged fifty structures (Northern Shenandoah Valley RC).
February 6, 1998	Much of the eastern portion of the state was affected by a slow moving Nor'easter. This storm caused severe coastal flooding in the Hampton Roads area and on the Eastern Shore. The causeway to Chincoteague Island was closed and the entire island was submerged under floodwaters. Several streets in Norfolk were closed due to over three feet of water, and at least one family in Gloucester County was rescued by rowboat. There were no reported injuries or fatalities, but damages were estimated at $75 million. (Eastern Shore HMP)
September 14 – 18, 1999	Hurricane Floyd described earlier in the discussion on federally declared disasters (section 3.3).
June 24, 2000	Several roads within the county were washed out as a result of flash flooding in Southampton County. (City of Franklin)
September 3, 2000	Fredericksburg - A flash flood hit the city after 2.2 inches of rain, which damaged the first floor of several homes and apartments. Also, vehicles became submerged in floodwaters causing several drivers to be rescued. (RADCO)
July 8, 2001	Thunderstorms in Tazewell County caused flash flooding, which resulted in an estimated $15 Million in damages.

Period of Occurrence	Description
March 17, 2002	Floods caused a state of emergency declaration for southwest Virginia. (Mt Rogers PDC).
April 17, 2002	Severe storms and flooding occurred in Smyth, Washington, and Wythe Counties. (Mt Rogers PDC).
July 25, 2002	A flash flood affected the Town of Pembroke (Giles County) causing $367,000 in damages and closing Route 460. (NRV PDC)
May 26, 2003	Heavy rains caused the flooding of at least three roads in Halifax County. One person was injured when the vehicle he was driving was swept away as the road gave way. (Southside PDC)
2003	Hurricane Isabel described earlier in the discussion on federally declared disasters (section 3.3).
2004	Tropical Depression Gaston described earlier in the discussion on federally declared disasters (section 3.3).
October 2006	A Nor'easter impacted the southeastern portion of the state causing minor flooding in the City of Chesapeake and the City of Hampton. The City of Franklin along the Blackwater River experienced their 2nd flood of record at 22.77 feet. This happened only 7 years after the city experienced their flood of record during Hurricane Floyd which crested at 26.27 feet, flood state is 12 feet.
June 16, 2006	Cameron Run in Fairfax County flooded, which resulted in 158 homes declared "uninhabitable" and $11 Million in estimated damages.
September 2006	Tropical Depression Ernesto described in the discussion of federally declared disasters (section 3.3).
May 2008	A strong low pressure system caused widespread flooding throughout the central portion of the state. Numerous roads were closed from the Northern Virginia area in the north to the City of Danville in the south. In Culpeper County, several people were evacuated from their homes due to the floods.

Flood Mapping Efforts

Due to enormous flood losses, in the latter half of the 20th century, the federal government made a shift in focus from flood "control" to flood "management". The goal of flood management is to prevent life loss, reduce flood damage and formulate effective plans for recovery and rehabilitation efforts. This transformation from flood control to flood management resulted in changes and improvements to federal policies. One of the major undertakings was to produce flood maps for the entire United States.

In 1968, the US Congress created the National Flood Insurance Program (NFIP). Their intent was to reduce future damage and to provide protection for property owners from potential losses through an insurance mechanism that allows a premium to be paid by those most in need of the protection. FEMA produced Flood Insurance Rate Maps (FIRMs) that show areas subject to flooding. The flood risk information presented on the FIRMs is based on historic, hydrologic, and hydraulic data, as well as open-space conditions, flood-control works, and development.

To prepare the flood maps, FEMA generally conducts engineering studies referred to as Flood Insurance Studies (FISs). Using the information gathered in these studies, FEMA engineers and cartographers delineate Special Flood Hazard Areas (SFHAs) on flood maps. SFHA are subject to inundation by a flood that has a 1-percent or greater chance of being equaled or exceeded in any given year. This type of flood is commonly referred to as the 100-year flood or base flood. A 100-year flood is not a flood that occurs every 100 years. In fact, the 100-year flood has a 26 percent chance of occurring during a 30 year period, the length of many mortgages. The 100-year flood is a regulatory standard used by Federal agencies and most state, to administer floodplain management programs. The 100-year flood is also used by the NFIP as the basis for insurance requirements nationwide. [4] The main recurrence intervals used on the FIRMS are shown below in Table 3.7-2.

Table 3.7- 2: Annual probability based on flood recurrence intervals.

Flood Recurrence Interval	Annual Chance of Occurrence
10 year	10.0%
50 year	2.0%
100 year	1.0%
500 year	0.2%

The FEMA Map Service Center website, http://store.msc.fema.gov/, provides access to currently available FEMA floodplain mapping. VDEM also maintains historical flood information in their library at http://www.vdem.state.va.us/library/ .

FEMA is currently wrapping up a 5-year map modernization program that updated and converted the paper Flood Insurance Rate Maps (FIRMs) into a digital format

[4] National Flood Insurance Program and www.fema.gov

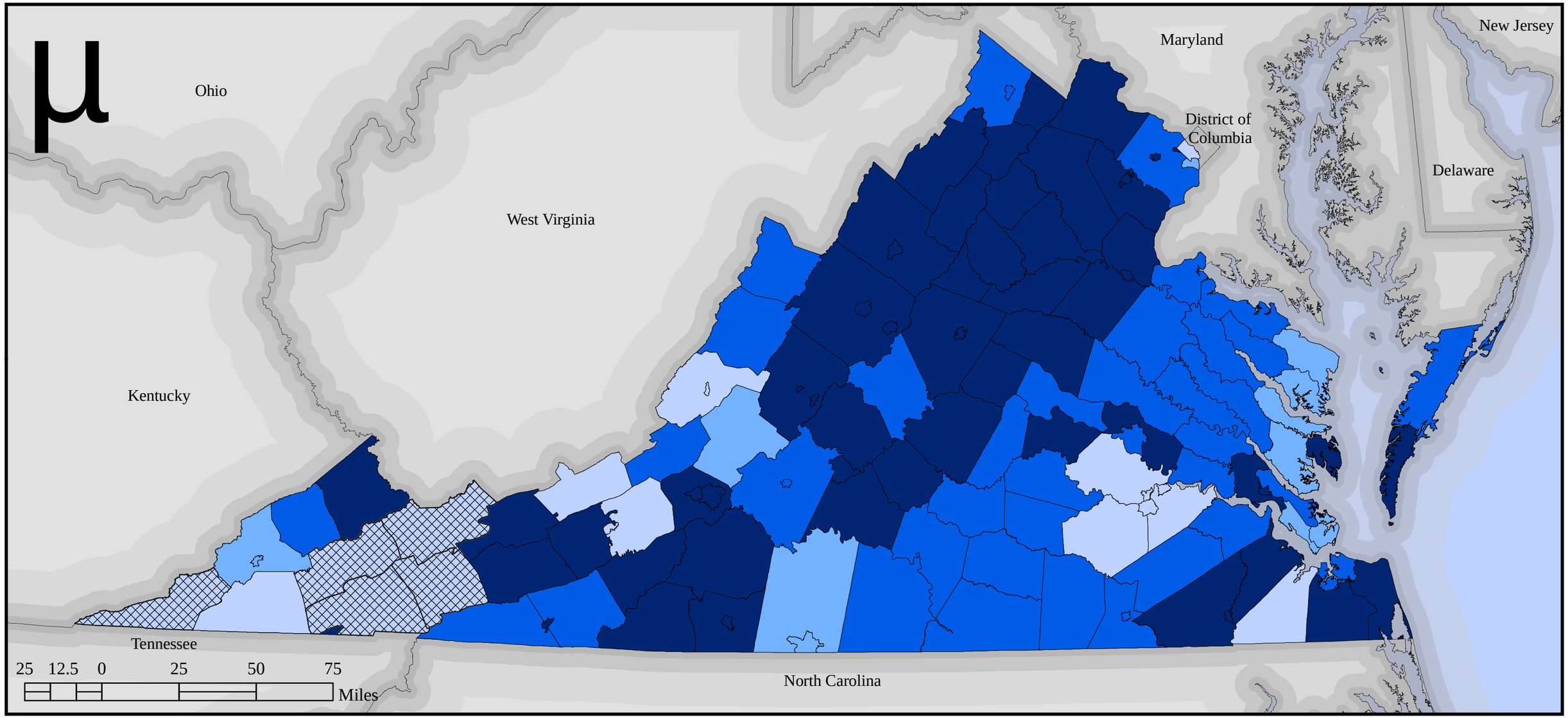
for mapping 90 percent of the Nation's highest-risk areas. FEMA Region III and the Virginia Department of Conservation and Recreation (DCR) are partners in the Map Modernization Program whose goal is to make Digital FIRMS available by 2009. The map modernization program also allows limited re-studies of flooding areas. It also facilitates centralization of all LOMAs and LOMRs for better identification of local flood risks, particularly due to increased development and modification of hydrology. The digital capabilities of flood maps will:

- Enable significant advantages in capability, precision, and cost
- Reduce costs associated with paper production, handling, and storage
- Encourage the use of quality local data to made administration of the NFIP more efficient and effective

Figure 3.7-1 shows the current status of DFIRMs in the Commonwealth. FEMA Region III has graciously allowed the use of preliminary DFIRM for this plan revision. This data is still considered preliminary and is not yet the governing maps for the locality until they have been approved and labeled as effective. For jurisdictions where the digital FIRMs were not available from FEMA this plan uses locally available digital versions of these maps. These are used to get a general sense of where flooding is for those locations. For local planning and flood enforcement, localities should always use the effective flood data from FEMA. Five jurisdictions did not have any digital form of the FIRM available for this analysis. For these communities a hazard ranking of "low" was used.

The next phase of map modernization is currently underway. This strategy has been named "Risk MAP" (Mapping, Assessment, and Planning) and will enable FEMA to improve, maintain, and expand the flood hazard identification while leveraging more benefits and community action from updated NFIP maps.

Figure 3.7-1: Digital Flood Data Status



DATA SOURCES:

FEMA FMPU DFIRM Status
VGIN Jurisdicational Boundaries
ESRI State Boundaries

PROJECTION: *VA Lambert Conformal Conic North American Datum 1983*

LEGEND:

Available Flood Data

- DFIRM (61 jurisdictions)
- PrelimDFIRM (41 jurisdictions)
- Q3 (13 jurisdictions)
- Digitized (14 jurisdictions)
- No Digital FIRMs Available (5 jurisdictions)

Status as of 01/31/2009

HAZARD IDENTIFICATION:

Digital Flood Data Status illistrates the best available data for each jurisdiction. FEMA Region III has provided preliminary data for 41 localities.

The preliminary maps are not final and are to be used for this hazard mitigation plan only.

DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

FEMA Repetitive Flood Claims Program

The Repetitive Flood Claims (RFC) grant program was authorized by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004 (P.L. 108–264), which amended the National Flood Insurance Act (NFIA) of 1968 (42 U.S.C. 4001, et al). Currently up to $10 million is available annually for FEMA to provide RFC funds to assist States and communities reduce flood damages to insured properties that have had one or more claims to the National Flood Insurance Program (NFIP).

Congress recognized that Severe Repetitive Loss (SRL) properties represent the greatest risk of sustaining repeated flood losses and, through the Flood Insurance Reform Act of 2004 (FIRA 2004), made it a top priority to reduce the number of SRL properties nationwide. As of March 2006, FEMA has identified approximately 8,300 properties nationwide that meet the standard for SRL; Virginia has approximately 92 SRL properties, 8 of which are in the process of being mitigated.

The strategy for reducing the number of SRL properties is twofold: First, the NFIP has centralized the processing of all flood insurance policies of SRL properties in order for FEMA to obtain additional underwriting information, verify loss information, and collect information about the flood risk to the SRL properties. Second, FEMA is implementing a new mitigation grant program authorized by FIRA 2004 to mitigate SRL properties.[5]

Repetitive Loss Properties

A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978.

Over $165 Million has been paid on non-mitigated repetitive loss properties in the Commonwealth through 7/1/2008. Figure 3.7-2 shows the approximate locations of the repetitive loss properties and total amount paid in insurance claims. Communities with over $1Million paid on repetitive loss properties are included in Table 3.7-3. Thirty-three jurisdictions in Virginia do not currently have repetitive loss properties.

Local Plan Comparison

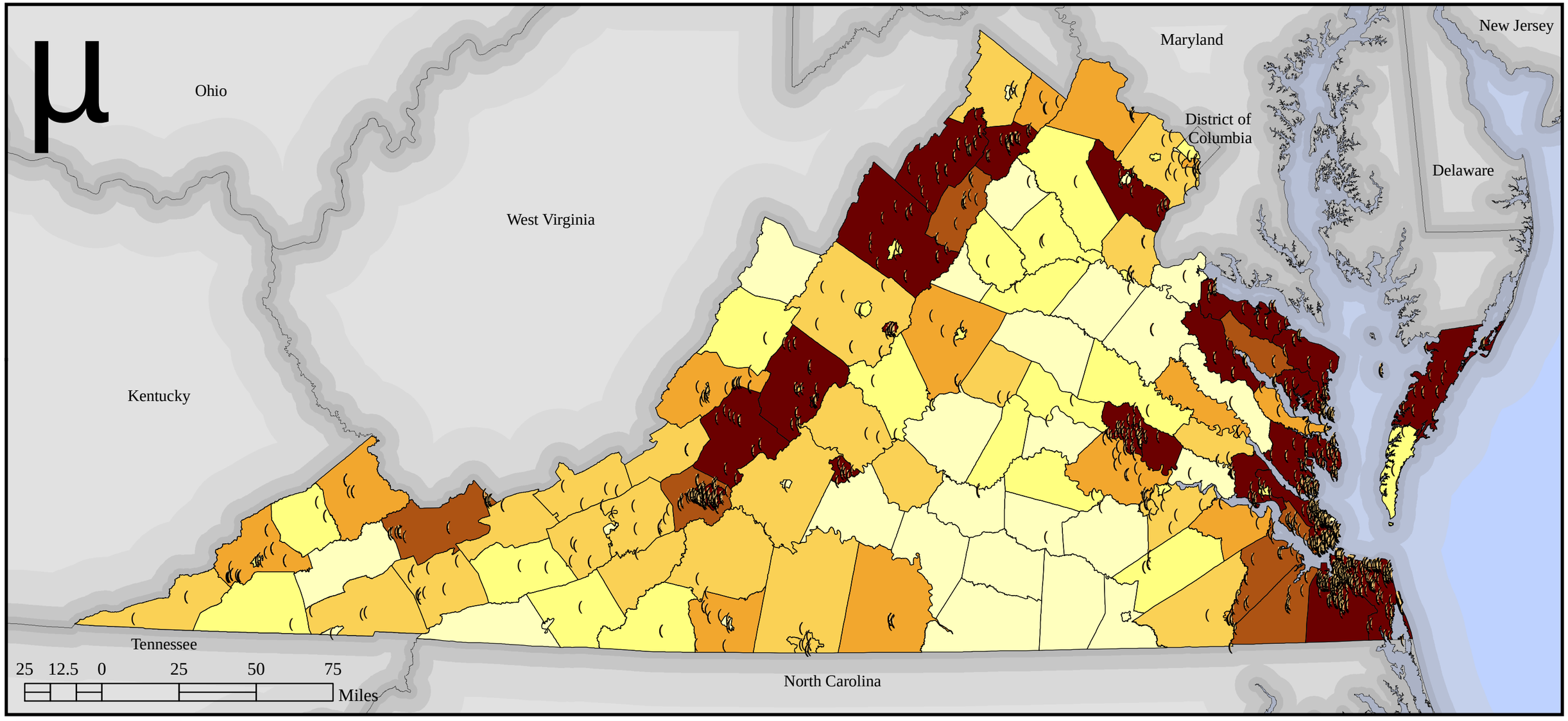
Twenty-four of the twenty-seven local plans discuss repetitive loss properties in their jurisdictions; of the remaining three plans, two (Lenowisco PDC and Cumberland Plateau PDC) discussed repetitive loss properties as mitigation action items. Southside PDC did not discuss repetitive loss properties in the current version of their plan.

[5] FEMA Severe Repetitive Loss Guidance for Severe Repetitive Loss Properties (http://www.fema.gov/pdf/nfip/manual200610/20srl.pdf 10/2006

Table 3.7- 3: NFIP insurance claims of over $1 million paid on RL.

Jurisdiction	Number of Properties	Total Paid
City of Salem	89	$14,220,535
City of Hampton	252	$11,241,082
City of Virginia Beach	316	$11,113,187
City of Norfolk	280	$10,466,634
City of Roanoke	88	$9,841,789
City of Richmond	72	$7,503,421
Mathews County	119	$6,491,486
City of Waynesboro	48	$4,933,183
City of Chesapeake	119	$4,887,152
Warren County	77	$4,860,064
Shenandoah County	47	$3,641,264
Northumberland County	60	$3,555,226
Lancaster County	61	$3,506,163
Gloucester County	59	$3,426,871
York County	221	$12,663,060
Westmoreland County	31	$3,321,821
Rockbridge County	35	$2,766,762
City of Portsmouth	59	$2,286,264
Essex County	32	$2,265,480
Botetourt County	36	$2,190,328
City of Lynchburg	18	$1,978,130
City of Buena Vista	30	$1,929,563
James City County	27	$1,839,330
Rockingham County	21	$1,650,991
Accomack County	40	$1,637,864
Prince William County	11	$1,580,536
Henrico County	21	$1,552,386
Tazewell County	38	$1,464,964
City of Newport News	35	$1,385,061
Roanoke County	32	$1,206,644
Richmond County	16	$1,198,494
Page County	22	$1,129,310
Isle of Wight County	19	$1,128,862
City of Suffolk	12	$1,109,333

Figure 3.7-2: Non-Mitigated Repetitive Loss Structures



Center for Geospatial Information Technology

VIRGINIA DEPARTMENT OF EMERGENCY MANAGEMENT

DATA SOURCES:

FEMA Region III Flood Claims
VGIN Jurisdicational Boundaries
ESRI State Boundaries

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

LEGEND:

RLS Total Loss Paid
- No Claims
- < $125,000
- $125,000 - $500,000
- $500,000 - $1M
- $1M - $1.5M
- > $1.5M

(RL Structures

Repetitive Loss Properties from 7/1/2008

HAZARD IDENTIFICATION:

A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978. A Severe Repetitive Loss (SRL) property has at least four NFIP claim payments over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or at least two separate claims payments with the cumulative amount exceeding the market value of the building.

Severe Repetitive Loss Properties

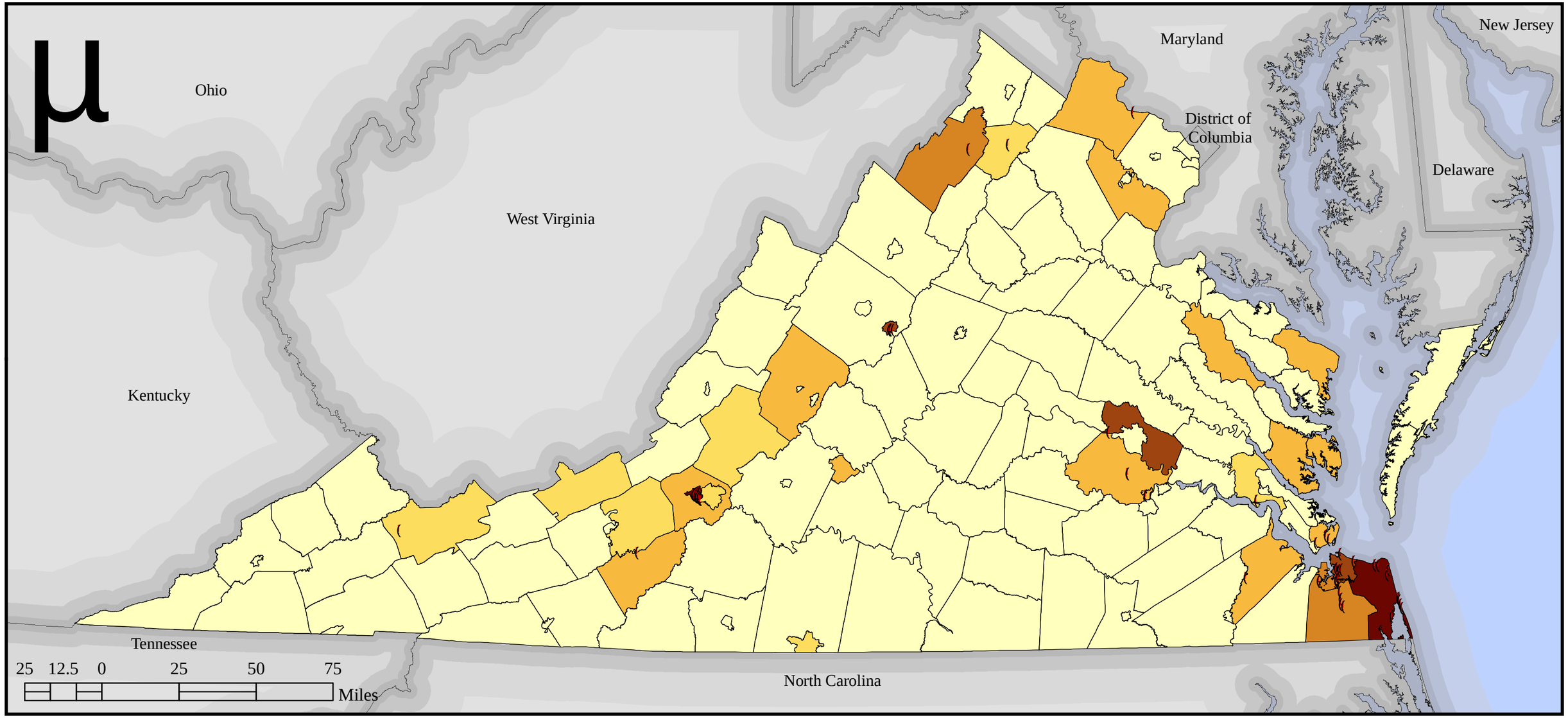
A Severe Repetitive Loss (SRL) property has at least four NFIP claim payments over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or at least two separate claims payments with the cumulative amount exceeding the market value of the building.

Over $18.9 Million has been paid on severe repetitive loss properties in thirty jurisdictions the Commonwealth through 4/30/2008. Figure 3.7-3 shows the approximate locations of the severe repetitive loss properties and total amount paid in insurance claims. Communities with any severe repetitive loss properties are included in Table 3.7-4.

Table 3.7- 4: NFIP insurance claims paid on severe SRL.

Jurisdiction	Number of Properties	Total Paid
City of Salem	21	$11,140,461
City of Virginia Beach	10	$1,093,498
Henrico County	5	$886,873
City of Norfolk	9	$772,953
City of Waynesboro	6	$632,344
City of Chesapeake	6	$412,068
Portsmouth City	4	$408,849
Shenandoah County	1	$273,300
City of Hampton	3	$249,635
Rockbridge County	1	$245,419
Chesterfield County	2	$237,683
Mathews County	1	$227,643
City of Colonial Heights	2	$217,912
Loudoun County	1	$207,983
Roanoke County	2	$207,049
Essex County	2	$194,520
Isle of Wight County	1	$192,520
Prince William County	2	$181,739
City of Lynchburg	1	$142,919
Northumberland County	1	$142,377
Floyd County	1	$137,622
Gloucester County	1	$134,919
Danville City	1	$89,761
James City County	1	$86,762
Giles County	1	$82,616
Roanoke City	1	$72,036
Montgomery County	1	$67,135
Botetourt County	1	$58,812
Tazewell County	1	$49,369
Warren County	1	$32,871

Figure 3.7-3: Severe Repetitive Loss Structures



DATA SOURCES:

FEMA Region III Flood Claims
VGIN Jurisdicational Boundaries
ESRI State Boundaries

LEGEND:

SRL Total Loss Paid

- No Claims
- < $100,000
- $100,000 - $250,000
- $250,000 - $500,000
- $500,000 - $1 Million
- > $1 Million

SRL Structures

Severe Repetitive Loss Properties from 4/30/2008

HAZARD IDENTIFICATION:

A Severe Repetitive Loss (SRL) property has at least four NFIP claim payments over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or at least two separate claims payments with the cumulative amount exceeding the market value of the building.

PROJECTION: *VA Lambert Conformal Conic North American Datum 1983*

DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

Risk Assessment

Probability

Flooding probability is in terms of designated zones on the FEMA Flood Insurance Maps (FIRMs). Table 3.7-5 below describes the different flood hazard areas and their associated probabilities.

Table 3.7- 5: FEMA Special Flood Hazard Area designations and probabilities.

Annual Probability of Flooding of 1% or greater	
A	Subject to 100-year flood. Base flood elevation undetermined.
AE or A1-A30	Both AE and A1-A30 represent areas subject to 100-year flood with base flood elevation determined.
AH	Subject to 100-year shallow flooding (usually areas of poundings) with average depth of 1-3 feet. Base flood elevation determined.
AO	Subject to 100-year shallow flooding (usually sheet flow on sloping terrain) with average depth of 1-3 feet. Base flood elevation undetermined.
V	Subject to 100-year flood and additional velocity hazard (wave action). Base flood elevation undetermined.
VE or V1-V30	Both VE and V1-V30 represent areas subject to 100-year flood and additional velocity hazard (wave action). Base flood elevation determined.
Annual Probability of Flooding of 0.2% to 1%	
B or X500	Both B and X500 represent areas between the limits of the 100-year and 500-year flood; or certain areas subject to 100-year flood with average depths less than 1 foot or where the contributing drainage area is less than 1 square mile; or areas protected by levees from the 100-year flood.
Annual Probability of Flooding of Less than 0.2%	
C or X	Both C and X represent areas outside the 500-year flood plain with less than 0.2% annual probability of flooding.
Annual Probability of Flooding of Less than 1%	
No SFHA	Areas outside a "Special Flood Hazard Area" (or 100-year flood plain). Can include areas inundated by 0.2% annual chance flooding; areas inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; areas protected by levees from 1% annual chance flooding; or areas outside the 1% and 0.2% annual chance floodplains.

Impact & Vulnerability

Populations and property are extremely vulnerable to flooding. Homes and business may suffer damage and be susceptible to collapse due to heavy flooding. Floodwaters can carry chemicals, sewage, and toxins from roads, factories, and farms; therefore any property affected by the flood may be contaminated with hazardous materials. Debris from vegetation and man-made structures may also be hazardous following the occurrence of a flood. In addition, floods may threaten water supplies and water quality, as well as initiate power outages.

Risk

For some activities and facilities, even a slight chance of flooding is too great a threat. Typical critical facilities include hospitals, fire stations, police stations, storage of critical records, and similar facilities. These facilities should be given special consideration when formulating regulatory alternatives and floodplain management plans. A critical facility should not be located in a floodplain if at all possible. If a critical facility must be located in a floodplain it should be provided a higher level of protection so that it can continue to function and provide services after the flood. Communities should develop emergency plans to continue to provide these services during the flood.

Under Executive Order 11988, Floodplain Management, Federal agencies funding and/or permitting critical facilities are required to avoid the 0.2% (500-year) floodplain or protect the facilities to the 0.2% chance flood level[6].

In order to assess risks due to flooding, this plan used the FEMA flood zones to intersect state and critical facility locations to determine what flood zone the structure is in. Jurisdictional risk has been calculated in terms of annualized loss using derivatives of the FEMA Benefit-Cost-Analysis (BCA) modules.

State Facility Risk

Spatially located state facilities (VAPs) were intersected with the available digital FIRMs in order to determine what facilities are at risk for flooding. If a building was located in more than one Special Flood Hazard Areas (SFHA) the percentage of each polygon was calculated; the flood zone with the highest percent area within the building was assigned as the dominate flood zone for that building location. Table 3.7-6 shows the results of this analysis.

As shown in Table 3.7-6, a very small number of state facilities are in FEMA designated SFHA. Approximately 8% of state facilities are in a mapped SFHA, with 4.6% in detailed study zones. A rough estimate of annualized damages for state facilities is $2,127,741; the 2003 HMP estimated an annualized loss of $1,894,882. The calculations used to come up with 2010 annualized loss values shown in Table 3.7-6 are further explained in the flood jurisdictional section.

[6] FEMA Critical Facility Definition, April 2007
http://www.fema.gov/plan/prevent/floodplain/nfipkeywords/critical_facility.shtm

Table 3.7- 6: State facilities in FEMA flood zones.

Flood Zones	Number of State Facilities	Building Value*	Annualized Loss*
AE Floodway	11	$633,439	$2,534
VE	27	$5,447,428	$21,790
AE	419	$852,875,865	$1,876,327
A/AO	200	$68,304,998	$95,627
500 Year	103	$469,513,263	$131,464
Total	**760**	**$1,396,774,993**	**$2,127,741**
**Building values for all facilities not available, based on values available from VAPS.*			

Ten state agencies have buildings that are located inside the AE floodway zone (Table 3.7-7) with a total of $633,439 in building value at risk, approximate annualized loss is $2,534. The Probation and Parole District #11 has one building located in the floodway that is valued at $388, 891 with an estimated $1,556 in flood 1oss per year. A majority of the state agencies located in the floodway did not have building value associated with them. Annualized loss due to flooding, as described in the jurisdictional risk section, is relatively low for state facilities. It should be noted that these values would increase with better detailed data for the structures (i.e. first floor elevations); the actuarial building value within the floodway could be significantly higher.

Table 3.7- 7: State agencies in an AE floodway zone.

Agency	Number of Buildings	Building Value*	Annualized Loss*
Probation and Parole District #11	1	$388,891	$1,556
Department of Forestry	1	$169,532	$678
Public Defender Commission	1	$75,016	$300
Department of Juvenile Justice	2	N/A	N/A
Department of Veterans Services	1	N/A	N/A
Department of Motor Vehicles	1	N/A	N/A
Department of Rehabilitative Service	1	N/A	N/A
Department of Social Services	1	N/A	N/A
Virginia Polytechnic Institute & State	1	N/A	N/A
Department of Alcoholic Beverage Control	1	N/A	N/A
Total	**11**	**$633,439**	**$2,534**
**Building values for all facilities not available, based on values available from VAPS.*			

Critical Facility Risk

Critical facility points were intersected with the FEMA FIRMs to determine what flood zone the facility was in. This simplified approach, as compared to the VAPS state facility analysis, is a result of having limited spatial and attribute data for critical facilities. Loss estimations were not calculated for critical facilities; with better location and attribute information this could be completed for state and critical facilities. Mitigation actions should address these data limitations.

As shown in Table 3.7-8, a limited number of critical facilities are in FEMA designated Special Flood Hazard Areas (SFHA). Approximately 4.3% of critical facilities are in a mapped SFHA, with 2.6% in detailed study zones. Schools have the highest number of facilities in the floodway. With schools being identified as potential shelters in many Emergency Operation plans, mitigation actions should be investigated to determine the best option for these facilities.

Table 3.7- 8: Critical facilities in FEMA flood zones.

Flood Zones	Law Enforcement	Fire Station	Hospital	Nursing Home	School	EOC	Total
AE Floodway	6	5	0	1	23	1	**36**
VE	0	0	0	0	1	0	**1**
AE	26	28	1	4	87	9	**155**
A	2	5	0	0	37	0	**44**
500 Year	19	11	5	5	42	1	**83**
Total	**53**	**49**	**6**	**10**	**190**	**11**	**319**

Comparison with Local Plan Critical Facility Risk

Twenty-two of the twenty-seven local plans provided some type of analysis on critical facilities located within the SFHA. A summary of these plans reveals that 512 critical facilities are located in a SFHA; this is 193 more facilities than what was determined in the statewide analysis. The analysis methods used in the local plans vary by locality and data available for analysis. Some used existing data from storm water management plans and floodplain management plans, visual inspection of structures in the floodplain, and others used GIS to intersect building information with FEMA FIRMs. Without a standardized analysis method the local plan results cannot be truthfully compared to each other or the statewide analysis.

As discussed in section 3.4, many of the local plans did not provide spatial data for their critical facilities. There is currently no standardized definition of what constitutes a critical facility, and the resolution of this issue should continue to be a mitigation action in this revision to ensure that future updates will be able to use standardized, locally created and maintained data.

Jurisdictional Risk

Overall jurisdictional flood risk was determined by intersecting floodplain mapping and demographic information. FEMA currently has a flood module for HAZUS that is both time and data intensive. A small test case was completed to determine the feasibility of using the flood module at the state level. It was determined that a statewide flood analysis using this package was outside of the scope for this revision. An alternative approach was thus created and compared to the test case results. The HAZUS annualized loss values were significantly higher than the alternative method that was developed. This was because the alternative method only calculated annualized loss for building / structural value, while HAZUS calculates damage to buildings and contents, economic loss (i.e. business interruptions), and social impacts. The alternative approach was accepted by the HIRA steering committee as a sufficient representation of flood loss based on the available data. The approach, as described below, uses census information, hazard information derived from HAZUS, Benefit Cost Analysis (BCA) tool kit documentation and FEMA flood zones.

To calculate annualized loss, a set of simplifying assumptions was necessary. This included determining the building value per unit area, and setting reasonable flood depths that would be used for calculating the percent building damage.

Total building value, or "exposure", in each census block was derived from the HAZUS census data geodatabase. Building value (in dollars) per unit area of the census block was calculated by dividing the total building value exposure by the census block area. The FEMA floodplains were intersected with the census blocks to determine the percentage in the different SFHA zones. The total building value exposure for each flood zone was calculated based on the area of special flood hazard areas (SFHA) in the census block.

To calculate annualized loss, certain probabilities and depths of flooding needed to be established. Table 3.7-9 and Graph 3.7-1 show the various building type scenarios that have been developed using Federal Insurance Administration (FIA) depth-damage data for the Benefit-Cost Analysis (BCA) toolkit[7]. Each building type would yield slightly different results; one story without basement seemed to be a moderate representation of building stock in Virginia for the general jurisdictional risk and annualized loss based on census block data. All buildings within mapped SFHA areas were assumed to be subject to 100-yr flooding. Table 3.7-10 shows the flood depth assumptions used for this analysis based on the severity of the flood. The building depth-damage function is the damage estimated to occur at each flood depth. Floodways and VE zones were assumed to have a flood depth of 6 feet to identify, by increasing the annualized loss values, areas that may have buildings in high risk zones.

The 2004 HMP used similar methods to approximate flood depth; the past version assumed historical, high-value buildings were at or above the 100-yr elevation, non-

[7] Benefit Cost Analysis (BCA) Toolkit Technical Flood Manuals. 2006.

historical structures built pre-FIRM were assume to have more damage than post-FIRM structures, and lower valued structures were also assumed to have more damage than higher value ones. The 2010 revision does not make these types of distinctions and results in a more liberal estimate of annualized flood damages. The driving factor in the new analysis is the type of flood zone that the census block intersects with, as discussed in the text that follows. Data exists, in some communities, to allow for more detailed loss estimation. This should be completed at the local level, where building-specific depths and losses can be calculated.

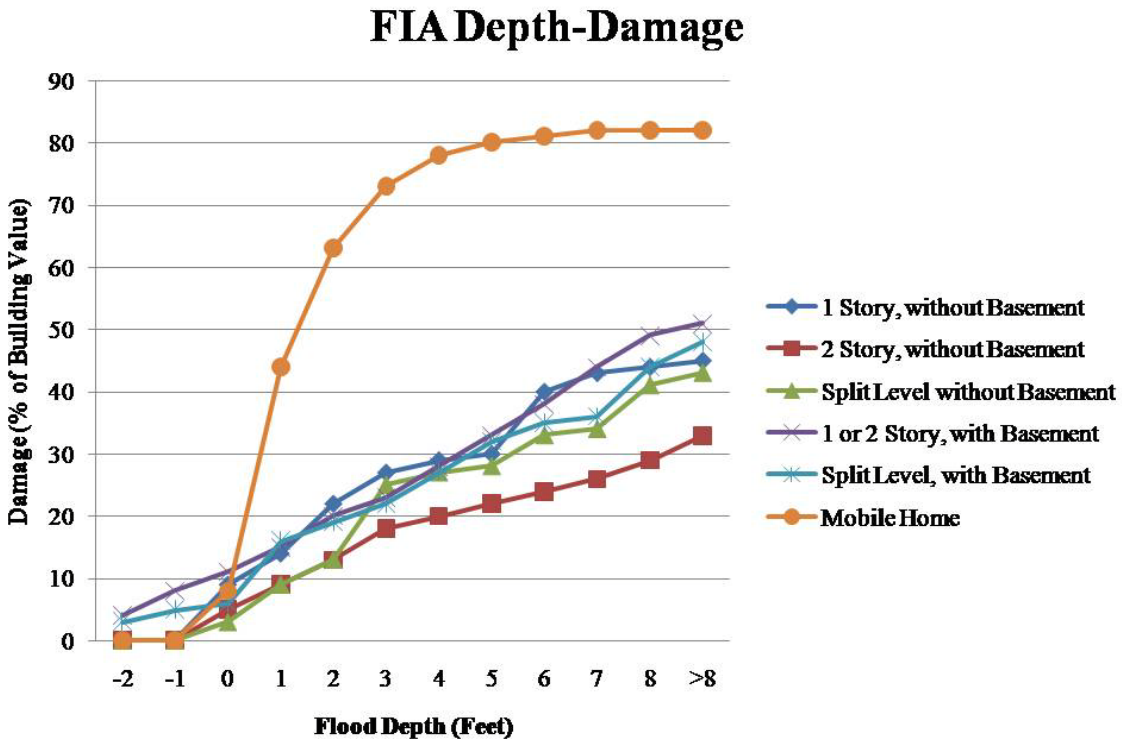
Table 3.7- 9: Federal Insurance Administration (FIA) Depth-Damage data as used in the FEMA Benefit Cost Analysis (BCA) tools

Building Type	**1 Story w/o Basement**	**2 Story w/o Basement**	**Split Level w/o Basement**	**1 or 2 Story w Basement**	**Split Level w Basement**	**Mobile Home**	**Other**
Flood Depth (ft)	Percent Damaged (% of Building Value)						
-2	0	0	0	4	3	0	0
-1	0	0	0	8	5	0	0
0	9	5	3	11	6	8	0
1	14	9	9	15	16	44	0
2	22	13	13	20	19	63	0
3	27	18	25	23	22	73	0
4	29	20	27	28	27	78	0
5	30	22	28	33	32	80	0
6	40	24	33	38	35	81	0
7	43	26	34	44	36	82	0
8	44	29	41	49	44	82	0
>8	45	33	43	51	48	82	0

Table 3.7- 10: Parameters for annualized loss calculations. Assumptions based on one story building without basement.

FEMA Flood Zone	**Flood Depth (feet)**	**Annual Probability**	**Percent Damaged**
Floodway, VE	6	0.0100	40%
AE	2	0.0100	22%
A, AO, AH	1	0.0100	14%
0.2 percent annual change	1	0.0020	14%

Graph 3.7- 1: Federal Insurance Administration (FIA) Depth-Damage data as shown in Table 3.7-9.



Once the depth, probability and building percent damaged were established, the annualized loss could be calculated at the census block level. The following equation was used to calculate annualized loss for each census block:

*Annualized Loss = Percent Damaged * Building $$ Exposure * Flood Probability*

The census block annualized loss was aggregated to a county level to produce jurisdictional-based annualized loss estimates. The Commonwealth is estimated to have **$78,791,612** in annualized damages based on the analysis described above. The five jurisdictions that did not have any digital form of the FIRM have not been included in this annualized loss value. Figure 3.7-4 show annualized loss by jurisdiction. Table 3.7-11 shows the annualized flood loss by jurisdiction. A high percentage of coastal communities have over one million dollars in annualized loss. The majority of the jurisdictions with over $500,000 in annualized loss have at least one non-mitigated repetitive loss or severe repetitive loss property. Appendix 3.7b provides a detailed account of the methodology and calculations used to derive the jurisdictional annualized loss for flooding.

Table 3.7- 11: Jurisdictional annualized loss based on modeled floodplains and zonal parameters.

Annualized Flood Loss Brackets			
> $1 Million per year			
City of Virginia Beach	$10,432,306	City of Portsmouth	$2,064,737
Fairfax County	$7,505,247	City of Alexandria	$1,997,414
City of Norfolk	$6,266,011	Accomack County	$1,828,762
City of Hampton	$4,788,589	City of Newport News	$1,730,994
City of Chesapeake	$3,584,407	Chesterfield County	$1,300,550
Prince William County	$3,069,348	City of Poquoson City	$1,180,467
Henrico County	$2,367,187	City of Roanoke	$1,164,685
Loudoun County	$2,157,842	York County	$1,158,671
$999,999 - $500,000 per year			
City of Salem	$944,057	James City County	$700,276
Stafford County	$885,944	Mathews County	$660,327
Hanover County	$861,990	Rockingham County	$649,432
Gloucester County	$861,004	Isle Of Wight County	$630,652
Roanoke County	$748,562	City of Winchester	$525,779
City of Richmond	$724,889	City of Suffolk	$524,330
Albemarle County	$703,537		
$499,999 - $250,000 per year			
Henry County	$486,415	City of Fredericksburg	$310,343
Fauquier County	$469,829	Arlington County	$308,235
City of Waynesboro	$427,009	Lancaster County	$306,709
Pulaski County	$426,453	Northampton County	$303,834
City of Fairfax	$420,031	Franklin County	$300,600
Bedford County	$398,956	Northumberland County	$298,539
City of Harrisonburg	$382,467	Middlesex County	$298,448
City of Lynchburg	$373,153	City of Danville	$292,023
Warren County	$372,786	Halifax County	$289,735
Spotsylvania County	$351,291	City of Staunton	$289,435
Augusta County	$348,335	Frederick County	$281,183
Wise County	$332,765	City of Bristol	$277,791
Montgomery County	$321,254	Southampton County	$276,474
Shenandoah County	$318,659		
$249,999 - $100,000 per year			
City of Charlottesville	$247,880	City of Petersburg	$161,405
Campbell County	$227,465	Wythe County	$158,767
Rockbridge County	$221,366	King William County	$156,498
Pittsylvania County	$219,281	Clarke County	$140,328
City of Manassas	$212,413	Caroline County	$138,123
Prince George County	$209,959	New Kent County	$135,686

$249,999 - $100,000 per year - *Continued*			
Botetourt County	$205,010	Powhatan County	$128,799
Westmoreland County	$203,906	City of Covington	$123,725
Culpeper County	$194,717	Page County	$122,933
Prince Edward County	$190,153	City of Falls Church	$122,540
Essex County	$188,455	City of Radford	$121,585
City of Colonial Heights	$186,604	Nelson County	$120,733
Giles County	$180,804	King George County	$116,217
Buchanan County	$180,001	Amherst County	$114,002
Alleghany County	$177,551	City of Emporia	$113,580
Mecklenburg County	$173,990	Dickenson County	$112,855
Goochland County	$172,147	City of Hopewell	$106,376
City of Franklin	$167,568	Sussex County	$105,667

< $99,999 per year			
Scott County	$94,357	Orange County	$41,441
Louisa County	$81,678	City of Lexington City	$41,150
Patrick County	$81,343	Rappahannock County	$39,643
Dinwiddie County	$75,203	Charles City County	$36,064
Brunswick County	$61,790	Madison County	$33,904
City of Martinsville	$61,230	Appomattox County	$31,555
Bland County	$58,832	Carroll County	$30,537
Fluvanna County	$57,832	Bath County	$28,848
City of Bedford City	$57,649	Charlotte County	$28,383
City of Buena Vista	$57,522	Craig County	$28,376
Grayson County	$56,358	City of Galax City	$21,507
Cumberland County	$56,326	Greene County	$16,806
Richmond County	$53,409	Lunenburg County	$15,317
King And Queen County	$51,691	Highland County	$13,165
Amelia County	$48,680	Nottoway County	$11,961
Greensville County	$47,438	Floyd County	$9,344
Surry County	$47,363	Washington County	*Not Calculated*
City of Norton City	$45,824	Russell County	*Not Calculated*
Buckingham County	$44,122	Lee County	*Not Calculated*
City of Williamsburg	$43,100	Smyth County	*Not Calculated*
City of Manassas Park	$41,588	Tazewell County	*Not Calculated*

Annualized damages were also calculated based on NCDC crop and property damages; based on NCDC data, the Commonwealth can expect approximately **$47,576,580** in damages per year for flood related events. NCDC annualized damages have been calculated by taking the total damages per jurisdiction and dividing by the period of record. The difference between the jurisdictional risk method estimate and the NCDC estimate can be attributed to a number of factors. NCDC loss values are only based on reported past damages, regardless of if the structure is in a designated SFHA, for the time period of 1993 through 2008. The

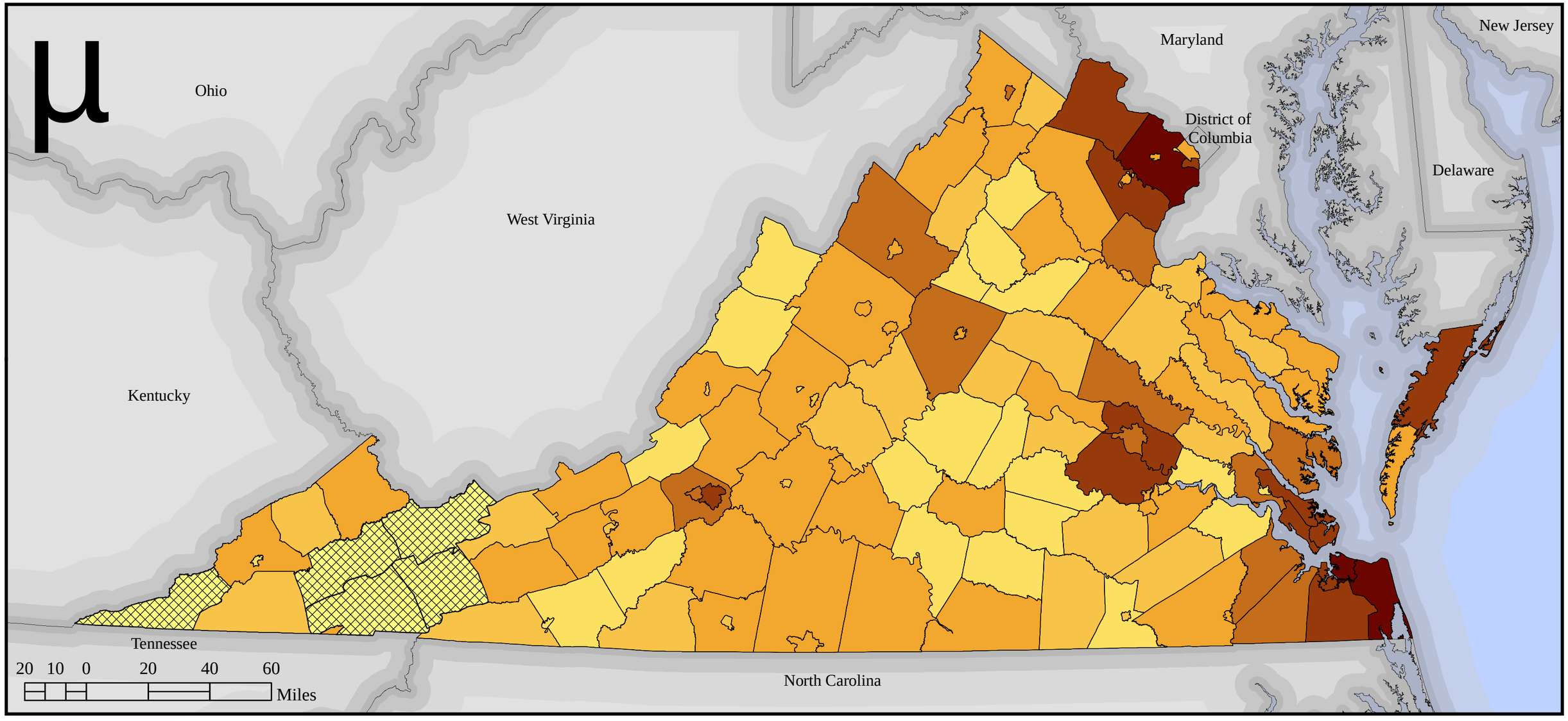
NCDC database cannot possibly track all instances of flooding, and there is some variability in the reporting. The jurisdictional risk method has its own imperfections: the lack of individualized, building-specific assessments of flood depth and building value. But, the jurisdictional risk method's estimate is more uniform and complete than the NCDC data, and is believed to be closer to the truth than the NCDC data, especially considering that HAZUS estimates would tend to be even higher.

Section 3.16 of this report compares flooding annualized loss and ranking to other hazards that impact Virginia. Flooding is considered one of the top hazards that impact all jurisdictions in the Commonwealth.

Geographic extent for flooding was determined as the percent of the jurisdiction in a FEMA SFHA zone. Flood zone probabilities were not taken into account in the current ranking algorithm. The geographic extent parameter is based on the percent of the jurisdiction in the SFHA; the Commonwealth does not currently have a complete floodplain data source available for a statewide analysis. Data for ranking has been annualized to be able to compare the results on a common system; this includes deaths and injuries, crop and property damage, and events. Annualized events are one way of using information on previous occurrences to predict future events, uniformly across the different hazards. The calculated annualized loss values in Table 3.7-11 were not used in the ranking for flood. The NCDC annualized crop and property damages were used to maintain consistency between the hazards. As discussed earlier, the NCDC annualized loss values are lower than what was calculated for the annualized loss. Section 3.5 of this chapter describes each of the parameters used in the ranking for each hazard. Figure 3.7-5 illustrates the parameters used for calculating risk due to flooding. The majority of jurisdictions have been ranked as high. This is not surprising as flooding (riverine, coastal and flash) is a major concern for most jurisdictions in the Commonwealth. Communities that have a high annualized loss also have been ranked high for overall flood risk, as seen by comparing Figure 3.7-4 and Figure 3.7-5.

A previous version of this plan suggested including RL and/or SRL data as a special weighting factor in the ranking methodology. This plan does not do this, for two reasons. First, the jurisdictional flood analysis used in this plan, based on FEMA mapping and U.S. Census demographics, is a uniform methodology that already accounts for the proximity of building values to mapped floodplains. Second, it is believed that some of the RL and/or SRL properties may be experiencing flooding resulting from low-frequency events, improper drainage engineering, and/or egregiously poor building practices. While these problems are important, they are highly local, and should be addressed at that level. The statewide jurisdictional risk assessment is intended to measure relative risks at a broader scale that can be compared equally, regardless of the level of RL or SRL reporting in each jurisdiction.

Figure 3.7-4: Flood Annualized Loss



DATA SOURCES:

CGIT Flood Analysis
VGIN Jurisdicational Boundaries
ESRI State Boundaries

PROJECTION: *VA Lambert Conformal Conic North American Datum 1983*

LEGEND:

Annualized Loss by County

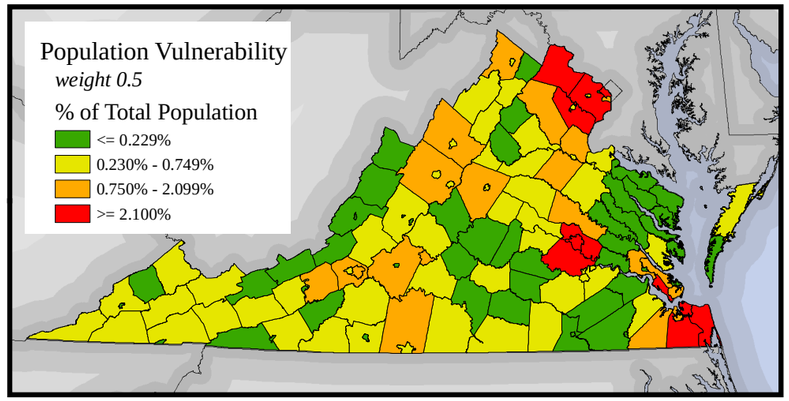
- No Digital FIRMs Available
- < $50,000
- $50,000 - $150,000
- $150,000 - $500,000
- $500,000 - $1 Million
- $1 Million - $5 Million
- > $5 Million

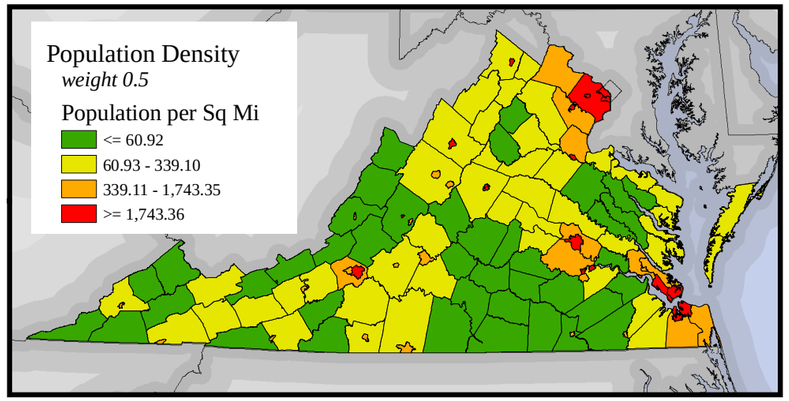
RISK ASSESSMENT:

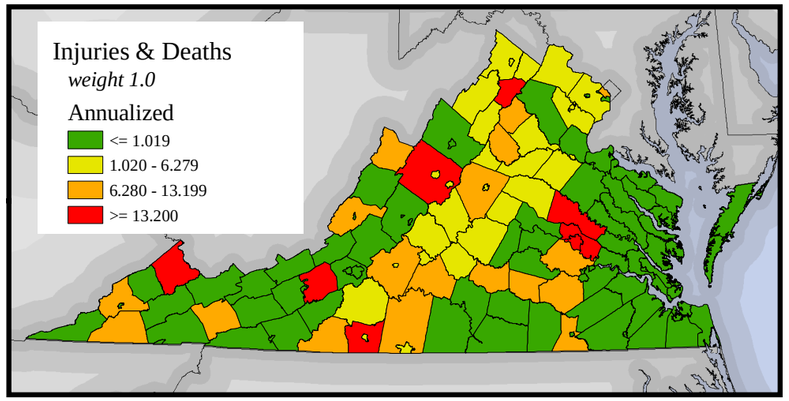
The total building value exposure for each flood zone was calculated based on the area of special flood hazard areas in the census block. Flood depths assumed based on the severity of the flood. The percentage of damage using flood depth was obtained from FIA Depth-Damage curves for riverine flooding using a 1-story building no basement.

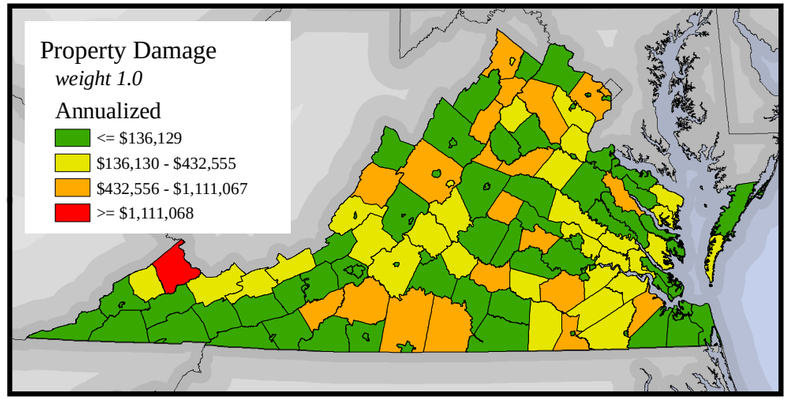
DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

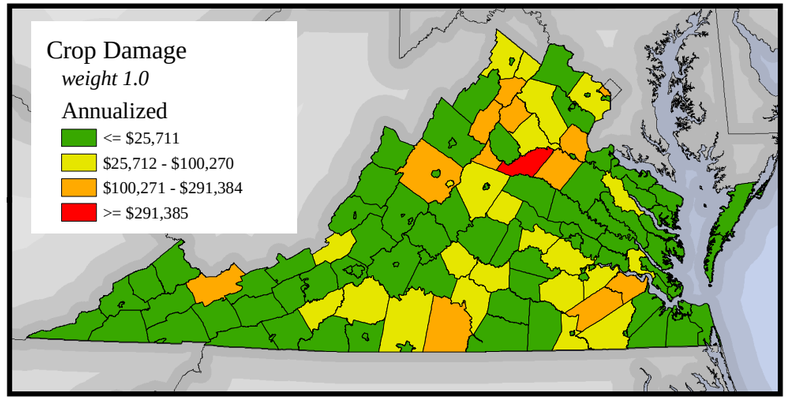
Figure 3.7-5: Flood Hazard Ranking Parameters and Risk Map

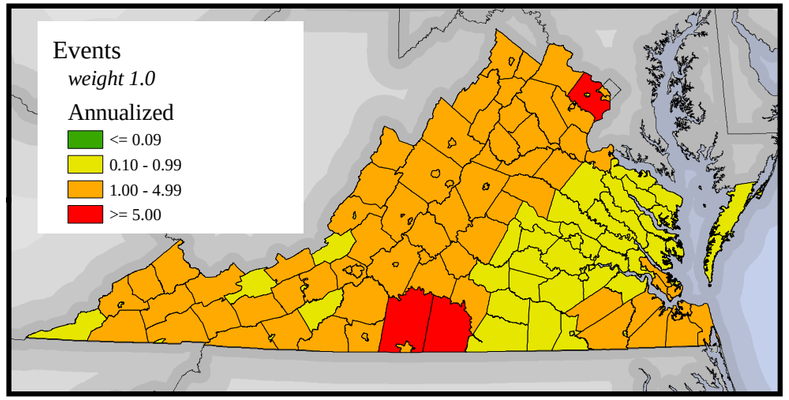


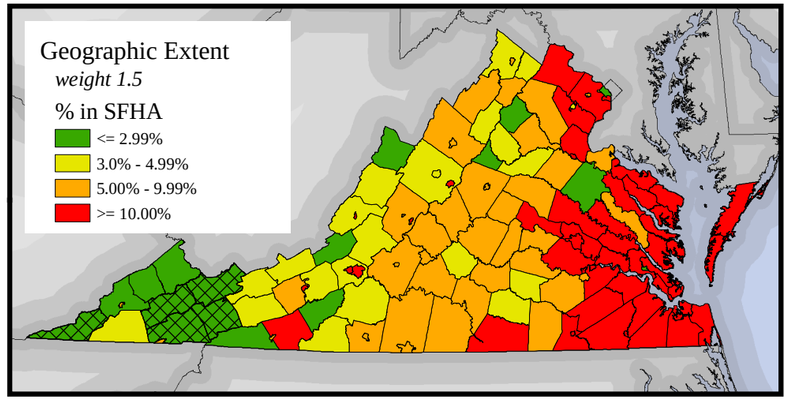


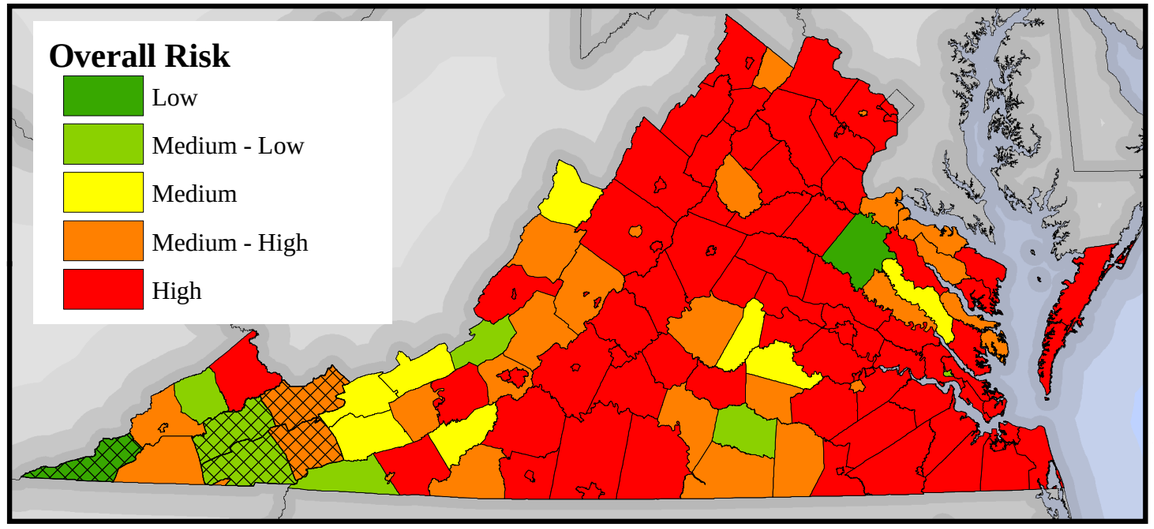












*No Digital FIRM Available

PROJECTION: *VA Lambert Conformal Conic*
North American Datum 1983

DISCLAIMER: Majority of available hazard data is intended to be used at national or regional scales. The purpose of the data sets are to give general indication of areas that may be susceptible to hazards. In order to identify potential risk in the Commonwealth available data has been used beyond the original intent.

HAZARD RANKING:

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 come up with the overall total ranking for each hazard.
Some factors were weighted based on imput from the HIRA sub-committee.
Section 3.5 explains each of the factors in detail.

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:

CGIT Ranking Methodology
VGIN Jurisdicational Boundaries
ESRI State Boundaries

Local Plan Risk Assessment

Each of the twenty-seven local plans were reviewed and summarized based on methodology and results for their flood analysis. Each plan varied based on the type of data available and analysis methodology. Techniques for assessing flood risk in the local plans included one or more of the following methods:

- FEMA HAZUS-MH
- NCDC statistics
- GIS intersections using FEMA FIRMs and Parcel/Census Data

Four plans utilized the FEMA HAZUS-MH module. All of these plans noted that they were a bit skeptical of the results. The Commonwealth RC, Virginia's Heartland noted "future plan updates should seek to reflect more realistic annualized flood losses for the county and its municipalities". Southside PDC also experienced similar results and decided to partially use HAZUS-MH and supplement with an additional method because "HAZUS estimations seem so very inaccurate".

The majority of the local plans performed some version of a GIS intersection with available building footprint, parcel, or Census data. Some percentage of the building value, or derivative of the BCA tools was used to determine flood damage. Of the plans that provided information, 107,418 structures were located within a SFHA with a value of $33.9 billion. It should be noted that some plans only considered the 100-year floodplain while others included the 500-year floodplain.

As discussed in section 3.6 and above, local plan hazard analysis and loss estimations vary considerably. Table 3.7-12 and Figure 3.6-1 (section 3.6) shows the summary of the local plans that provided annualized flood losses. None of the annualized loss values for the local plan are the same as the values calculated for this revision. For example, the City of Franklin was calculated as having an annualized loss of $167,568 in the statewide revision and as $8,687,000 in the local plan; a difference in these estimates of $8,519,432 should not be taken lightly. The City of Franklin's estimates were based on HAZUS losses including damages to structure value, contents and other (loss of function, etc.) while the statewide plan has developed a broad method to be able to calculate loss on the same scale for all the jurisdictions in the Commonwealth. The statewide methodology results in conservative annualized loss estimates.

Table 3.7- 12: Comparison of local and statewide annualized loss.

PDC/Jurisdiction	Annualized Flood Loss	
	Local Plan	2009 Statewide
Southside Hampton Road	$48,172,702*	$28,339,666
Northern Virginia RC	$3,912,000	$15,834,658
Central Shenandoah PDC	$3,681,938	$2,458,729
Crater PDC	$5,145,573	$2,354,144
Northern Shenandoah Valley RC	$4,137,773	$1,761,670
West Piedmont PDC	$4,635,928	$1,440,892
Region 2000 LGC	$2,194,531	$1,202,779
Northern Neck PDC	$2,838,730	$862,563
Rappahannock-Rapidan RC	$1,597,725	$779,534
Commonwealth RC (Virginia's Heartland)	$1,443,916 *	$346,262
Southampton County	$361,142*	$276,474
City of Franklin	$8,687,000*	$167,568

*HAZUS-MH Used for Analysis

It should be noted that no effort was made to determine differences due to data sources and loss calculations in the local plans. These factors can have a huge impact on how the results can be interpreted; this variation led to the decision to develop a statewide annualized loss calculation that has been fully described in the Jurisdictional Risk portion of this section.

Fifteen out of the twenty-seven plans (55%) did not include an annualized flood loss estimate. Five of these plans did provide total flood losses but were not annualized, these include:

Accomack-Northampton PDC
Amelia County
City of Chesapeake
Roanoke Valley-Allegheny RC
Southside PDC

Ten plans did not provide any form of loss estimation. These include:

Cumberland Plateau PDC
George Washington RC
Lenowisco PDC
Middle Peninsula PDC
Mount Rogers PDC
New River Valley PDC
Peninsula Group
City of Poquoson
Richmond Regional PDC
Thomas Jefferson PDC

Twenty plans provided an estimate of the number of structures located within the SFHA; twenty-three plans provided an estimate of the structure value at risk. Table 3.7-13 below provides a summary of the number and value of the structure at risk due to flooding from the local plan results. It should be noted that some plans only provided information for structures and facilities located within the 100-year floodplain while others provided information for all of the SFHAs. The total structure value at risk, from local plan analysis, was $33,924,245,435 accounting for

107,418 structures at risk. For comparison, the total building value exposure used for the statewide annualized loss estimate was $529,500,314,000. Approximately 92% of the total exposure is located within a SFHA.

Table 3.7- 13: Number and value of structures at risk due to flooding from local hazard mitigation plans.

Jurisdiction	Structures at Risk	Structure Value at Risk
Lenowisco PDC	5,427	$200,000,000
Cumberland Plateau PDC	6,045	$290,000,000
Mount Rogers PDC	1,352	$123,003,282
New River Valley PDC	781	$80,030,641
Roanoke Valley-Allegheny RC	1,964	NA
Central Shenandoah PDC	9,736	$1,149,173,500
Northern Shenandoah Valley RC	NA	$578,736,146
Northern Virginia RC	6,587	$1,963,566,900
Rappahannock-Rapidan RC	1,171	$178,226,500
Thomas Jefferson PDC	1,505	$188,858,478
Region 2000 LGC	NA	$346,443,566
West Piedmont PDC	NA	$705,503,260
Southside PDC	25	$89,457,000
Commonwealth RC (Virginia's Heartland)	NA	$144,391,800
Richmond Regional PDC	NA	$3,935,000,000
George Washington RC	2,226	$103,642,400
Northern Neck PDC	3,571	$465,807,800
Middle Peninsula PDC	6,414	$530,038,300
Crater PDC	NA	$1,391,781,710
Accomack-Northampton PDC	6,354	NA
Southside Hampton Roads	35,482	$11,032,679,686
Peninsula Planning Group	NA	$8,170,786,866
Amelia County	2	$199,900
Southampton County	1,326	NA
City of Chesapeake	13,328	$1,891,017,700
City of Franklin	1,281	NA
City of Poquoson	2,841	$365,900,000
Total	**107,418**	**$33,924,245,435**

The City of Franklin was the only local plan to include a break-down of loss estimates for structures, contents and loss of function.

Comparison with Local Ranking

Twenty-two out of the twenty-seven local and regional hazard mitigation plans ranked flood as a high hazard, four ranked as medium, and one as low (Amelia County).

The local plan ranking average for flood was high (section 3.6). The 2010 statewide analysis has ranked flood as high and is consistent with the local plans. Section 3.6 (Table 3.6-2) includes the complete ranking of all the local plans.

Local Plan Changes in Development

The majority of local plans did not specifically address changes in development for each hazard or the effects of changes in development on loss estimates. In most cases overall development patterns were discussed in general. Seventeen of the twenty-seven local plans cite their comprehensive plans for current and future land use changes (section 3.2). A few plans exclusively noted that they prohibit construction in the floodplain. Development in the floodplain would drastically increase loss estimates.

Storm Surge Description

Storm surge results from water being pushed towards the shore by approaching hurricane winds. Storm surge is the difference between the storm-induced water level and the normal water level. The storm surge is a large dome of water often 50-100 miles wide that sweeps across the coastline near where the hurricane makes landfall. The surge of high water topped by waves is devastating. The shallower the coastal water, the higher the surge. Depending on the configuration of the shore and ocean bottom, the storm surge may reach heights of eighteen feet or more above the normal (astronomical) tide level along Virginia's coast. Many factors are involved in the formation and degree of propagation of a storm surge. These include the intensity of the hurricane, its size, its forward speed, bottom conditions where the surge comes ashore, the position or angle of the hurricane's track as it crosses the coastline, and the physical configuration of the coastline where the surge comes ashore[8]. The threat of storm surge poses a large concern for the Commonwealth as there are many coastal areas, some of which contain high populations.

The Hurricane Emergency Response Plan states that storm surge is the most dangerous hazard that results from a hurricane; high winds and rainfall being the other hazards produced by a hurricane. Nine out of ten hurricane related deaths are attributed to storm surge. The flooding and non-rotational wind sections include information about high winds and rainfall related to hurricanes.

The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model is a tool, developed by the National Weather Service (NWS) that is used to evaluate the threat from storm surge. The model estimated storm surge heights and winds results from historical, hypothetical , or predicted hurricane by taking into account pressure, size, forward speed, track, and winds[9].

VDEM is coordinating the development of a statewide digital storm surge inundation zone dataset, with fields for jurisdictions and storm surge categories, as part of the 2008 Update to the Virginia Hurricane Evacuation Study (VHES). The zones for each jurisdiction were created from 2003-2008 by the US Army Corps of Engineers, and delivered to VDEM and each jurisdiction. While this dataset was originally created to support the 2008 update to the VHES, the dataset was also created to support hurricane planning activities throughout the Commonwealth of Virginia. Figure 3.7-6 shows the results of this effort. This dataset is critical to the planning process, and will be useful to entities involved in the hurricane planning process, especially those looking at the impacts of storm surge flooding at regional and statewide levels. The storm surge data was also used in this revision to identify state and critical facilities located in the 5 mapped surge zones. The surge zone categories and corresponding wind speeds are shown in Table 3.7-14 below.

[8] Commonwealth of Virginia Emergency Operations Plan, Hurricane Emergency Response Plan Volume 5. Appendix 1: Hurricane Hazards. June 2006.
[9] National Hurricane Center Hurricane Preparedness Slosh Model. http://www.nhc.noaa.gov/HAW2/english/surge/slosh.shtml

Communities represented in the SLOSH model include:

Accomack County
City of Alexandria
City of Arlington
City of Chesapeake
Fairfax County
Gloucester County
City of Hampton
Isle of Wight County
Lancaster County
Mathews County
Middlesex County
City of Newport News
City of Norfolk
Northampton County
City of Poquoson
Northumberland County
City of Portsmouth
Richmond County
City of Suffolk
Surry County
City of Virginia Beach
Westmoreland County
York County

Table 3.7- 14: SLOSH storm surge categories.

Storm Surge Categories	Wind Speed (mph)
0	Not Studied
1	74-95
2	96-110
3	111-130
4	131-155
5	>155

Risk Assessment

Infrastructure, such as transportation, has not been included in this analysis. However it should be noted that storm surge also has the ability to inundate coastal roadways and areas subject to tidal flooding hours before the eye of the hurricane makes landfall. This is one of the reasons evacuations should be completed prior to the arrival of the tropical storm force winds. The Hurricane Emergency Response Plan does include information about transportation infrastructure during hurricanes. In an effort to avoid replication this plan should be referenced for evacuation and planning efforts related to hurricanes.

Table 3.7-15 is an excerpt of Appendix 4: Selected Hurricane Evacuation Data from the Commonwealth of Virginia's Emergency Operations Plan Hurricane Emergency Response Plan. Data is from the 1992 Virginia Hurricane Evacuation Study. It is noted that this will be updated upon completion of the restudy that is ongoing at the time of the Hurricane Plan's revision in June 2006. The report also includes information on evacuation destinations, shelter requirements, et cetera.

Maximum surge heights vary based on jurisdiction and the modeled storm scenario. Gloucester, Northumberland and York Counties and the cities of Newport News, Norfolk, Portsmouth and Virginia Beach could expect to see greater than 15 feet surge heights for category 3 or 4 events.

Localities with 90 percent of their population that will evacuate for a category 3 or 4 event include:

Accomack County
Northampton County
City of Norfolk
City of Virginia Beach
City of Hampton
City of Newport News
Poquoson County

Localities with 75 percent of their population that will evacuate for a category 3 or 4 event include:

City of Chesapeake
City of Portsmouth
York County
Gloucester County
Mathews County

Analysis of state and critical facilities was based on the storm surge zones provided by VDEM. State and critical facilities were intersected with these zones to determine if and what zone the facilities were within.

Table 3.7- 15: Selected Hurricane Evacuation Data (excerpt EOP Hurricane Plan)

Jurisdiction	Saffir-Simpson Category	Storm Scenario	Maximum Surge Height (ft) Still Water Elevation	Vulnerable Population with Tourist Occupancy		
				Low	Medium	High
Accomack County	1-2	A	10.4 Wachapreague 19.8 Chincoteague	13,937	--	13,960
Accomack County	3-4	B	9.1 Wachapreague 18.9 Chincoteague	19,173	--	29,196
City of Chesapeake	1-2	A	3.8	--	--	6,858
City of Chesapeake	3	B	9.3	--	--	20,948
City of Chesapeake	4	C	15	--	--	48,408
Gloucester County	1-2	A	9.0 Glass (Severn R) 9.5 Yorktown	--	--	8,654
Gloucester County	3-4	B	16.2 Glass (Severn R) 15.5 Yorktown	--	--	10,670
City of Hampton	1-2	A	8.3 Grandview 9.1 Landley AFB	--	--	40,794
City of Hampton	3	B	11.6 Grandview 12.7 Landley AFB	--	--	44,508
City of Hampton	4	C	14.6 Grandview 15.8 Landley AFB	--	--	76,886
Lancaster County	1-4	A	9.7 Windmill Point 11.3 Corrotown 10.1 Mollusk	--	--	2,140
Mathews County	1-2	A	8.0 New Point Comfort 5.8 Diggs 5.3 Gwynn Island	--	--	2,922
Mathews County	3	B	11.1 New Point Comfort 8.5 Diggs 8.0 Gwynn Island	--	--	4,902
Mathews County	4	C	14.4 New Point Comfort 10.9 Diggs 10.4 Gwynn Island	--	--	6,326
Middlesex County	1-4	A	10.4 Gwynn Island 9.7 Windmill Point	--	--	1,212
City of Newport News	1-3	A	12.4 Newport News 8.9 Newport News Shipyard	--	--	8,890
City of Newport News	4	B	15.7 Newport News 11.5 Newport News	--	--	25,410
City of Norfolk	1-2	A	8.7 Little Creek Inlet 9.8 Willoughby Spit 8.0 Waterside	47,249	--	59,143
City of Norfolk	3	B	12.1 Little Creek Inlet 12.5 Willoughby Spit 12.3 Waterside	133,953	--	145,847
City of Norfolk	4	C	15.0 Little Creek Inlet 15.5 Willoughby Spit 15.0 Waterside	167,537	--	179,431

Jurisdiction	Saffir-Simpson Category	Storm Scenario	Maximum Surge Height (ft) Still Water Elevation	Vulnerable Population with Tourist Occupancy		
				Low	Medium	High
Northampton County	1-2	A	10.7 Capeville 10.9 Hog Island	--	--	2,460
Northampton County	3-4	B	20.1 Capeville 22.6 Hog Island	--	--	4,930
Northumberland County	1-4	A	10.7 Dividing Creek 9.6 Sandy Point 7.1 Smith Point 8.6 Yeocomico River	--	--	1,336
City of Poquoson	1	A	4.6	--	--	4,116
City of Poquoson	2-4	B	14.9	--	--	8,412
City of Portsmouth	1	A	4.3	--	--	500
City of Portsmouth	2-3	B	10.9	--	--	21,168
City of Portsmouth	4	C	15	--	--	60,238
Richmond County	1-4	A	10.1 Mollusk 10.7 Tappahannock	--	--	708
City of Suffolk	1-4	A	15.8	--	--	3,522
City of Virginia Beach	1-2	A	3.6 Back Bay 8.2 Sandbridge 8.2 Rudee Inlet 8.2 Lynnhaven Inlet	45,091	69,024	77,726
City of Virginia Beach	3	B	5.2 Back Bay 11.7 Sandbridge 11.4 Rudee Inlet 11.7 Lynnhaven Inlet	71,747	95,680	104,382
City of Virginia Beach	4	C	15.0 Back Bay 14.4 Sandbridge 14.4 Rudee Inlet 14.3 Lynnhaven Inlet	96,813	120,746	129,448
Westmoreland County	1-4	A	8.6 Yeocomico River 10.7 Colonial Beach 8.9 Coles Point	--	--	1,412
York County	2-4	A	13.5 Croaker Landing 15.6 Yorktown	--	--	12,182

State Facility Risk

Approximately 5% of the state facility locations are in one of the five surge zones. Table 3.7-16 shows the distribution of state facilities and building value by hurricane risk zone. It should be noted that the number of facilities and building value at risk can be viewed as cumulative as the storm surge zones increase above category 0; 584 facilities are located in a storm surge zone accounting for $1.27 trillion in building value at risk . About 6% of the total known building value for the state is located within a storm surge zone.

Table 3.7- 16: Cumulative total of number of state facilities and building value at risk by storm surge zone.

Storm Surge Zone	Number of Buildings	Building Value at Risk*
Category 0	12	$14,863,583
Category 1	59	$25,204,855
Category 2	244	$485,139,216
Category 3	473	$964,634,809
Category 4	584	$1,277,069,418
**Building values for all facilities not available, based on values available from VAPS.*		

The Jamestown-Yorktown Foundation has approximately 12 buildings, valued at over $14.8 million, located in storm surge category 0. Category 0 represents areas that were not studied during the creation of the inundation zone dataset.

Facilities located in storm surge category 1 and 2 have the greatest risk of being impacted, since category 1 and 2 hurricanes are more frequent than category 3 or 4 hurricanes, in Virginia. Table 3.7-17 shows the agencies located within category 1 through 4 events, these tables are not cumulative like in Table 3.7-14. The last two columns of this table show the total number of buildings and building value located in a mapped storm surge zone. There are approximately 584 state owned or operated buildings located within a storm surge zone, with a total building value at risk of over $1.2 billion.

It should be noted that the storm surge categories are cumulative in risk, for example a category 1 location would also be susceptible for the storm surge categories 2, 3, and 4+. Additional information on state facilities located within the storm surge categories can be found in the state facilities database.

Table 3.7- 17: State facilities located within mapped storm surge categories.

Agency	Category 0		Category 1		Category 2		Category 3		Category 4		Total Number of Buildings	Total Building Value*
	Number of Buildings	Building Value*	Number of Buildings	Building Value*	Number of Buildings	Building Value*	Number of Buildings	Building Value*	Number of Buildings	Building Value*		
Jamestown-Yorktown Foundation	12	$14,863,583									12	$14,863,583
Old Dominion University			2	$5,245,33	88	$376,043,18	36	$261,272,76	3	$17,550,320	129	$660,111,609
Virginia Institute of Marine Sciences			7	$1,588,52	22	$10,624,292					29	$12,212,813
Tidewater Community College			8	$1,320,37	6	$31,374,848	16	$64,308,861	13	$35,480,716	43	$132,484,796
Virginia Polytechnic Inst. & State University			2	$760,582	2	NA	1	NA			5	$760,582
Marine Resources Commission			2	$742,930			1	NA	1	$3,670	4	$746,600
Dept. of Game and Inland Fisheries			13	$488,533	4	$231,857			2	$2,820	19	$723,210
Public Defender Commission			1	$195,002	4	$225,272			1	$214,624	6	$634,898
Dept. of Alcoholic Beverage Control			5	NA	7	NA	9	$88,716	13	$286,887	34	$375,603
Dept. of Juvenile Justice			1	NA	2	NA					3	NA
Dept. of Social Services			1	NA	1	NA					2	NA
Dept. of Taxation			1	NA							1	NA
Norfolk Day Reporting Center			1	NA							1	NA
P & P Dist. 002			3	NA							3	NA
Norfolk State University					1	$30,659,998	2	$19,563,412	33	$167,810,330	36	$218,033,740
Dept. of Corrections: Employee Relations					1	$6,789,429					1	$6,789,429
Dept. of Health					8	$3,102,888	8	$1,307,158	5	$968,400	21	$5,378,446
Dept. of Conservation & Recreation					26	$865,894	53	$5,179,031			79	$6,044,925
Dept. of Transportation					1	$16,695	17	$2,513,378	17	$2,195,741	35	$4,725,814
Dept. of Motor Vehicles					3	NA	2	$2,242,800	3	$1,922,897	8	$4,165,697
Dept. of Rehabilitative Service					1	NA	2	NA	4	NA	7	NA
Dept. of Veterans Services					1	NA	1	NA			2	NA
Dept. of Environmental Quality					1	NA			1	NA	2	NA
Dept. for the Blind & Vision Impaired					1	NA					1	NA
Dept. of Agri. & Consumer Services					1	NA					1	NA
Dept. of Criminal Justice Services					1	NA					1	NA
Dept. of Fire Programs					1	NA					1	NA
P & P Dist. 003					1	NA					1	NA
P & P Dist. 030					1	NA					1	NA
St. Brides Correction Center							14	$43,045,939			14	$43,045,939
Dept. of Forensic Science							1	$33,594,000			1	$33,594,000
VA School F/T Deaf Blind & Multi-Disabled							15	$22,481,947			15	$22,481,947

Agency	Category 0		Category 1		Category 2		Category 3		Category 4		Total Number of Buildings	Total Building Value*
	Number of Buildings	Building Value*	Number of Buildings	Building Value*	Number of Buildings	Building Value*	Number of Buildings	Building Value*	Number of Buildings	Building Value*		
Indian Creek Correctional Facility							31	$21,004,136			31	$21,004,136
Virginia Employment Commission							2	$2,521,863	1	$727,885	3	$3,249,748
Environmental Service Unit							5	$371,584			5	$371,584
Thomas Nelson Community College							1	NA	9	$81,342,460	10	$81,342,460
Dept. of Military Affairs							4	NA	3	$3,927,859	7	$3,927,859
Court of Appeals of Virginia							1	NA	1	NA	2	NA
Dept. of Charitable Gaming							1	NA			1	NA
Dept. of Correctional Education							1	NA			1	NA
Dept. of Housing & Community Dev.							1	NA			1	NA
Dept. of Labor & Industry							1	NA			1	NA
Dept. of State Police							1	NA			1	NA
Office of the Attorney General							1	NA			1	NA
VA Workers Compensation Commission							1	NA			1	NA
VA Commonwealth University: Academic Div.									1	NA	1	NA
Total	**12**	**$14,863,583**	**47**	**$10,341,2**	**185**	**$459,934,36**	**229**	**$479,495,59**	**111**	**$312,434,609**	**584**	**$1,277,069,418**

** Building values for all facilities not available, in some cases this is an underrepresentation of the building value at risk. Building values are based on the VAPS database.*

Critical Facility Risk

Approximately 7% of the mapped critical facilities are located within a surge zone; with 38% of those facilities being located in a Category 3 zone. Schools account for two-thirds of the critical facilities in the surge zones. Table 3.7-18 below shows the distribution of critical facilities in the five surge zones. As with the state facilities, the number of critical facilities at risk can be viewed cumulatively as the storm surge zones increase above category zero. Approximately 429 facilities are within a storm surge risk zone; 135 of those facilities are located in storm surge zones that happen frequently in the Commonwealth (categories 0 through 2).

Table 3.7- 18: Cumulative total of critical facilities located in mapped surge zones.

Risk Zone	Law Enforcement	Fire Station	Hospital	Nursing Home	School	EOC	Total
Category 0	0	0	2	0	1	0	**3**
Category 1	4	11	2	0	14	1	**32**
Category 2	17	22	7	5	80	4	**135**
Category 3	36	30	11	15	200	5	**297**
Category 4	46	32	12	23	308	8	**429**

FEMA VE zones are coastal high hazard areas where wave action and/or high-velocity water can cause structural damage, there are areas were wave-heights could be three feet or greater. In comparing table 3.7-16 and 3.7-8 there seem to be discrepancies of the critical facilities in the VE zone. One would assume that the critical facilities the Category 1 storm surge zone (4-5 feet storm surge height) would also be in the VE zone. For example, the EOC located within the category 1 zone was investigated and it was determined that EOC was located in the AE zone, not a VE zone. The four EOCs and ten fire stations located in the category 3 and 4 storm surge zones were all located within flood zone X. Since the storm surge and FEMA FIRMs used different models to develop the datasets it is difficult to use the two in conjunction without knowing the recurrence interval for each of the storm surge categories.

The larger number of critical facilities in a storm surge zone (429), compared to a FEMA SFHA (319), may be a result of the differences in the mapping and return periods for the two hazards. The majority of communities have floodplain ordinances that prohibit building in or near the floodplain. The technological advances in storm surge modeling will hopefully be incorporated into the DFIRM map modernization efforts for coastal communities.

Jurisdictional Risk

Jurisdictional loss estimates were not calculated for this revision. The FEMA FIRMs were used to represent coastal flooding. Jurisdictional risk for flooding should be used as a conservative estimate for annualized loss in coastal communities.

Local Plan Risk Assessment

Southside Hampton Roads PDC was the only local plan to include an annualized loss estimate for damages related to storm surge. This was calculated using local property tax data and assuming that the worst case scenario storm surge event for a Category 3 hurricane occurs once every 150 years. Additional information about methodology was not documented in the plan. Annualized loss due to storm surge for Southside Hampton Roads PDC has been estimated at $206,624,689.

The City of Chesapeake's local plan has described storm surge and intersected critical facilities with a SLOSH model. The plan states that since the SLOSH model does not include surge depths loss estimates were not calculated.

It should be noted that further documentation and standardization is needed to assess the ability to group the local plan data together for use in the statewide plan. For example, in this region of the state plan the storm surge risk to infrastructure is analyzed cumulatively since properties in the Category 3 storm surge zone are also at risk for Category 1 and 2 events. As shown in the Southside Hampton Roads PDC the analysis was not done cumulatively. Data sources for the SLOSH model need to be documented to ensure that the same data is being used by the different localities.

Comparison with Local Ranking

Local hazard mitigation plans did not include a storm surge or coastal flooding category in their rankings. Broad categories of flooding, coastal erosion, and hurricane include, in some plans, the impacts due to coastal flooding or storm surge. The ambiguity in hazard naming conventions has resulted in slight differences in all of the local plans; this is discussed in detail in section 3.6 and 3.6 of this chapter.

Changes in Development

The majority of local plans did not specifically address changes in development for each hazard or the effects of changes in development on loss estimates. In most cases overall development patterns were discussed in general. Seventeen of the twenty-seven local plans cite their comprehensive plans for current and future land use changes (section 3.2). Development in the designated storm surge zones could increase loss estimates depending on the first floor elevations of the structures compared to the surge height; local zoning ordinances should be upheld.

Discrepancies between Storm Surge and Flood Insurance Rate Maps

As stated above, data sources that are used for the creation of FIRMs are often not the same data that are used to create storm surge zones (SLOSH model). This may be a result of different contractors or agencies performing the work, type(s) of data needed for the analysis, model inputs, age of data, or funding availability. It was thought that theses two sources could be compared in an effort to determine which populations of people are in mapped surge zones but are not in mapped FEMA floodplains. Comparing these in numeric form would most likely lead to false conclusions or a need to caution the reader about what this comparison would mean for mitigation purposes. Figures 3.7-7 and 3.7-8 highlight the differences in these two data sets.

In most cases, the FIRM flood zones cover areas similar to the category 1 and 2 storm surge zones. Special Flood Hazard Areas (SFHA) VE and coastal AE are areas inundated by the 100-year flood with velocity hazards (wave action). FEMA has over ten accepted coastal models that can be used to revise or create coastal flood hazard zones. Storm surge category 3 and 4 events appear to be outside of the mapped flood zones, or located within zone X. Category 3 and 4 hurricane events, as described in section 3.8 of this chapter, occur less frequently in Virginia as compared to category 1 and 2 events.

It should be noted that both types of data offer information about potential flooding in coastal communities and, when appropriate, should be used together for a complete picture of potential inundation regions.

Figure 3.7- 7: Comparison of FIRM and storm surge mapping (City of Virginia Beach)

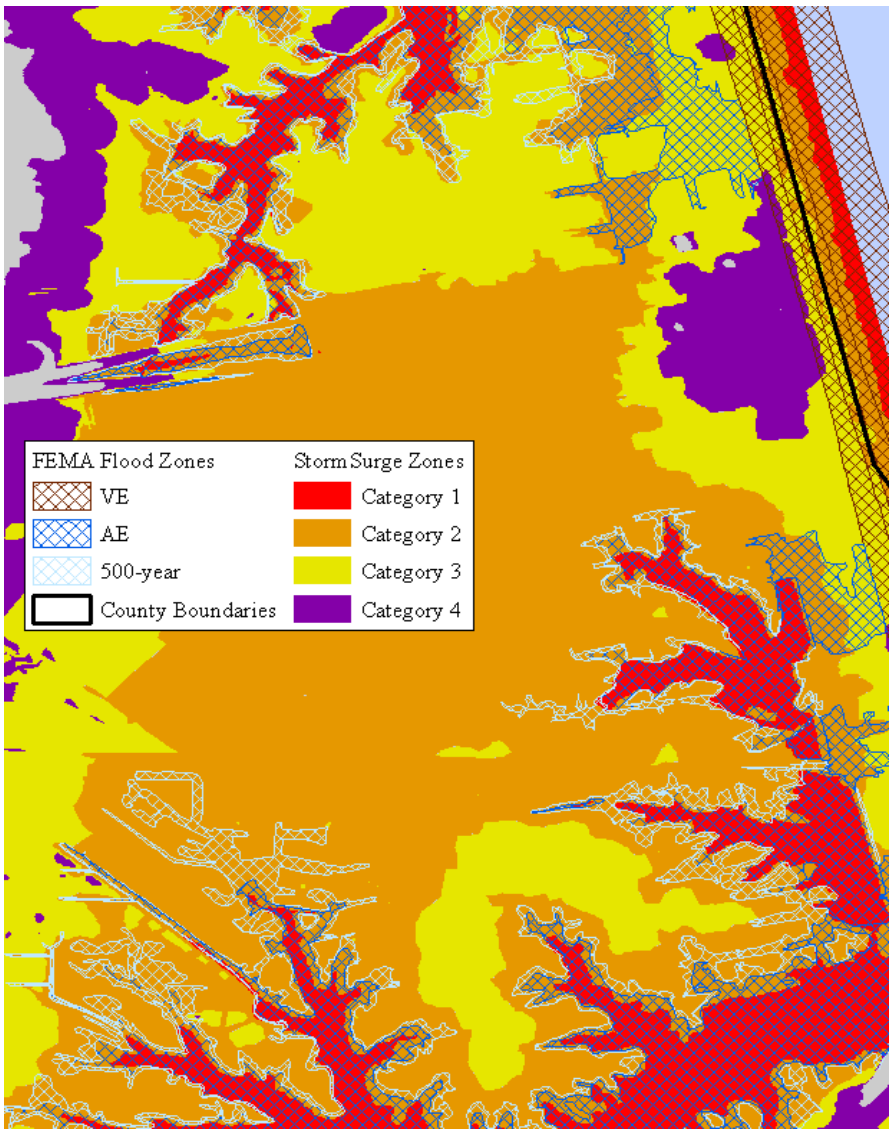


Figure 3.7- 8: Comparison of FIRM and Storm surge mapping (Accomack County)

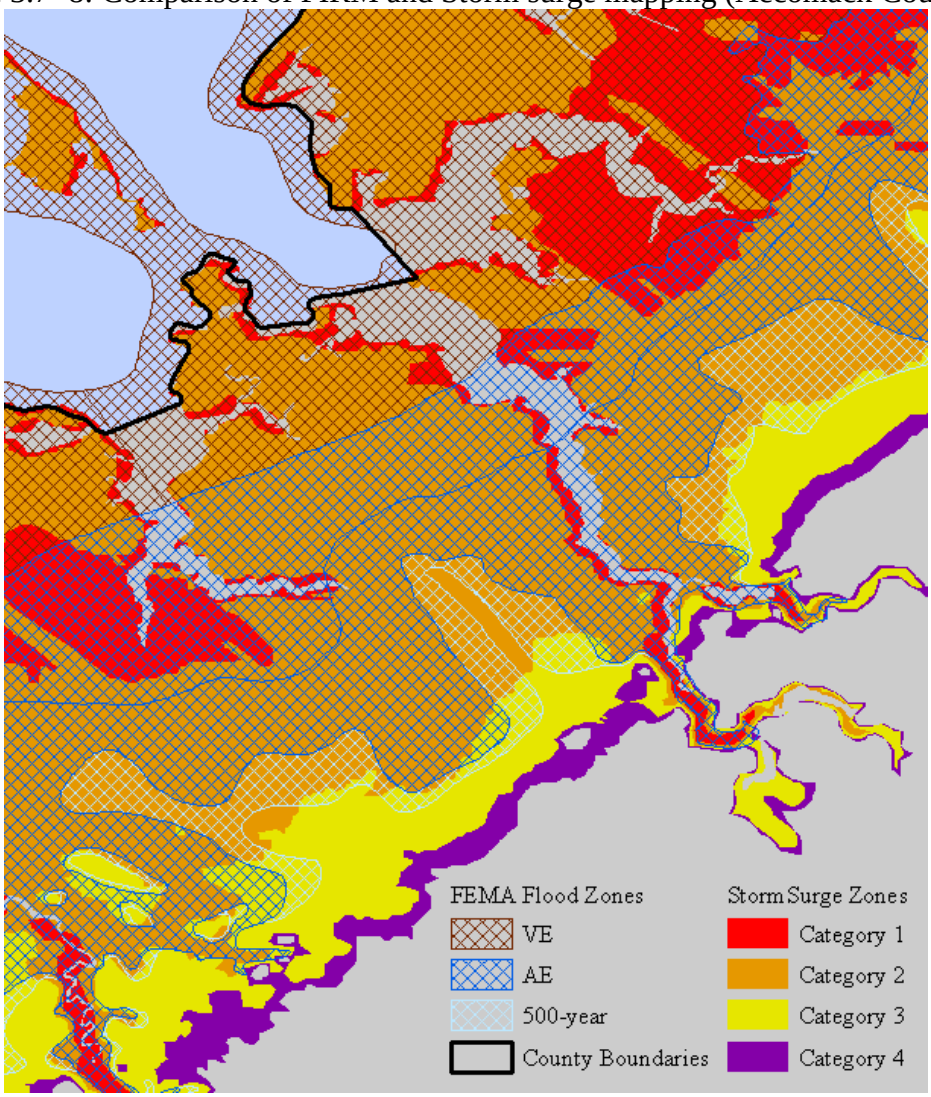


Table 3.7-19: EMAP Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impact expected to be severe to extensive for event areas and minor for other adversely affected areas.
Health and Safety of Response Personnel	Localized impacts expected to be limited unless the response personnel live within the impacted area, or the flood contains HAZMAT
Continuity of Operations	Damage to facilities/personnel in the area of the event may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Depending on the magnitude of the event, localized impact to facilities, residential properties, and infrastructure in the area of the event could be extensive.
Delivery of Services	Localized disruption of roads, facilities, communications and/or utilities caused by the event may postpone the delivery of some services.
The Environment	Localized impact expected to be severe for the event area due to erosion, crop damages, and HAZMAT and moderate to light damage to the outlying areas of the event.
Economic and Financial Condition	Local economy and finances adversely impacted, possibly for a prolonged period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery time is not sufficient. Local and state land development policies may be in question.

*****_Table was modeled from the Missouri State Hazard Mitigation Plan_