March 2023

Commonwealth of Virginia
Hazard Mitigation Plan

Executive Summary

The Commonwealth of Virginia Hazard Mitigation Plan provides guidance for hazard mitigation activities within the Commonwealth. This vision is supported by goals and actions that will reduce or prevent injury from natural hazards to residents, communities, state facilities, and critical facilities. The 2023 plan is an update from the 2018 plan.

Chapter 1 – Introduction describes the purpose of the hazard mitigation plan, lays out an overview of contents that must be included in the plan, discusses assurances and adoption and briefly discusses who coordinated this plan update.

<u>Planning Coordination Team</u>

VDEM Hazard Mitigation Planner
Old Dominion University's (ODU) Virginia Modeling and Simulation Center
ODU Institute for Coastal Adaptation & Resilience
University of Virginia's Center for Risk Management of Engineering Systems
Salter's Creek Consulting, Inc.
Moffatt and Nichol

Chapter 2 – Planning Process lays the foundation for developing an effective plan and maintaining, updating, integrating, and improving it. It also provides the basis for tracking and evaluating progress on the State's mitigation efforts. The planning process consisted of four phases and ten steps that were used to create the project scope and timeline.

Chapter 3 – Hazard Identification and Risk Assessment defines and analyzes the natural hazards that impact the Commonwealth. This section provides general background information, local data, and historical occurrences for each hazard. The hazards are listed below:

1. Drought
2. Earthquake
3. Erosion
4. Extreme Cold
5. Extreme Heat
6. Flooding
7. Hurricane
8. Impoundment Failure
9. Karst (Sinkholes)
10. Landslide
11. Land Subsidence
12. Non-Tornadic Wind
13. Pandemic
14. Tornado
15. Space Weather
16. Wildfire
17. Winter Weather

The individual hazard profile sections cover three requirements for the HIRA, which are identifying and profiling hazards, assessing vulnerabilities, and estimating potential losses. Each sub-section follows the same format throughout the plan, and includes background information, location and spatial extent, significant historical events, and probability of future occurrences. There are four sub-sections within probability of future occurrences: impact and vulnerability, risk, future conditions (including climate change discussion), and jurisdictional risk (including linkages to FEMA's Community Lifelines).

2023 Overall Hazard Ranking

High	Medium-High	Medium	Medium-Low	Low	Negligible
Flood Hurricane Winter Weather	Extreme Heat Non-Tornadic Wind Tornado	Drought Extreme Cold	Earthquake Pandemic Wildfire	Erosion Impoundment Failure Karst (Sinkholes) Landslide	Land Subsidence Space Weather

Chapter 4 – Capability Assessment is conducted to verify that the State's final mitigation strategy is based on the principles found in or missing from existing authorities, policies, programs, and resources, as well as the State's ability to expand and improve these existing tools.

Chapter 5 – Mitigation Strategy identifies and prioritizes proposed actions to reduce future risk to natural hazards. The mitigation vision is supported by four major goals and related objectives. This section also contains mitigation actions that contribute to reducing risk in the Commonwealth.

There are **74** total mitigation actions in this plan, **28** are new, **41** are retained with modification, **3** in progress, and **2** ongoing.

Chapter 6 – Local Plan Coordination provides details on funding for hazard mitigation plans, history of the plan development process, plan updates, and technical assistance provided by VDEM and other agencies involved in mitigation throughout the Commonwealth.

Chapter 7 – Enhanced Plan Requirements document current VDEM programmatic standards reflective of enhanced plan requirements. The enhanced pre-disaster planning efforts documented directly support state and local governments' efforts to articulate accurate, targeted, and prioritized needs for hazard mitigation that will reduce exposure to natural and human-caused hazards. These planning efforts will result in timely allocation of funding and more effective risk reduction strategies and projects.

Chapter 8 - Plan Maintenance and Implementation procedures help to ensure the plan is reviewed, revised, and updated as conditions and information change, and with input from stakeholders.

Appendices A-J contain supporting documentation that may not be essential for every reader or user of the plan. It is available for review but is not critical for use and implementation of the plan and program. Appendices were used to ensure the document was not overly cumbersome, but still supported all planning requirements

Contents

1.1 2023 Update

Each section of the plan has been revised and updated to reflect current conditions in the Commonwealth of Virginia. At the beginning of each section is a short summary of the changes made and the primary updates featured in that section as a result of the 2023 update. Section 1 was updated to provide information on the National Mitigation Framework, to refresh the contents overview, and to update the Virginia Department of Emergency Management (VDEM) Hazard Mitigation Planner.

1.2 Purpose of the State Hazard Mitigation Plan

The *Commonwealth of Virginia Hazard Mitigation Plan* provides guidance for hazard mitigation activities within the Commonwealth. The plan's vision is supported by goals, objectives and prioritized actions for Virginia that aim to reduce damages or injuries from natural hazards to residents, communities, state facilities, and critical facilities. The *Commonwealth of Virginia Hazard Mitigation Plan* has undergone a full review for this required 2023 update, and changes made for 2023 are summarized at the beginning of each main section to familiarize users with what content has changed.

The *Commonwealth of Virginia Hazard Mitigation Plan* was first issued as part of the *Commonwealth of Virginia Emergency Operations Plan* in July 2001 and was first approved by the Federal Emergency Management Agency (FEMA) Region III on September 28, 2004. The Commonwealth received approval of its enhanced plan status on March 14, 2007, a designation which recognizes a state's additional efforts to coordinate mitigation grant administration at the state level. The plan was updated again in 2010 and 2013; however, during the 2013 update the Commonwealth did not pursue enhanced plan status. The 2018 update documented additional FEMA enhanced plan requirements. While the Commonwealth of Virginia is not pursuing an enhanced plan status immediately upon completion of the 2023 plan, many of these elements are kept throughout the 2023 plan in an effort to make the pursuit of this status easier in the future.

This plan fulfills the standard state mitigation planning requirements of the Disaster Mitigation Act of 2000, found in Section 44, §201.4 of the Code of Federal Regulations (CFR). Commonly referred to as "DMA2K", Public Law 106-390 was signed into law October 10, 2000, and amends the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act. DMA2K reinforces the importance of mitigation planning, emphasizing planning for disasters before they occur. Section 322 of the act specifically addresses mitigation planning at state and local levels. DMA2K allowed Hazard Mitigation Grant Program (HMGP) funds to be used for mitigation activities and projects for states and localities with FEMA-approved hazard mitigation plans.

Local and state governments must develop and adopt hazard mitigation plans to remain eligible for federal disaster assistance and grant funds. These enhanced pre-disaster planning efforts at all levels of government are intended to support governments' efforts to articulate accurate, targeted, and prioritized needs for hazard mitigation that will reduce exposure to natural hazards and threats. This plan will assist in timely allocation of funding and more effective risk reduction strategies and projects at the local and state levels.

In addition to DMA2K, the National Mitigation Framework establishes a common platform and forum for coordinating and addressing how the Nation manages risk through mitigation capabilities. Mitigation reduces the impact of disasters by supporting protection and prevention activities, easing response, and speeding recovery to create better prepared and more resilient communities. This Framework describes mitigation roles across a whole community. The Framework addresses how the Nation will develop, employ, and coordinate core mitigation capabilities to reduce loss of life and property by lessening the impact of disasters. Building on a wealth of objective and evidence-based knowledge and community experience, the Framework seeks to increase risk awareness and leverage mitigation products, services, and assets across a whole community or, in this case, across a state.

National Mitigation Framework, Second Edition, June 2016, was published by the Department of Homeland Security (DHS) to further discuss seven core capabilities required for entities involved in mitigation: threats and hazards identification, risk and disaster resilience assessment, planning, community resilience, public information and warning, long-term vulnerability reduction, and operational coordination. The document focuses on creating a culture that embeds risk management and mitigation in all planning, decision making and development.

The operational work plan for this plan update considered the objectives of the National Mitigation Framework in many aspects of its design and implementation: building the committees across various agencies and levels of government and creating feedback opportunities; providing risk and vulnerability data early in the planning process; requesting capability update information from agencies to foster understanding of capability gaps early in the planning process; identifying best practices in other states and regions; and creating state mitigation actions that help create a culture of mitigation statewide based on input from a large variety of stakeholders.

1.3 Overview of Contents

Section 44 of CFR, §201.4(c), Plan content, identifies elements that must be included in a state hazard mitigation plan:

1) a description of the planning process used to develop the plan;
2) risk assessments that provide the factual basis for activities proposed in the strategy portion of the mitigation plan;
3) a mitigation strategy that provides the state's blueprint for reducing losses identified in the risk assessment;
4) a section describing coordination of local mitigation planning;
5) a plan maintenance process, including a method and schedule for monitoring, evaluating and revising the plan; a system for monitoring implementation of mitigation strategies and projects; and a system for reviewing progress in achieving goals, objectives and strategies as well as project implementation;
6) a plan adoption process for formal adoption by the State prior to submittal to FEMA for final review and approval; and
7) assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to grant funding periods, in compliance with 44 CFR §13.11(c). The state must amend its plan whenever needed to reflect changes in state or federal laws and statutes as required by 44 CFR §13.11(d).

Revisions to plans per FEMA guidance issued January 14, 2008, must also include a repetitive loss strategy for state eligibility for 90% federal funding for the Flood Mitigation Assistance (FMA) Program.

In fulfillment of the plan content requirements, this plan is laid out to include 8 sections and several supporting appendices. Section 2 describes the planning process, Section 3 is the risk assessment, Section 4 reviews the Commonwealth's mitigation capabilities, and Section 5 contains the mitigation strategy. Section 6 sets out local plan coordination mechanisms, Section 7 describes how the Commonwealth meets enhanced plan requirements, and Section 8 describes plan review, adoption, and implementation measures. All appendices are included in the Table of Contents and referenced within the text to provide data and documentation that support the plan sections.

1.4 Assurances & Adoption

This plan serves as the *Commonwealth of Virginia Hazard Mitigation Plan,* and is formally adopted by the Governor of Virginia. The Code of Virginia at §44-146.17 allows the Governor to appoint an Emergency Coordinator to carry out all provisions of the Code of Virginia related to emergency preparedness, response, and recovery. The Code of Virginia at §44-146.22 specifically authorizes the Governor to consider hazard mitigation measures to prevent or reduce the harmful consequences of disasters. The Governor is expected to make recommendations to the General Assembly, local governments, and appropriate public and private entities.

The 2023 plan supersedes all previous versions of the plan.

The Commonwealth of Virginia Department of Emergency Management, pledges that it will:

1) Comply with all applicable federal statutes and regulations in effect with respect to periods for which it receives grant funding, in compliance with 44 CFR §13.11(c); and
2) Amend this plan whenever necessary to reflect changes in state or federal laws and statutes as required in 44 §CFR 13.11(d).

1.5 State Hazard Mitigation Plan Coordinator

The VDEM State Hazard Mitigation Plan Coordinator oversees the plan update process, coordinates with other agency and committee representatives, reviews drafts, and administers contracts for assistance. For the 2023 update, the Old Dominion University's (ODU) Virginia Modeling and Simulation Center (VMASC) provided VDEM with project administration assistance under Memorandum of Understanding: PO 220337. Other members of the team included ODU Institute for Coastal Adaptation & Resilience (ODU-ICAR), University of Virginia's Center for Risk Management of Engineering Systems, Salter's Creek Consulting, Inc., and Moffatt & Nichol. The VDEM State Hazard Mitigation Plan Coordinator was:

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Contents

2.1 2023 Update

This section was substantially revised to provide a more comprehensive summary of the planning process. Background regarding key decisions during committee development, scheduling of meetings, and document review was added. Committee members and other details were updated to reflect the 2023 process. Meeting summaries were updated and expanded.

2.2 Overview of Mitigation Planning

Hazard mitigation planning involves the process of organizing available resources, identifying and assessing hazard risks, and determining how to minimize or manage those risks. This process results in a hazard mitigation plan that identifies specific actions designed to meet the goals established by those that participate in the planning process. To ensure the functionality of each mitigation action, responsibility is assigned to a specific department or agency along with a schedule for its implementation. Plan review procedures are established to help ensure that the plan is implemented, as well as evaluated and enhanced, as necessary. Developing clear plan review procedures helps ensure that the plan remains a current, dynamic, and effective planning document over time.

Participating in a hazard mitigation planning process can help officials and other stakeholders achieve the following results:

- save lives and property;
- save money;
- speed recovery following disasters;
- reduce future vulnerability and increase future resiliency through wise development and post-disaster recovery and reconstruction;
- enhance coordination within and across neighboring jurisdictions;
- expedite the receipt of pre-disaster and post-disaster grant funding; and
- demonstrate a firm commitment to improving community health and safety.

Mitigation planning is an important tool to produce long-term recurring benefits by breaking the repetitive cycle of disaster loss. A core assumption of hazard mitigation is that pre-disaster investments will significantly reduce the demand for post-disaster assistance by lessening the need for emergency response, repair, recovery, and reconstruction. Furthermore, mitigation practices will enable local residents, businesses, and industries to re-establish themselves in the wake of a disaster, getting the affected region's economy back on track sooner and with less interruption.

The benefits of mitigation planning go beyond reducing hazard vulnerability. Measures such as the acquisition or regulation of land in known hazard areas can help achieve multiple community goals, such as preserving open space, improving water quality, maintaining environmental health, and enhancing recreational opportunities. It is the intent of this document to help identify overlapping objectives and facilitate the sharing of resources to achieve multiple aims, and to include information wherever possible to demonstrate when the plan is or has been implemented through other planning mechanisms.

2.3 Preparing the Plan

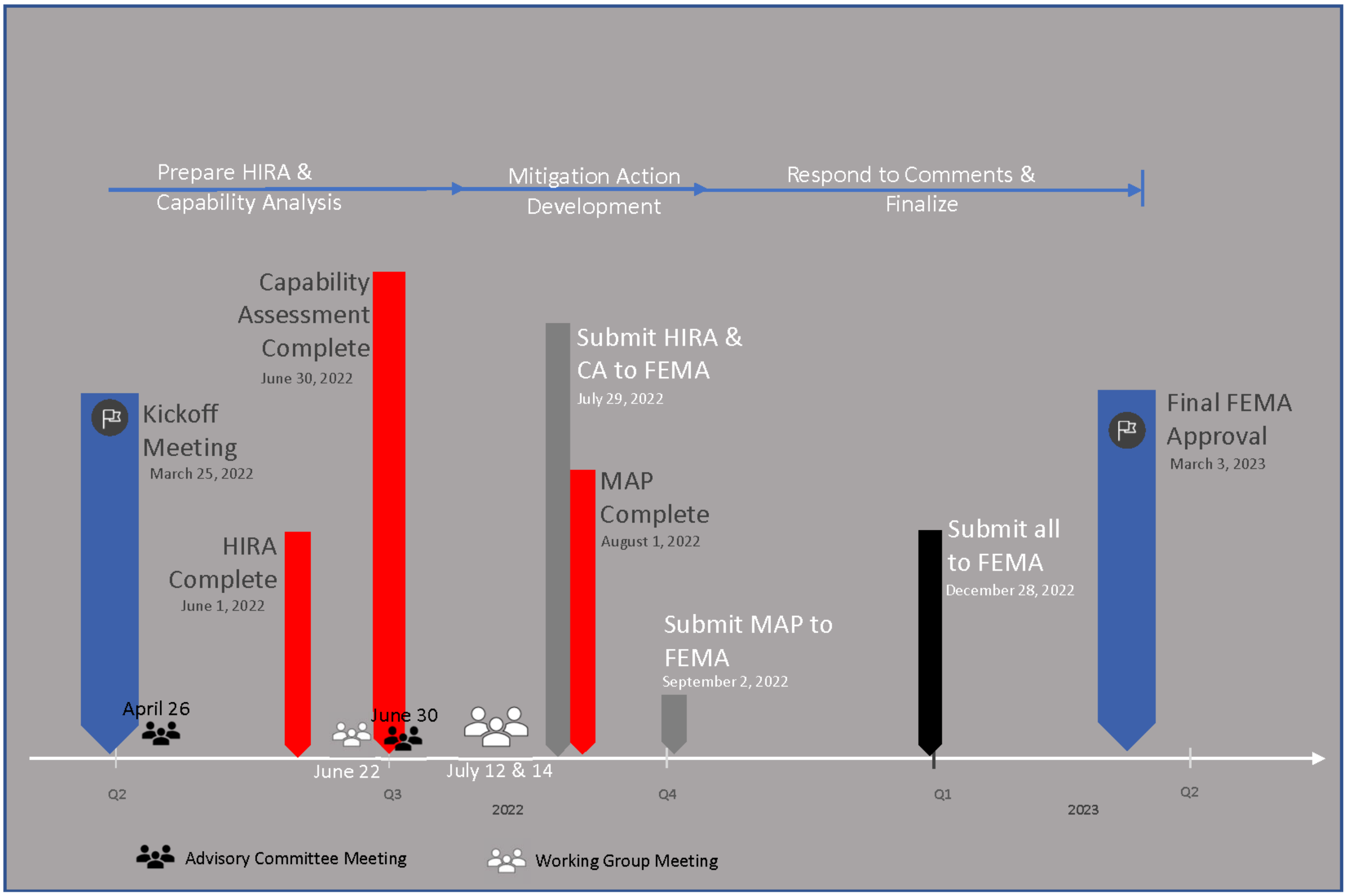
The planning process included ten major steps that were completed during 2022 and 2023. Table 2.1 summarizes the 4-phase, 10-step process followed for this plan. Project leaders used these steps to prepare the project scope and timeline. Each of the planning steps shown in Table 2-1 resulted in work products and outcomes that collectively make up the *2023 Commonwealth of Virginia Hazard Mitigation Plan*.

Table 2-1 – Hazard Mitigation Planning Process

Phases	Steps
Phase I: Organize Resources	Step 1. Get Organized Step 2. Plan for Stakeholder Involvement Step 3. Coordinate with Other Departments & Agencies
Phase II: Assess Risk	Step 4. Identify the Hazards Step 5. Assess the Risks
Phase III: Develop Mitigation Plan	Step 6: Review Mitigation Alternatives Step 7: Set Planning Goals Step 8: Draft an Action Plan
Phase IV: Adopt & Implement	Step 9: Adopt the Plan Step 10: Implement the Plan

The project timeline was developed early in the process, and due to the condensed timeline available to the team for project completion, adjustments were made throughout this unique, phased-submittal planning process. Figure 2-1 shows the plan timeline at the outset of the project; it was adjusted throughout the planning period to reflect advances and delays in component delivery and review.

Figure 2-1 - State Hazard Mitigation Planning Process Initial Timeline, 2023 Update

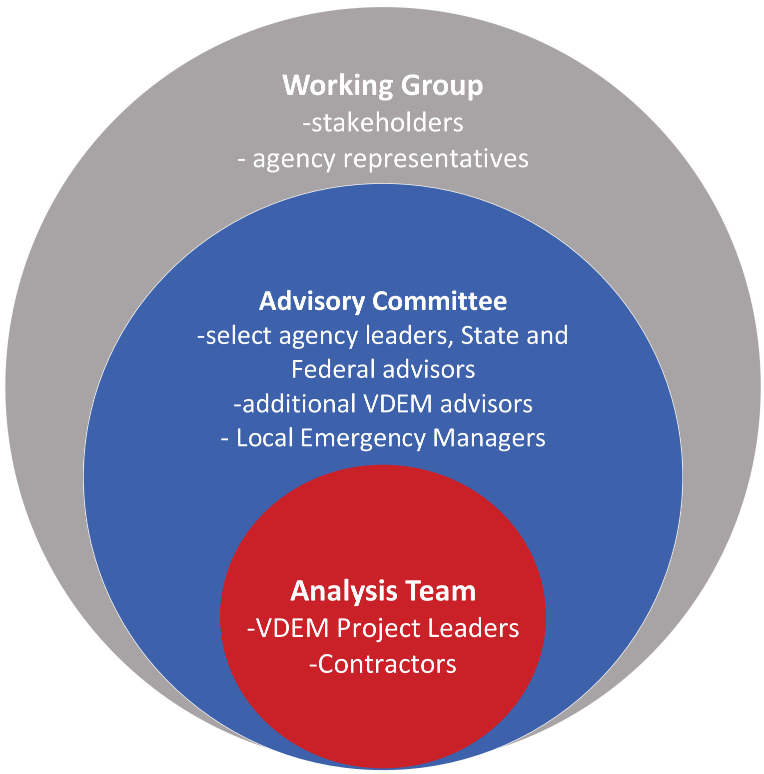


2.4 The Planning Committee

A planning team comprised of key state government officials, local government representatives and key stakeholders has continually helped guide the development of this plan. The committee organized meetings to discuss and complete tasks associated with preparing the plan, including reviewing plan drafts, and providing timely comments. Additional participation and input from other identified stakeholders were sought through emails and phone calls that described the planning process, the findings of the risk assessment, and the proposed mitigation actions.

The committee and subcommittees convened through the first seven months of 2022. Both the Virginia Hazard Mitigation Advisory Committee (VHMAC) and Virginia Hazard Mitigation Working Group (VHMWG) were involved in the 2023 update. The VHMAC is a small group, or subset, of decision makers, and the VHMWG is a larger group of subject matter experts than were brought in to assist and inform the planning process, as needed. A core team of project leaders also convened weekly during the planning process to track progress and adjust timelines and expectations; this group was termed the 'Analysis Team', and was composed of VDEM leaders and contractors on the project. Figure 2-2 shows how these committees worked together and indicates the primary components of each group.

Figure 2-2 - Composition of Committees



Tables 2-2, 2-3 and 2-4 show the committee members who represented a wide range of state agencies, partners and stakeholders. The VHMAC made a concerted effort to reach out to many more important groups with the 2023 update to reflect the growing importance of mitigation planning, the breadth of mitigation partnerships, and the need to incorporate mitigation tenets in a variety of state, regional and local endeavors. VDEM specifically invited the agency's Community Impact Specialist, Olajumoke Akinrimisi, to participate as an Advisory Committee member in order to ensure the plan addressed equity in an informative and useful manner so that equity becomes a central tenet of the Commonwealth's mitigation work. She had the opportunity to attend all workshops, and review all plan components. While the 2018 plan had

20 VHMAC members directing the effort, the 2023 committee had 45 members. The 2018 VHMWG had 43 members, while 71 people actively supported the 2023 effort.

Table 2-2 – Analysis Team Members

Name	Agency or Firm
Stacy McKinley	Virginia Department of Emergency Management (VDEM) Planning
Suzen Collins	VDEM Planning
Barry Ezell	ODU VMASC
Kaleen Lawsure	ODU VMASC
Jennifer Lindgens	ODU VMASC
Jess Whitehead	ODU Institute for Coastal Adaptation and Resilience (ICAR)
Afi Anuar	ODU ICAR
Wie Yusuf	ODU ICAR
George Mcleod	ODU ICAR
Tom Allen	ODU ICAR
Jim Lambert	University of Virginia (UVA) Center for Risk Management of Engineering Systems
Thomas Polmateer	UVA Center for Risk Management of Engineering Systems
Davis Loose	UVA Center for Risk Management of Engineering Systems
Ronnie Hill	UVA Center for Risk Management of Engineering Systems
Brian Joyner	Moffatt & Nichol
Allison Bryan	Moffatt & Nichol
Amy Mindick	Moffatt & Nichol
Sarah Hamm	Moffatt & Nichol
Rachel Baker	Moffatt & Nichol
Leigh Chapman	Salter's Creek Consulting

Table 2-3 - VHMAC Members

Name	Office/Department/Agency
Robbie Coates	VDEM Financial Management
Debbie Messmer	VDEM Financial Management
Alex Krupp	VDEM
Jenny McKee	VDEM GIS
Jumoke Akinrimisi	VDEM Office of Diversity, Equity, and Inclusion
Wendy Howard-Cooper	Virginia Department of Conservation and Recreation (DCR), Dam Safety & Floodplain Management
Angela Davis	DCR
Will Isenberg	Virginia Department of Environmental Quality (DEQ), Coastal Zone Management Program
Eric Seymour	National Weather Service
Jason Braunstein	Virginia Department of Forestry
Ross Weaver	Wetlands Watch
Jessica Swinney	Wise County - Emergency Manager
Paul Hoyle	Grayson County - Emergency Manager
Marc Holma	Department of Historic Resources, Project Review Architectural Historian
Megan Melinat	Department of Historic Resources
Kyle Flanders	Department of Housing and Community Development (DHCD), Senior Policy Analyst & Regulatory Administrator
Paul Messplay IV	DHCD
Anne Witt	Virginia Energy
Matt Lott	Virginia Department of Transportation (VDOT) Emergency Management

Name	Office/Department/Agency
John Scrivani	VDOT
Jonathan Kiser	Virginia Department of Health (VDH)
Chris Patterson	VDH
Hui-Shan Walker	City of Hampton – Emergency Manager
James Redick	City of Norfolk – Emergency Manager
Brandon de Graaf	Virginia Department of General Services (DGS)

Table 2-4 - VHMWG Members

Name	Office/Department/Agency
Bruce Sterling	VDEM, Hurricanes
Peter Corrigan	VDEM, Flood/Dams
Tom Jordan	VDEM, Chief, Technological Hazards
John Zelsnack	VDEM, GIS
Nicholas Buccella	VDEM, GIS
Archer Stark	VDEM, Virginia Emergency Support Team (VEST)
James Moss	VDH, Hospital/Healthcare
Matt Ettinger	VDH, Radiological Health
Holly Brown	VDH, Office of Drinking Water, Emergency Services Coordinator
Jason Burrow	Virginia Department of Military Affairs
LT Jon Totty	Virginia State Police, Fusion Center Director
Chris Cruz	Secretary of Public Safety - Cyber Security
Shannon Burke	FEMA Reg 3
Mari Radford	FEMA Reg 3
Caroline Considine	ODU ICAR
Faraz Ahmed	U.S. Army Corps of Engineers (USACE), VA Silver Jackets / Program Manager for Flood Plain Management Services
Richard Harr	USACE, Program Manager for Planning Assistance to States
Kim Koelsch	USACE, Program Manager for Continuing Authorities Program
Joseph Martinez	Virginia Institute for Marine Science (VIMS)
Mark Brabham	VIMS, Executive Director of Facilities
Martin Chapman	Virginia Tech Seismological Observatory
Allyson Kuriger	Virginia Voluntary Organizations Active in Disaster
Matt Dalon	DCR
Mark Killgore	DCR
Kate Archie	Department of Social Services, Emergency Manager
Freda Rosso	Jamestown-Yorktown Foundation, Facilities Manager
Phil Miskovic	Dept of Behavioral Health and Developmental Services
Steve Pellei	Dept of Corrections
Matt Doxey	Virginia Department of Corrections
Brian Mensing	Virginia Department of Medical Assistance Services
John Kirk	Virginia Department of Wildlife Resources
Tanya Brown	John Tyler Community College
Jared Hoernig	ODU
Travis Perry	The University of Virginia at Wise
Brandy Ellard	University of Mary Washington
Dan Shantler	UVA
Megan Cruz	VCU
Robert Underwood	The Colonial Williamsburg Foundation
Mike Lavin	Jamestown Rediscovery
Jennifer Hurst-Wender	Preservation Virginia
Cliff Edwards	Frontier Culture Museum
Matt Henderson	NPS

Name	Office/Department/Agency
Jennifer Ahlin	VDOT
Kimberly Pryor	VDOT
Maria Mutuc	VDOT
Shane Anderson	UVA Health
Chief Robert Gray	Pamunkey Indian Tribe
Laura Hahn	Upper Mattaponi Indian Tribe, Emergency Management Coordinator
Morgan Martin	Chickahominy Indian Tribe - Eastern Division, Emergency Management Coordinator
Steven Nelson	Rappahannock Indian Tribe, Director of Emergency Services
Rebecca Joyce	Central Shenandoah Planning District Commission (PDC)
John Sadler	Hampton Roads PDC
Christy Straight	New River Valley Regional Commission
Gavin Blevins	Mount Rogers PDC
John Crockett	Northern Shenandoah Valley Regional Commission
Sarah Stewart	PlanRVA
Katie Moody	PlanRVA
Eddie Wells	Roanoke Valley-Alleghany Regional Commission
Ashley Mills	Accomack-Northampton PDC
John Bateman	Northern Neck PDC
Patrick Mauney	Rappahannock-Rapidan Regional Commission
Isabella O'Brien	Thomas Jefferson PDC
Ian Baxter	Thomas Jefferson PDC
Chad Neese	Southside PDC
Matthew Merritt	NOVA Healthcare, Emergency Preparedness Manager
Mike Prailey	NOVA Healthcare, Director of Public Safety and Emergency Management, UVA Health
Harry Gruenspecht	Northern Virginia Hospital Alliance, Training & Exercise Coordinator
Jen Early	Virginia Commonwealth University Hospital
John Williams	Valley Health Medical Center
Michael Mulhare	Virginia Tech
Scott Marshall	State Corporation Commission, Pipeline Safety Program Manager

In addition to the team members shown in Table 2-4 above, an additional 77 agencies or groups were contacted to request representation in the planning process. Most of these requests were unanswered, including the Virginia Economic Development Partnership, 10 utilities, 7 Planning District Commissions, 7 Indian tribes, and 19 colleges or universities. Despite the lack of direct feedback from these potential participants, project leadership continued to send correspondence regarding meeting invitations and requests to review documents. Email communications were the predominant method of committee communication outside of the committee meetings described in Section 2.5 below. The VMASC also set up a shared content web site to facilitate the work of the Analysis Team and to set up meetings throughout the planning period. Future planning efforts and committee membership may be expanded by reaching out to nonresponsive stakeholders via direct telephone, or by elevating the request for participation to supervisory/leadership levels.

2.5 Committee Meetings

Over the course of the planning period, 2 VHMAC and 3 VHMWG meetings took place to further the purposes of this update. After the Kickoff Meeting, Analysis Team meetings took place at weekly intervals throughout the process and included VDEM representation. Table 2-5 provides a summary of the timing, location and purpose of each meeting or workshop held as part of the planning process. Due to the ongoing prevalence of COVID in the community especially during the early stages of the planning process, the simplicity of virtual meeting technology, and the distance many members would be required travel to convene in person, the VHMAC determined that virtual meetings were appropriate for most of the meetings. Attendance logs and agendas are provided in Appendix C. Detailed meeting materials (presentations and recordings) are available upon request from VDEM.

Table 2-5 - Hazard Mitigation Planning Workshop Summaries

Date	Meeting Name	Invitees	Summary
25 March 2022	Kickoff Meeting	Analysis Team – virtual	Analysis Team and VDEM introduced key players. Project leaders finalized project milestones and timeline, reviewed the planning process, and discussed which groups would work on various components of the plan. Data needs for the Hazard Identification and Risk Assessment (HIRA) were discussed, and the group reviewed the 2018 hazard list. Immediate next steps for each group were outlined to prepare for the first Advisory Committee Workshop the following month.
26 April 2022	VHMAC Workshop #1	Analysis Team, VHMAC – hybrid virtual and in person	The Analysis Team led discussion on project components, the projected milestones, and data needs. The group focused on the list of hazards (both new and existing) to be included in the HIRA. Strategies for incorporating the impacts of climate change were discussed, and the group reviewed methodologies for incorporating social vulnerability through various indices. UVA introduced their gap analysis methodology.
22 June 2022	VHMWG Workshop #1	Analysis Team, VHMAC, VHMWG	Following a brief update on progress, project leaders provided a detailed look at results of the HIRA, including a summary of hazard ranking, recent disaster declarations, how the National Risk Index was used to assess social vulnerability, and how community lifelines were analyzed as part of the risk assessment. Flooding, hurricanes, extreme heat, tornadoes, and winter weather were discussed in detail. Appendix K updates to identified threats, including Hazardous Materials Incidents, Complex Coordinated Attacks, Cyber Attacks, Improvised Nuclear Devices, and Electromagnetic Pulse were presented. The group then participated in an interactive, online hazard ranking survey to gather feedback on the perception of risk for various hazards in the Commonwealth.
30 June 2022	VHMAC Workshop #2	Analysis Team, VHMAC	In addition to reviewing the hazard ranking results from VHMWG Meeting #1, the group discussed the plan for VHMWG Meetings #2a (virtual) and #2b (in person), scheduled for July. Project leaders solicited feedback on a variety of logistical inputs, including meeting times, format, material to be presented, and room layout, in an effort to maximize the usefulness of the final two workshops focused on preparing the Mitigation Strategy.

Date	Meeting Name	Invitees	Summary
12 July 2022	VHMWG Workshop #2a	Analysis Team, VHMAC, VHMWG	The group reviewed updated capabilities and was introduced to the gap analysis results which highlighted efforts of other states to mitigate a variety of hazards. Attendees then reviewed goals and objectives from a variety of other plans, both at the state and local level and from other states to provide context for a subsequent review of Virginia's existing plan mitigation goals. The group developed a set of recommended revisions to include new objectives that reflect how the Commonwealth can achieve updated goals. These goals and objectives were all reviewed and edited interactively in real time during the meeting to reflect the group's feedback. In addition, the group reviewed types and examples of various mitigation actions in preparation for the final workshop two days later.
14 July 2022	VHMWG Workshop #2b	Analysis Team, VHMAC, VHMWG – in person only	Using a variety of handouts and consulting with experienced hazard mitigation planners, the group reviewed existing and recommended mitigation actions, and developed new mitigation actions to reflect current priorities. Facilitators helped foster inter- and intra-agency partnerships with other stakeholders, and guided attendees through the development of targeted mitigation actions.

In addition to the rapid succession of workshops, calls and emails were exchanged between members of the groups, to clarify questions or obtain additional guidance to keep the project on track. Draft sections of the updated plan were provided to the VHMWG members for their review and comment prior to creation of the final draft of that section.

At Advisory Committee Workshop #1, the Analysis Team and VHMAC reviewed the hazards from the 2018 plan and determined several changes were necessary to reflect Virginia's recent experiences with hazards and the group's consensus on hazard terminology and inclusion. Several grouped hazards were separated, new hazards were added, and several were renamed. Whereas the previous plan had 13 hazards and 4 threats in Appendix K as shown in Table 2-6, the revised plan includes 17 hazards and 5 threats.

Table 2-6 - Finalizing the List of Hazards for 2023

2018 Hazards	2023 Hazards
Communicable Disease	Pandemic
Drought (including Extreme Heat)	Drought
	Extreme Heat - NEW
Earthquake	Earthquake
Flood	Flooding
Impoundment Failure	Impoundment Failure
Karst	Karst (Sinkholes)
Landslide	Landslide
Land Subsidence	Land Subsidence
Non-Rotational Wind	Non-Tornadic Wind
Solar Storm	Space Weather
Tornado	Tornado

2018 Hazards	2023 Hazards
Wildfire	Wildfire
Winter Weather (including Extreme Cold)	Winter Weather
	Extreme Cold - NEW
	Erosion – NEW
	Hurricane – NEW
Appendix K – Threats	
Hazardous Materials Incident	Hazardous Materials Incident
Complex Coordinated Attack	Complex Coordinated Attack
Cyber Attack	Cyber Attack
Improvised Nuclear Device	Improvised Nuclear Device
	Electromagnetic Pulse - NEW

2.6 Draft Review

Drafts of various sections of the plan were circulated for review and comment prior to submittal to VDEM leadership and FEMA Region III. Review periods ranged from 2 weeks to 4 weeks, depending on internal working deadlines necessitated by the project's short timeline.

Contents

3.1 2023 Updates

The Hazard Identification and Risk Assessment (HIRA) was reviewed and updated to provide a more current and thorough assessment of the risks facing the Commonwealth of Virginia. Hazards were reviewed and updated with current hazard history information from several sources, including the National Centers for Environmental Information (NCEI), National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), and Virginia's Department of Conservation and Recreation (DCR). In addition, the list of hazard names was updated per discussions at the first Advisory Group Workshop and in accordance with VDEM agency guidance. All hazards were assessed for potential impacts to vulnerable populations using FEMA's National Risk Index (NRI) tool, and a description of impacts expected with regard to climate change was appended to each hazard section. Each hazard was also analyzed to assess linkages to FEMA's Community Lifelines, to facilitate development of mitigation actions that address each of those lifelines. Local plan information and data were also updated and included.

In addition to the changes to the list of hazards directed by the Advisory Committee, Extreme Heat, Extreme Cold, and Erosion are categorized as standalone hazards for this update; however, no detailed analysis was performed for these lower risk hazards. Distinctions in wind type were necessary to be able to determine relevant historical events and to develop methodology to calculate future probability, vulnerability, and impact from wind.

The HIRA presents the general findings from the local and regional plans and summarizes them at a county-wide and state-wide level. Local plans were evaluated to capture changes to the recent hazard rankings at the regional level. The analysis of state and critical facilities was updated based on data availability. Estimates and extrapolation of building and content values for numerous regions and localities were replaced with actual values, if available.

Tables were updated to include new data, where available, and tables regarding conclusions on hazard risk were all updated. Figures were updated to reflect current conditions or recent GIS analysis. The Hazard Identification, Risk Assessment and Vulnerability Analysis chapter of the 2023 plan update consolidates, updates, and streamlines content from the previous plan. Sections have been reorganized for ease of review for the reader, including alphabetization of hazards.

3.2 Overview

This HIRA section of the State Hazard Mitigation Plan describes the natural hazards that threaten the Commonwealth of Virginia and provides general background information, local data (e.g., the location and spatial extent), and historical occurrences for each hazard. This section also presents best available data regarding notable historical damages within the region.

The individual hazard profile sections of this chapter cover the following three requirements for the HIRA:

- Identifying and profiling hazards;
- Assessing vulnerabilities; and,
- Estimating potential losses.

The hazard profile subsections follow the same general format throughout the plan, and includes a Background, Location and Spatial Extent, Significant Historical Events, and Probability of Future Occurrences sections. The Probability of Future Occurrences section includes the following sub-sections: Impact and Vulnerability, Risk, Future Conditions (includes a climate change discussion), and Jurisdictional Risk (includes linkages to FEMA's Community Lifelines).

Two important considerations that permeate this chapter are overall data availability and ability to compare hazards to each other. FEMA guidelines emphasize using the best available data for this plan. Section 3.6 describes the facility datasets that were used to complete this revision and include strategies for increasing the usability of locally maintained datasets.

A wide range of hazards have the potential to threaten both life and property in Virginia. These hazards were classified as weather related, geological related, and other hazards. Local plans were evaluated to verify the consideration and ranking of these hazards. Section 3.8 of this chapter defines these hazards and how they are incorporated into this revision.

The ranking and analysis in the HIRA section are in terms of relative risk to other jurisdictions in the Commonwealth. For example, the tornado ranking and analysis in this chapter is an effort to highlight the jurisdictions within Virginia that are more likely to be at risk. The highest-ranking communities in Virginia, when compared to the states in the Midwest 'tornado alley', would probably be considered low risk.

Several hazards have been renamed or altered per the discussions documented from Advisory Committee Meeting #1 in Section 2 of this plan. As a result of those discussions, the final hazards discussed in this section are as follows:

1. Drought
2. Earthquake
3. Erosion
4. Extreme Cold
5. Extreme Heat
6. Flooding
7. Hurricane
8. Impoundment Failure
9. Karst (Sinkholes)
10. Landslide
11. Land Subsidence
12. Non-Tornadic Wind
13. Pandemic
14. Tornado
15. Space Weather
16. Wildfire
17. Winter Weather

3.2.1 HIRA Section Outline

The following subsections include the results of the hazard identification and risk assessment process. The process used to identify the hazards that impact Virginia and available data sources were reviewed and endorsed by both the Advisory Committee and the Technical Working Group. The HIRA chapter is structured in the following manner according to **Table 3-1**.

Table 3-1 - HIRA Chapter Structure

HIRA Background	Description
Introduction to the HIRA	Describes the overall process that was used to revise the HIRA.
Introduction to Virginia	Local and statewide land use and development patterns are addressed. Describes the political, demographic, and physiographic boundaries of the Commonwealth.
Federally Declared Disasters and NCEI Hazard History	Description of available datasets. Describes past declared disasters and hazard events that have happened in the Commonwealth.
Commonwealth and Critical Facilities	Local datasets are evaluated and discussed. Describes the available datasets for state and critical facilities and the limitations of this data.
Ranking Methodology	Detail of parameters used in analysis. Standardizes terminology, describes the development of the ranking methodology.
Local Plan Incorporation	Discussion of standardization of risk assessment and loss estimates. Review of local/regional hazard mitigation plans, comparison of local rankings.
Hazard Profile Sections	**Description**
Drought	Discussion of the types of droughts and the criteria used for determining the severity.
Earthquake	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
Erosion	Textual description only.
Extreme Cold	Textual description only.
Extreme Heat	Textual description only.
Flooding	Discussion of repetitive loss structures and FEMA RiskMAP Program. Simplified analysis is performed using digital flood insurance rate maps (DFIRMs), US Census data and Benefit-Cost Analysis (BCA) assumptions.
	Riverine Flooding - Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
	Storm Surge Flooding - Analysis of critical and state facilities.
	Stormwater Flooding - Textual description only.
Hurricane	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates. Flood hazards associated with hurricanes are included under the “Flooding” hazard profile section.
Impoundment Failure	Textual description only.
Karst (Sinkholes)	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
Landslide	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
Land Subsidence	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates. Risk and loss estimates associated with aquifer issues.
Non-Tornadic Wind	Non-Tornadic wind includes all wind events that are not tornadic or hurricane.
Pandemic	Analysis and impacts to the Commonwealth of Virginia.
Tornado	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
Space Weather	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
Wildfire	Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
Winter Weather	Includes discussion of types of winter weather and the limitations of analysis. Analysis of critical and state facilities, jurisdictional risk, and annualized loss estimates.
Summary	
Summary/Conclusions	Overall conclusions regarding risk.

The Hazard Assessment and Ranking Methodology Section of this plan, expands upon the concepts underlying the hazard identification and risk assessment process and the methods used to rank hazard risk. Because technological, radiological, hazardous materials, and terrorism-related hazards necessitated discussion, but are not mitigated through the same programs as natural hazards, technological hazards and historical occurrences thereof are summarized in Appendix D of this plan.

The findings presented in this section regarding each hazard were developed using best available data, and the methods applied have resulted in an approximation of risk. These estimates should be used to understand relative hazard risk and the potential losses that may be incurred; however, uncertainties are inherent in any loss estimation methodology, arising from incomplete knowledge concerning specific hazards and their effect on the built environment, as well as incomplete data sets, and from approximations and simplifications that are necessary to provide a meaningful analysis.

To a large extent, historical records are used to identify the level of risk within the planning area, with the assumption that the data sources cited are reliable and accurate. Maps are provided to illustrate the location and spatial extent for those hazards within the region that have a recognizable geographic boundary (i.e., hazards that are known to occur in particular areas of the region, such as the 100-year floodplain). For those hazards with potential risk not confined to a particular geographic area (such as winter storms and tornadoes), historical event locations and/or general information on the applicable intensity of these events across the entire area are used to explain the geographic impacts.

3.2.1.1 FEMA's National Risk Index – Community Lifelines

The National Risk Index (NRI) is a relatively new dataset and online application from FEMA that identifies communities most at risk to various natural hazards. For each of the 18 natural hazards explored in the NRI, risk is calculated by multiplying each hazard's expected annual losses by social vulnerability (a consequence enhancing component of risk that measures the susceptibility of social groups to the adverse impacts of natural hazards) and dividing by community resilience (a consequence reduction component of risk that measures the ability of a community to plan for, absorb, recover from, and adapt to the impacts of hazards). In other words:

Risk = Expected Annual Loss x Social Vulnerability x (1/Community Resilience)

In the risk equation, each component is represented by a unitless index score that depicts a community's score relative to all other communities at the same level. All further calculations for the national-level data are performed separately at the county and Census tract levels, so scores are relative only within the county or Census tract level. It must be stressed that scores are relative, representing a community's relative position among all other communities for a given component and level. Scores are not absolute measurements and should be expected to change over time either by their own changing measurements or changes in other communities.

For every score, there is also a qualitative rating that describes the nature of a community's score in comparison to all other communities at the same level, ranging from "Very Low" to "Very

High." Because all ratings are relative, there are no specific numeric values that determine the rating. For example, a community's Risk Index score for a single hazard could be 8.9 with a rating of "Relatively Low," but its Social Vulnerability score may be 11.3 with a rating of "Very Low." The rating is intended to classify a community for a specific component in relation to all other communities at the same level.

For the 2023 HIRA update, FEMA's Community Lifelines were integrated into each of the individual hazards to identify which lifeline a particular hazard may impact. FEMA developed the community lifelines construct to increase effectiveness in disaster operations and position the agency to respond to catastrophic scenarios. The construct allows FEMA to characterize the incident and identify the root causes of priority areas and to distinguish the highest priorities and most complex issues from other incident information. The goal is to restore basic lifeline services or capabilities to survivors of the event. FEMA has identified seven community lifelines as follows[i]:

Safety and Security - Law Enforcement/Security, Fire Service, Search and Rescue, Government Service, Community Safety

Food, Water, Shelter - Food, Water, Shelter, Agriculture

Health and Medical - Medical Care, Public Health, Patient Movement, Medical Supply Chain, Fatality Management

Energy - Power Grid, Fuel

Communications - Infrastructure, Responder Communications, Alerts Warnings and Messages, Finance, 911 and Dispatch

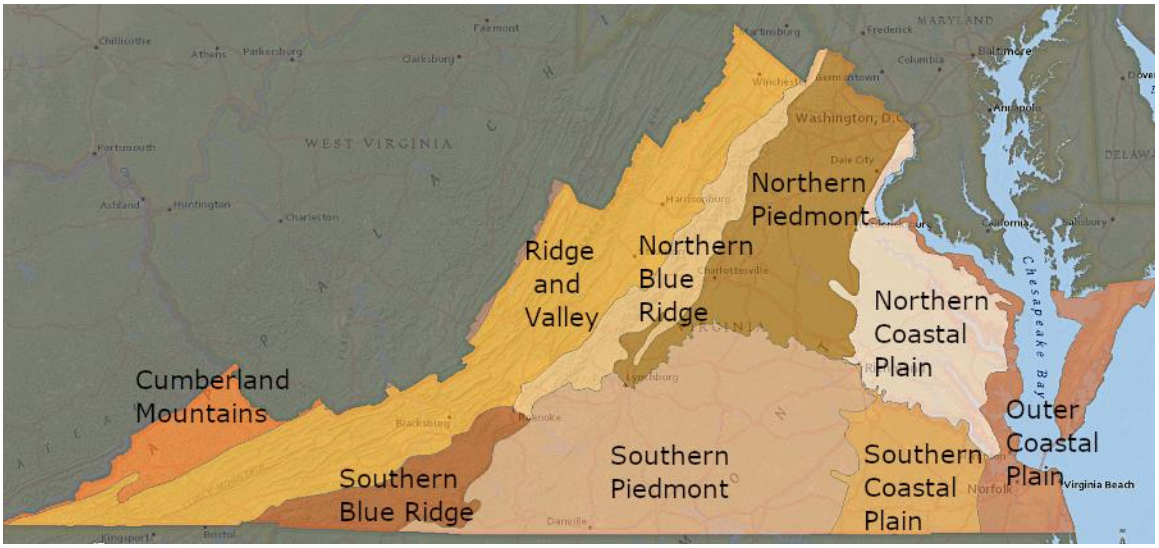
Transportation - Highway/Roadway/Motor Vehicle, Mass Transit, Railway, Aviation, Maritime

Hazardous Material - Facilities, HAZMAT, Pollutants, Contaminants

3.3 Introduction to Virginia

The Commonwealth of Virginia is located on the Mid-Atlantic coast of the continental US. Virginia displays a unique geography including the Cumberland and Blue Ridge Mountains to the west and northwest, Piedmont in central and south-central Virginia, and the coastal plain area east of the Interstate-95 corridor. The eastern portion of the state is adjacent to the Chesapeake Bay and Atlantic Ocean, which offer unique economic opportunities as well as emergency management challenges. The map in **Figure 3-1** illustrates the physiographic regions of Virginia.

Figure 3-1 - Physiographic Regions of Virginia[ii]



Several major watersheds are found in the state, as shown in Figure 3-4. Most of the streams and rivers in northern and central Virginia flow east toward Chesapeake Bay. The southeastern and central southern parts of the state drain through North Carolina directly to the Albemarle and Pamlico Sounds. The southwestern portion of the state drains into the Mississippi River and Gulf of Mexico via the Holston, Clinch-Powell, New, and Big Sandy rivers.

The climate of Virginia is moderate with four well-defined seasons. Daytime temperatures usually range from 30° F in the winter to 90° F in the summer, although historic temperature extremes above 100° F, and below 0° F, have been observed with higher temperatures more common on an annual basis. On average, the coastal region is the warmest due to maritime influences, with temperatures gradually decreasing across the Piedmont toward the west. The climate of the western part of the state, which reaches a maximum elevation of 5,729 feet above sea level at Mount Rogers, is significantly cooler on average throughout the year.

Figure 3-2 - Watersheds within the Commonwealth of Virginia

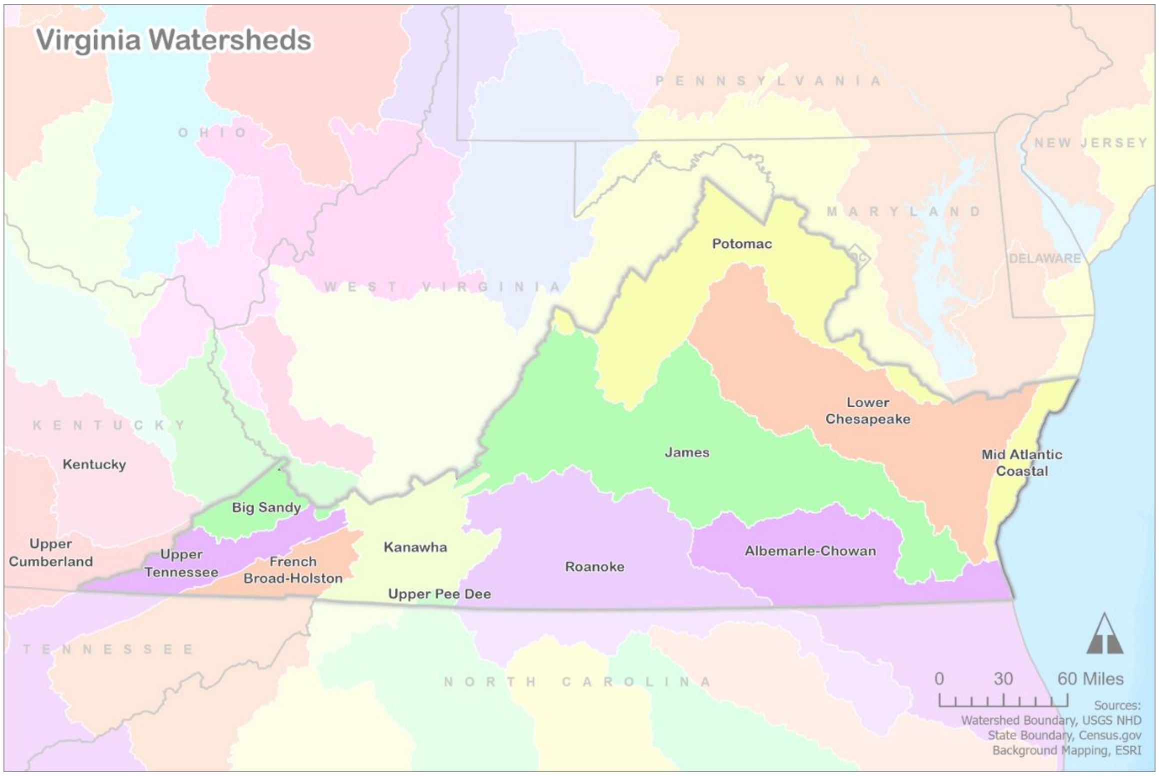
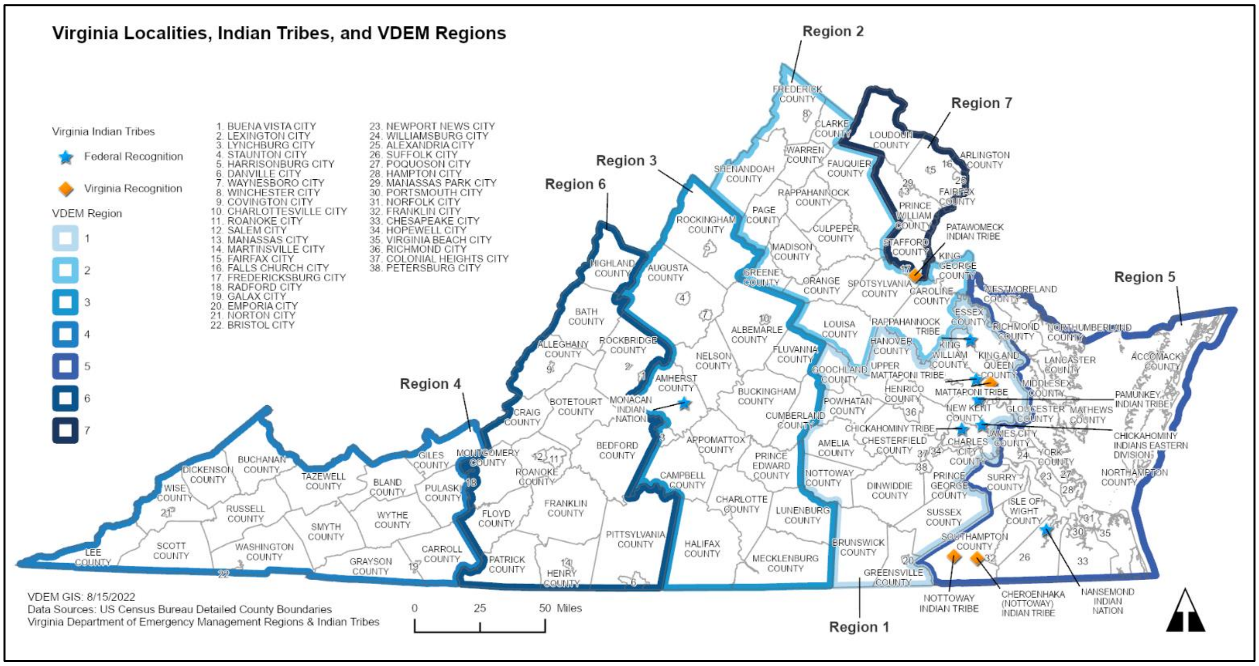


Figure 3-3 shows the 95 counties and 38 independent cities that make up the Commonwealth of Virginia. The national capital, Washington, D.C., is located on the Potomac River at Virginia's northern border with Maryland. The state capital is the City of Richmond. Unlike most other states, cities and counties in Virginia are each independent political jurisdiction. As of 2022, there are 190 incorporated towns in the Commonwealth of Virginia. An incorporated town in Virginia has governmental authority roughly equivalent to cities in many other states.

The first known residents of present-day Virginia were Native Americans, whose ancestors arrived in North America thousands of years ago. In the late 1500s and early 1600s, Europeans began to sail across the Atlantic Ocean, exploring and colonizing Virginia. The first lasting English settlement in Virginia, dating to 1607, was located at Jamestown. As colonization of the Americas progressed, Virginia grew into an important center of trade and government. Many Virginians were notable figures in the American Revolution, and many of the early Presidents were native Virginians. In 1861, Virginia seceded from the union and Richmond became the capitol of the Confederate States of America and was the site of many battlegrounds in the subsequent American Civil War. Following the reunification of the US, Virginia continued to develop, with many large urban areas in the eastern and northern parts of the state. Today, Virginia's culture reflects a mixture of the old and new, urban, and rural.

Virginia has seven federally recognized tribes: the Pamunkey Indian Tribe, Chickahominy Indians, Chickahominy Indians Eastern Division, Upper Mattaponi Indian Tribe, Rappahannock Tribe, Nansemond Indian Nation and Monacan Indian Nation. The Pamunkey Nation was the first federally recognized tribe in the Commonwealth[1]; the latter six gained recognition through passage of federal legislation in the 21st century. All of the tribes are located east of Interstate 95, with the exception of the Monacan Indian Nation, which is north of Lynchburg, near the center of the state. Virginia recognizes all seven Federally recognized tribes as well as four additional tribes, the Mattaponi Tribe, Nottaway Indian Tribe, Cheroenhaka (Nottoway) Indian Tribe, and the Patawomeck Tribe.

Figure 3-3 - Virginia Localities, Indian Tribes and VDEM Regions



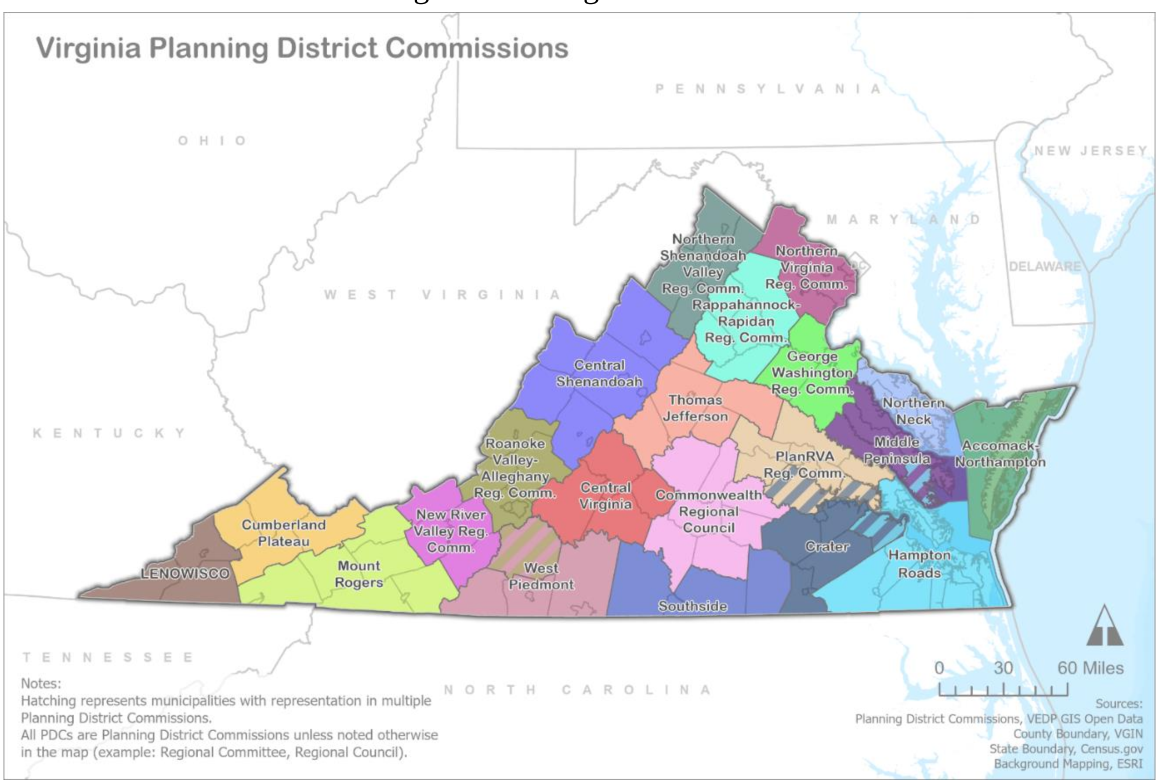
The cities and counties in Virginia are organized into 21 Planning District Commissions (PDCs), as shown in Figure 3-5. These commissions provide a platform for regional planning and communication in land use planning, transportation, and economic development. The PDCs have governing authority (Regional Cooperation Act) beyond the will of their constituent local governments. Each of the 20 local hazard mitigation plans in the Commonwealth of Virginia were completed on a regional basis through the PDCs. Some PDCs combine resources to create and maintain their local hazard mitigation plan. The PDCs are as follows:

- 01 – LENOWISCO Planning District Commission
- 02 – Cumberland Plateau Planning District Commission
- 03 – Mount Rogers Planning District Commission
- 04 – New River Valley Regional Commission
- 05 – Roanoke Valley-Alleghany Regional Commission
- 06 – Central Shenandoah Planning District Commission
- 07 – Northern Shenandoah Valley Regional Commission
- 08 – Northern Virginia Regional Commission
- 09 – Rappahannock-Rapidan Regional Commission
- 10 – Thomas Jefferson Planning District Commission
- 11 – Central Virginia Planning District
- 12 – West Piedmont Planning District Commission

- 13 – Southside Planning District Commission
- 14 – Commonwealth Regional Commission
- 15 – RVA Regional Commission
- 16 – George Washington Regional Commission
- 17 – Northern Neck Planning District Commission
- 18 – Middle Peninsula Planning District Commission
- 19 – Crater Planning District Commission
- 22 – Accomack-Northampton Planning District Commission
- 23 – Hampton Roads Planning District Commission
  (Note: There is no PDC assigned number 20 or 21.)

The Richmond Regional PDC and the Crater PDC share Chesterfield County and Charles City County. The Middle Peninsula PDC and the Hampton Roads PDC share Gloucester County. The Crater PDC and the Hampton Roads PDC share Surry County. The Roanoke Valley-Alleghany Regional Commission and the West Piedmont PDC share Franklin County. Cumberland County and Nottoway County became members of the Commonwealth Regional Council (CRC) in 2020 joining Buckingham, Charlotte, Lunenburg, and Prince Edward. Franklin county is a member of Roanoke Valley-Alleghany Regional Commission and West Piedmont PDC.

Figure 3-4 - Commonwealth of Virginia Planning District Commissions

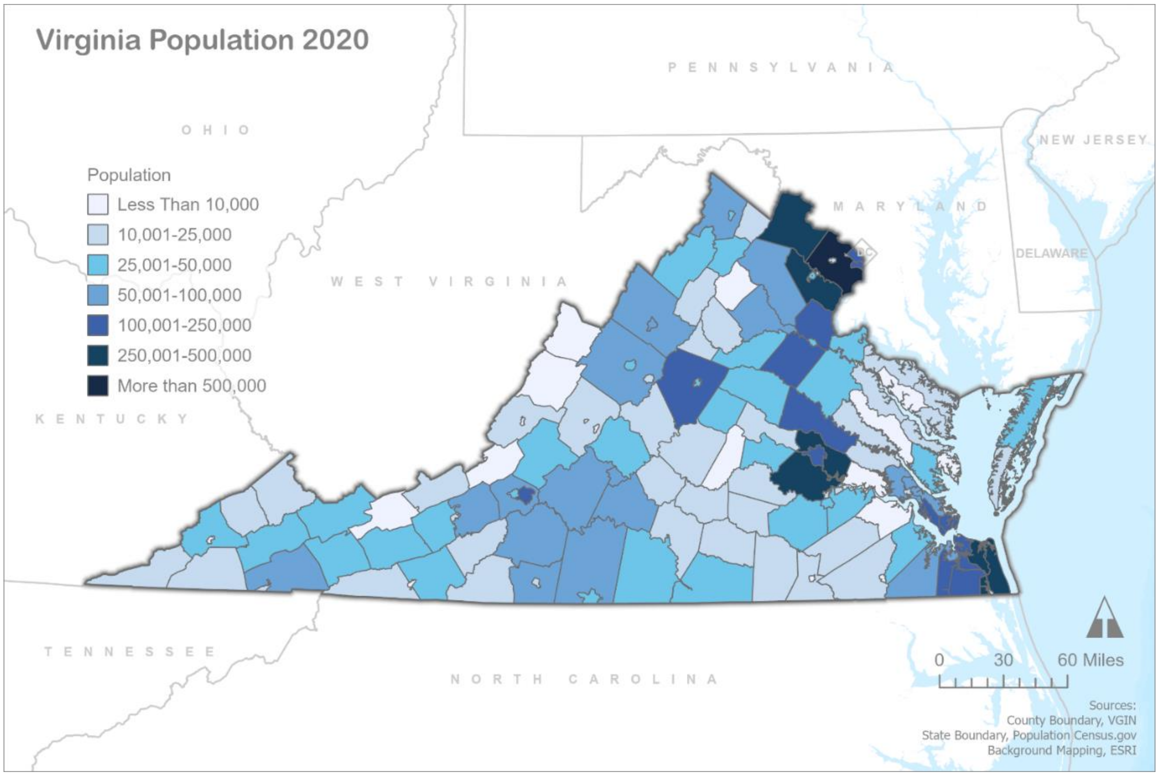


3.3.1 Demographics

Per the US Census, the population of Virginia was estimated at over 8.3 million in 2022, making it the 12th most populous state in the nation. Most residents live in the eastern part of the state, along the corridor running from Washington, D.C. to Virginia Beach, known as the Golden

Crescent. A great deal of the state's economy is driven by activity in the urban areas of northern and eastern Virginia. In recent years, Fairfax and Loudon counties in Northern Virginia have routinely been ranked at or near the top in nationwide comparisons of household income. The remainder of the state is largely rural, with several smaller urban areas. Figure 3-5 shows the population distribution in the Commonwealth based on the 2020 Census.

Figure 3-5 - Population Distribution within the Commonwealth of Virginia: 2020



The overall population of Virginia continues to increase annually, although the rate of growth has declined somewhat in the past few years. Approximately half of Virginia's population growth since 2000 can be attributed to natural increase; that is, population growth that occurs when the birthrate exceeds the death rate. Immigration from other states and foreign countries accounts for the other half of the state's population growth. More than 70% of Virginians live in the Northern Virginia, Richmond, and Hampton Roads regions.

Population trends show uneven change throughout the state. Figure 3-6 shows the population change since the 2010 Census, as calculated by the Demographics Research Group at the University of Virginia.

Table 3-2 shows the top ten jurisdictions, in terms of percent population change, between 2010 and 2020.

Figure 3-6 - Population Change in the Commonwealth of Virginia: 2010-2020

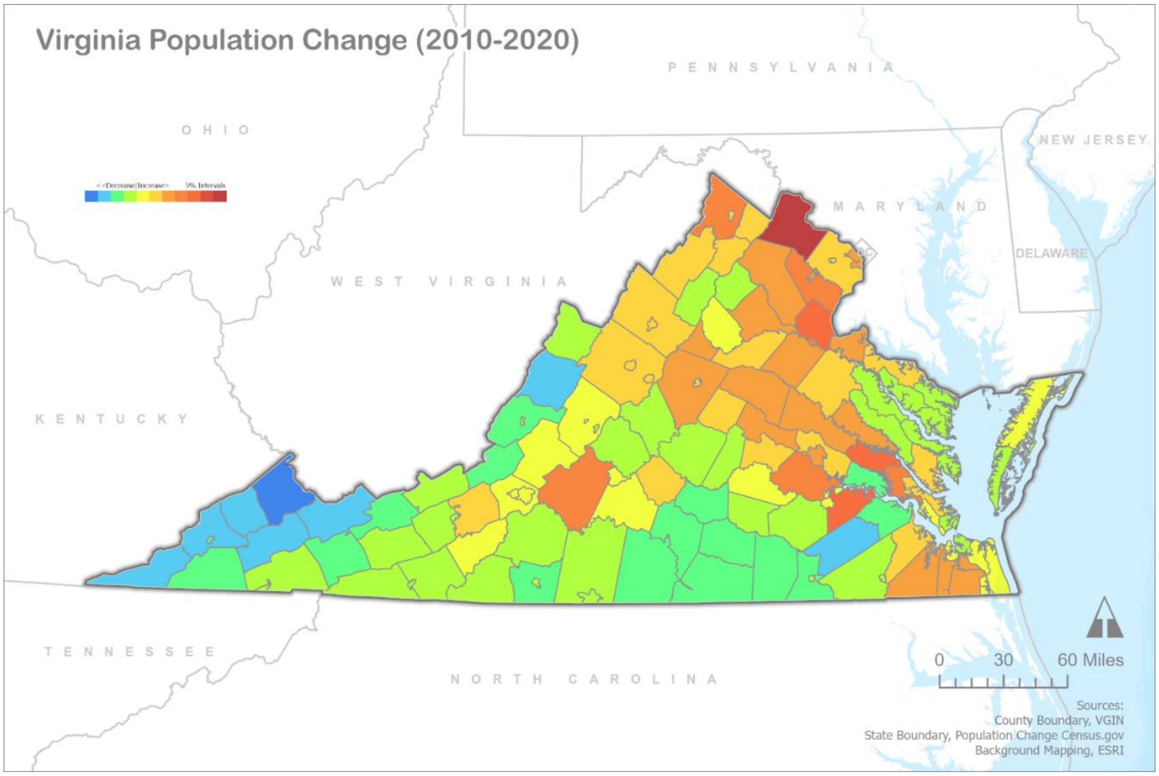


Table 3-2 - Top 10 Jurisdictions with the Highest Growth Rates (2010 – 2020) based on US Census Population Data[10]

Community Name	2010 Population	2020 Population	% Population Change
Loudoun County	312,311	420,959	35%
New Kent County	18,429	22,945	25%
Stafford County	128,961	156,927	22%
Manassas Park City	14,273	17,219	21%
Prince George County	35,725	43,010	20%
Prince William County	402,002	482,204	20%
Falls Church City	12,332	14,658	19%
James City County	67,009	78,254	17%
Frederick County	78,305	91,419	17%
Bedford County	68,676	79,462	16%

The US Census Bureau's Population Division estimates that the population of Virginia will continue increasing, with most growth occurring in the form of urban sprawl. The population of Fairfax County has exceeded 1.1 million and is expected to grow over 13% between 2020 and 2040[11]. The jurisdictions in Table 3-3 are projected to have greater than 25% population growth between 2020 and 2040[12]:

Table 3-3 - Communities with Greater than 25% Projected Population Growth, 2020 to 2040

Community Name	2020 Population	Projected % Population Change, 2020-2040
Loudoun County	420,959	55%
New Kent County	22,945	38%
Prince William County	482,204	37%
City of Manassas Park	17,548	36%
Stafford County	156,927	36%
James City County	78,254	35%
King George County	26,723	33%
Culpeper County	52,552	31%
Spotsylvania County	140,032	30%
Fredericksburg City	27,982	30%
Frederick County	91,419	30%
City of Suffolk	94,324	29%
Louisa County	37,596	27%
Falls Church City	14,658	26%

Population decline appears mostly in the rural counties of Virginia. Table 3-4 shows the 10 jurisdictions with the largest population decline for the years 2010 through 2020[13].

Table 3-4 - Jurisdictions with Declining Populations (2010-2020) based on US Census Population Data[14]

Community Name	2010 Population	2020 Population	% Population Change
Buchanan County	24,098	20,355	-16%
Lee County	25,587	22,173	-13%
Wise County	41,452	36,130	-13%
Dickenson County	15,903	14,124	-11%
Bath County	4,731	4,209	-11%
Russell County	28,897	25,781	-11%
Sussex County	12,087	10,829	-10%
Tazewell County	45,078	40,429	-10%
Brunswick County	17,434	15,849	-9%
Charlotte County	12,586	11,529	-8%

Jurisdictions projected to have a decline in population of greater than 15% between 2025 and 2045 are shown in Table 3-5[15]:

Table 3-5 - Communities with Greater than 15% Projected Population Decline, 2025 to 2045

Community Name	2020 Population	Projected % Population Decline, 2025-2045
Buchanan County	20,355	-34%
City of Danville	42,590	-27%
City of Martinsville	13,485	-25%
Accomack County	33,413	-24%
Grayson County	15,333	-24%
Bath County	4,209	-20%
Alleghany County	15,223	-20%

Community Name	2020 Population	Projected % Population Decline, 2025-2045
Dickenson County	14,124	-19%
Henry County	50,948	-19%
Russell County	25,781	-18%
Highland County	2,232	-18%
Brunswick County	15,849	-18%
Northampton County	12,282	-16%
Covington	5,737	-16%

3.3.2 Land Use, Cover, and Development

In evaluating both natural hazards and future conditions relating to those hazards, land use trends are an important factor impacting potential future damages. Urbanization and suburbanization are particularly important and mirror the trends in population change throughout the state. Data showing land use/land cover changes in the US are readily available for certain time periods. The Multi-resolution Land Characteristics Consortium (MRLC) has assessed land use/land cover over the entire US based on satellite imagery; this is known as the National Land Cover Database (NLCD). The MRLC has produced a land cover change analysis between 2001 and 2019 (the most recent year of analysis offered), in the form of a raster image with pixel values representing the change of one land use to another. Figure 3-7 shows the current (2019) land cover in Virginia, while Figure 3-8 shows the land cover change throughout the Commonwealth of Virginia since 2001. In general, the areas in Figure 3-7 that appear as developed (low, medium, and high intensity) correlate to the areas shown in Figure 3-8 land use change as urban. Areas that are already developed, continue to see changes that further their urban characteristics.

Figure 3-7 - Land Cover in Virginia, 2019

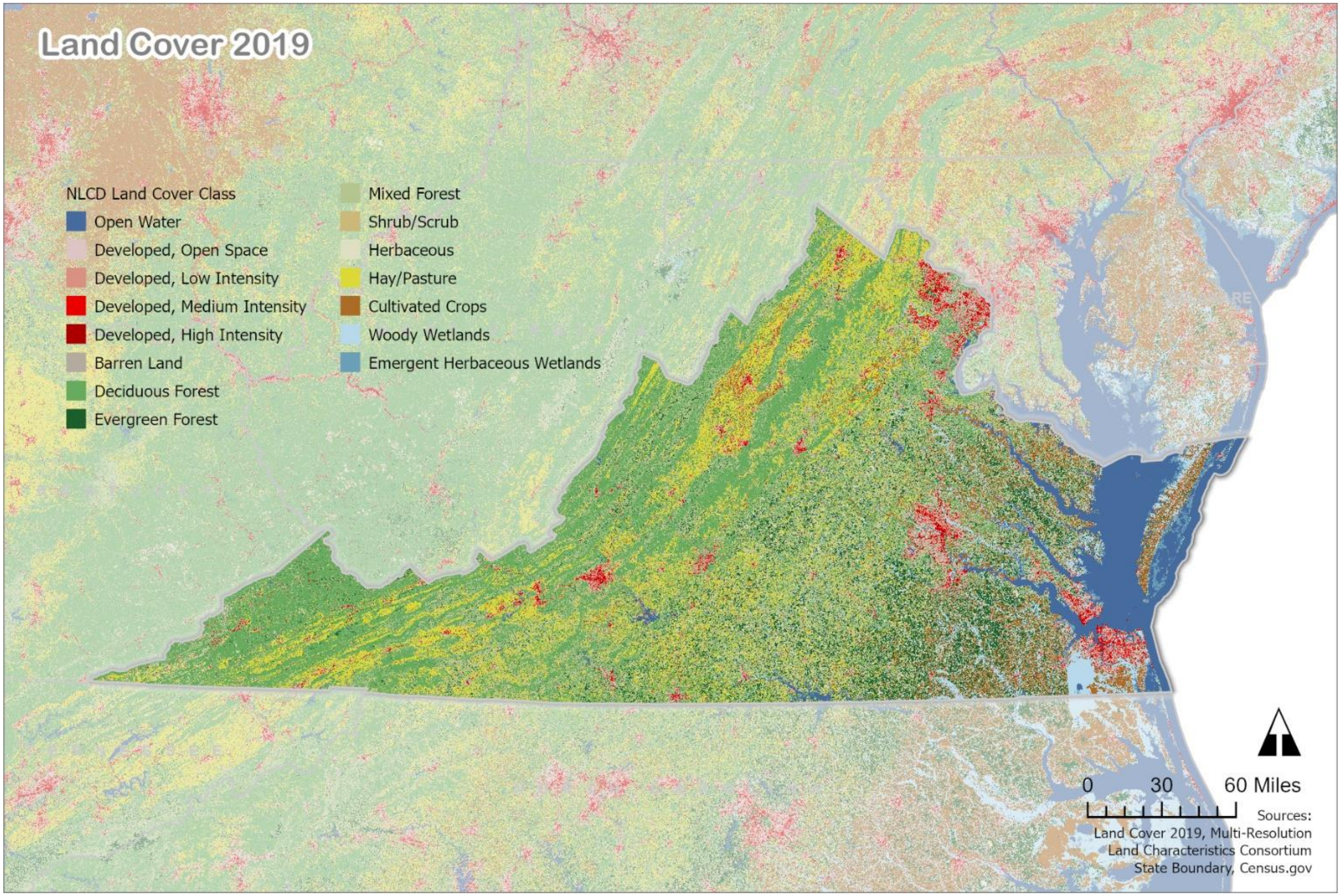
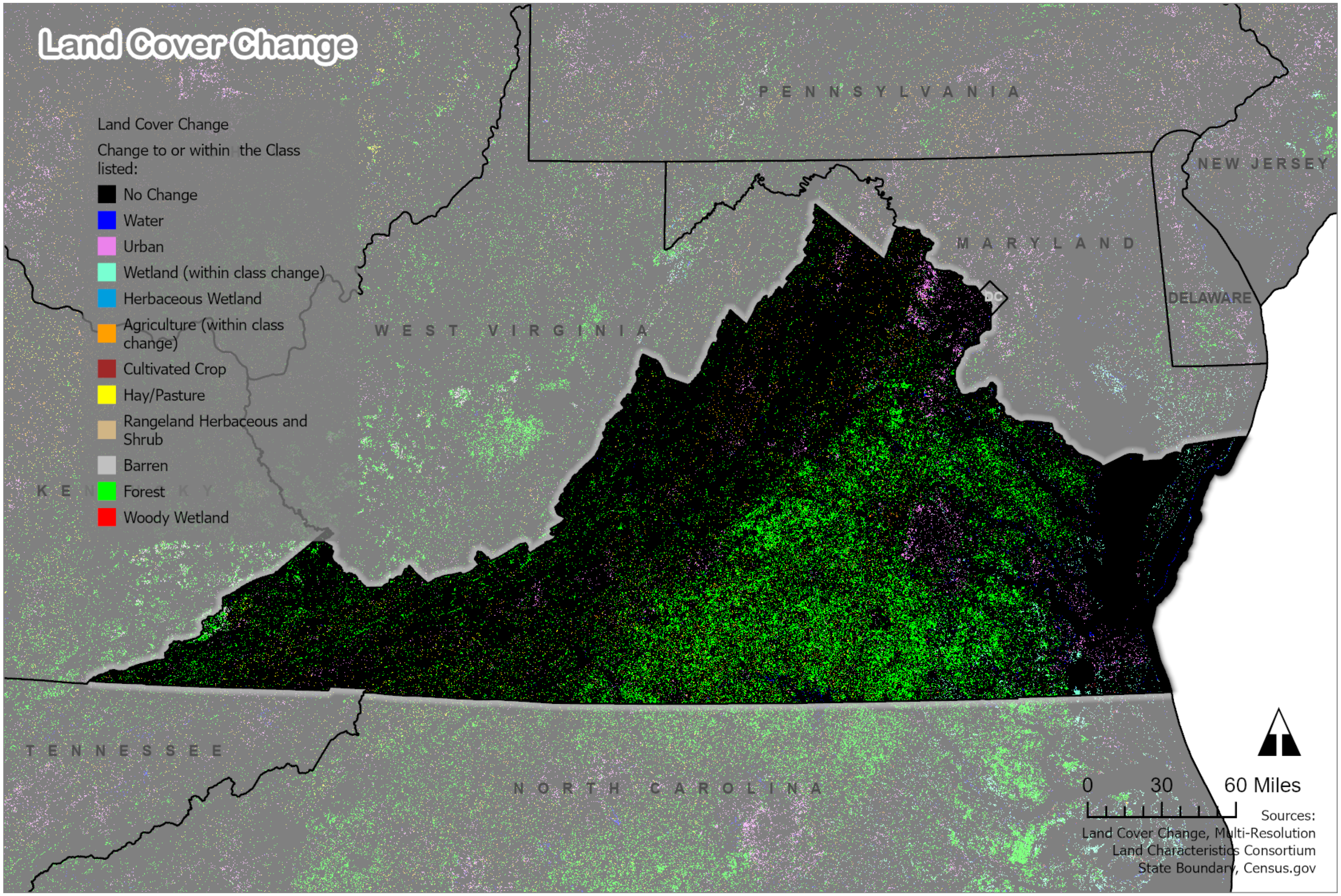


Figure 3-8 - Land Cover Change in Virginia, 2001-2019



3.4 Summary of Disaster Declarations

3.4.1 Disaster Declarations Background

Local and state governments share responsibility for public health and safety and for helping residents recover after disaster strikes. In some cases, a disaster is beyond the response capabilities of the state and local governments. In 1988, the *Robert T. Stafford Disaster Relief and Emergency Assistance Act* was enacted to support state and local governments and their citizens when disasters overwhelm and exhaust available resources. This law, as amended, establishes a process for requesting and obtaining a federal disaster declaration, defines the type and scope of assistance available from the federal government, and sets the conditions for obtaining that assistance[1].

A presidential disaster declaration is issued when a disaster event is determined to be beyond the response capabilities of state and local governments. A presidential disaster declaration could result from a hurricane, earthquake, flood, tornado, major fire, or other event which the President determines warrants supplemental federal aid. If declared, funding comes from the President's Disaster Relief Fund, which is managed by FEMA, and disaster aid programs of other participating federal agencies. Federal disaster declarations typically follow these steps:

- Local governments respond first, supplemented by neighboring communities through mutual aid agreements and volunteer agencies. If overwhelmed, local governments turn to the state for assistance.
- The state responds with state resources, such as the Virginia Emergency Support Team, National Guard, and other state agencies.
- A Rapid Needs Assessment (RNA) which focuses on lifesaving needs, imminent hazards, and critical lifelines is performed, usually within the first 24 hours of an event.
- An Initial Damage Assessment (IDA) is performed by the local government, which evaluates damages to residences, businesses, and public infrastructure (i.e., roads, bridges, public utilities, etc).
- IDAs determine if there is sufficient damage to warrant a Joint Preliminary Damage Assessment (PDA) which consists of local, state, and federal staff verifying the IDAs to determine if enough damage exists to warrant federal recovery assistance.
- A Major Disaster Declaration is requested from the Governor to the FEMA Region III Administrator, who evaluates the request and provides recommendations to the President based on the RNA, PDAs, and the type of federal assistance requested.
- A request for hazard mitigation assistance usually accompanies the disaster declaration request.
- Depending on the nature of the disaster and the type of assistance being requested, a Presidential Declaration could be approved within a couple of hours to a couple of weeks;
- A Presidential Declaration can also be approved prior to an event (i.e., hurricane) to pre-position resources if it anticipated that the damage will be severe;
- Federal funds for mitigation post-disaster are based on 15% of the Stafford Act disaster recovery assistance that is provided to the jurisdictions statewide.

An important source for identifying hazards that can affect the Commonwealth is the record of federal disaster declarations. Since 1953, the first-year presidential disaster declarations were issued in the US, Virginia has been named in fifty-five such declarations (Table 3-6). Under a presidential disaster declaration, the state and affected local governments are eligible to apply for federal funding to pay 75% of the approved costs for debris removal, emergency services related to the storm, and the repair or replacement of damaged public facilities. In addition, there have been ten emergency declarations, and three fire management assistance declarations for Virginia, dating back to 1957. Table 3-6 shows the federal emergency and disaster declarations in Virginia from 1957 through March 2022. Tropical systems, flooding, and winter weather tend to have greater impacts and result in the most declarations in the Commonwealth; in 1996 and 2003 one of each of these hazards was declared in Virginia. Twelve jurisdictions have had 24 or more disasters during the period 1969 to March 2022.

Table 3-6 - Federal Emergency and Disaster Declarations in Virginia 1957-2022

Disaster Number	Date of Declaration	Disaster Type	Jurisdictions Declared
68	February 1957	Flood	NA
123	March 1962	Severe Storms, High Tides, Flooding	NA
149	March 1963	Flood	NA
274	August 1969	Severe Storms and Flooding (Hurricane Camille)	27
339	June 1972	Hurricane Agnes	106
358	October 1972	Severe Storms and Flooding	3
359	October 1972	Severe Storms and Flooding	31
3018*	October 1976	Drought	38
525	January 1977	Ice Conditions	39
530	April 1977	Severe Storms and Flooding	16
3046*	July 1977	Drought	62
543	November 1977	Severe Storms and Flooding	8
593	July 1979	Storms and Flash Flooding	1
606	September 1979	Severe Storms and Flooding	1
707	May 1984	Severe Storms and Flooding	3
755	November 1985	Severe Storms and Flooding	52
847	November 1989	Severe Storms, Mudslides, and Flooding	1
944	May 1992	Severe Storms and Flooding	28
3112*	March 1993	Severe Winter Storm	136
1007	December 1993	Severe Storms and Tornadoes	1
1014	March 1994	Severe Ice Storms, Flooding	72
1021	April 1994	Severe Winter Ice Storm	33
1059	July 1995	Severe Storms and Flooding	24
1086	January 1996	Blizzard of 1996 (severe storm)	127
1098	January 1996	Flooding -- Snow Melt	27
1135	September 1996	Hurricane Fran	55
1242	September 1998	Hurricane Bonnie	5
1290	September 1999	Tropical Storm Dennis	1
1293	September 1999	Hurricane Floyd	47
1318	February 2000	Winter Storms	109

Disaster Number	Date of Declaration	Disaster Type	Jurisdictions Declared
1386	July 2001	Southwest VA Floods	10
3168*	September 2001	Terrorist Attack Emergency Declaration	1
1392	September 2001	Pentagon Attack	1
2394**	November 2001	Heard Mountain Fire Complex	2
2393**	November 2001	Shenandoah Gap Fire Complex	1
2390**	November 2001	Far Southwest Fire Complex	3
2397**	February 2002	Fultz Run Fire	1
1406	April 2002	Southwest VA Floods	10
1411	May 2002	Floods/Tornadoes	9
1458	April 2003	NOVA Snowstorm and SW VA Floods	22
1491	September 2003	Hurricane Isabel	100
1502	November 2003	SW Virginia Floods	6
1525	June 2004	Severe, Storms, Tornadoes, and Flooding	4
1544	September 2004	Severe Storms, Flooding and Tornadoes Associated with Tropical Depression Gaston	10
1570	October 2004	Severe Storms and Flooding from the remnants of Hurricane Jeanne	10
3240*	September 2005	Hurricane Katrina Evacuation	1
2637**	April 2006	Bull Mountain Fire	1
1655	July 2006	Severe Storms, Tornadoes, And Flooding	10
1661	September 2006	Tropical Depression Ernesto, Severe Storms and Flooding	22
1862	December 2009	Severe Storms and Flooding Associated with Tropical Depression Ida and a November Nor'easter	12
1874	February 2010	Severe December Winter Storm (Heavy snow, rain and high winds)	50
1905	April 2010	Severe February Winter Storms and Snowstorms	38
2860**	February 2011	Smith Fire	1
2861**	February 2011	Coffman Fire	1
3329*	August 2011	Hurricane Irene	30
4024	September 2011	August Hurricane Irene	48
4042	November 2011	August Earthquake	9
4045	November 2011	Remnants of September Tropical Storm Lee	8
4072	July 2012	June and July Severe Storms and Straight-line Winds (Derecho)	69
3359*	October 2012	Hurricane Sandy	134
4092	November 2012	October Hurricane Sandy	28
4262	January 2016	Severe Winter Storm and Snowstorm	30
4291	October 2016	Hurricane Mathew	8
4401	October 2018	Hurricane Florence	32
4411	December 2018	Hurricane Michael	36
4512	April 2020	COVID-19 Pandemic	Statewide
4602	May 2021	Severe Winter Storms	31
4628	October 2021	Flooding, Landslides, and Mudslides	1
4644	March 2022	Severe Winter Storm and Snowstorm	28

*FEMA Emergency Declarations
**FEMA Fire Management Assistance Declarations

Following is a summary description of selected declared disasters; dollar value of damages is not adjusted for inflation:

- **Ash Wednesday Storm in 1962 -** Damage was experienced throughout the Tidewater region. Houses along the coast and bay region were damaged and flooded by high waves and seven to nine-foot water rises. Virginia Beach's concrete boardwalk and sea wall were damaged, and extensive shoreline erosion occurred. The City of Hampton had an estimated $4 million in wind and flood damage. Two feet of snow fell from Charlottesville (21 inches) to Luray (24 inches), to Winchester (22 inches) setting new records.
- **Hurricane Camille in 1969 -** This major storm made landfall out of the Gulf of Mexico as a Category 5 Hurricane and weakened to a tropical depression before reaching Virginia. Nelson County received more than 27 inches of rain and the area from Lynchburg to Charlottesville received over 10 inches. Flooding and landslides, triggered by saturated soils, resulted in catastrophic damage. More than 150 people died, another 100 were injured, and 113 bridges were washed out. At the time, damage was estimated at more than $113 million.
- **Hurricane Agnes in 1972 -** This event produced devastating flooding throughout the Mid-Atlantic States. Some areas of eastern Virginia received more than 15 inches of rainfall. The Potomac and James Rivers experienced major flooding, which created five to eight foot flood waters in many locations. Richmond was impacted the most by these high-water levels. Water supply and sewage treatment plants were inundated, as were electric and gas plants. Four of the five bridges that cross the James River were impassable, the downtown area was closed for several days, and businesses and industries in the area suffered immense damage. A total of 16 people lost their lives and damage was estimated at $222 million. In all, 63 counties and 23 cities qualified for disaster relief.
- **Tornado in 1973 -** This F3 tornado impacted heavily populated areas of Northern Virginia and caused $25 million in damage. The tornado touched down in Prince William County and traveled through the cities of Fairfax and Falls Church before dissipating. Fairfax was hit hardest by this tornado; within a six-mile damage path, a high school, two shopping centers, an apartment complex, and 226 homes were damaged or destroyed. A total of 37 people were injured.
- **Super Tornado Outbreak in 1974 -** This was the worst recorded tornado outbreak in US history at the time, generating the most tornadoes in a 24-hour period. Virginia was one of states struck with 148 observed tornadoes that killed 315 people and injured thousands. Eight tornadoes occurred in Virginia, with wind damage reported in counties from Russell northward to Loudoun. Hundreds of homes, barns, and mobile homes were damaged or destroyed.
- **The Blizzard of 1983 -** An unusually large area of the state was covered with more than 12 inches of snow, setting new records in many places. Richmond received 18 inches, while portions of northern Virginia had almost 30 inches. 25 mph wind gusts created high snowdrifts and complicated road clearing, resulting in more than $9 million in snow removal costs.
- **Severe Weather Outbreak in 1984 -** Severe weather pushed through the state on May 8, spawning tornadoes and producing significant downburst wind damage in central and

eastern Virginia. A strong F3 tornado occurred in Hopewell and tracked into Charles City County as an F2. There was extensive home, mobile home, building, and tree damage from these cluster thunderstorms, imbedded tornadoes and windstorms; total damage costs exceeded $50 million.

- **Election Day Flood in 1985 -** Heavy rainfall, indirectly related to Hurricane Juan, from October 31 through November 6, 1985, caused record-breaking floods over a large region, including western and northern Virginia. The Roanoke River rose seven feet in one hour and 18 feet in six hours, cresting at 23 feet on November 5. There were 22 flood related deaths in Virginia. FEMA declared 50 jurisdictions disaster areas. Approximately 1.7 million people were affected by the flooding; damages were estimated at $800 million.
- **The Storm of the Century in 1993 -** Affecting nearly the entire East Coast, this winter storm killed 200 people and generated several billion dollars in damage and snow removal. Although its effects in Virginia did not exceed the Ash Wednesday Storm in 1962, it affected communities from the Chesapeake Bay to Southwest Virginia. Blizzard conditions in western Virginia dropped two to three feet of snow and produced snowdrifts up to 12 feet deep. Snow removal and clean-up costs were estimated at $16 million for the state.
- **The Petersburg/Colonial Heights Tornado in 1993 -** This tornado outbreak killed four people and injured 238. The strongest tornado touched down in Petersburg as an F4, with maximum winds estimated at 210 mph. The tornado jumped I-95 and smashed into a Wal-Mart causing the ceiling to collapse. Three people died. Major damage occurred in the Old Towne section of Petersburg, destroying several stores and businesses in Colonial Heights. Other tornadoes hit the same day in the Cities of Newport News and Chesapeake. In four hours, 18 tornadoes carved paths through southeast Virginia, setting a Commonwealth record. Total damage was estimated at $52.5 million.
- **Ice Storm of 1994 -** This winter storm coated large portions of eastern and southeastern Virginia with one to three inches of ice, freezing rain, and sleet. This led to the loss of approximately 10 to 20 percent of trees in some counties, which blocked roads and caused many customers to be without power for a week. There were numerous automobile accidents and injuries from people falling on ice. Damages were estimated at $61 million.
- **The Blizzard and Flooding of Winter 1996 -** Also known as the ‘Great Furlough Storm’ due to Congressional impasse over the federal budget, the blizzard paralyzed the Interstate 95 corridor, and reached westward into the Appalachians where snow depths of more than 48 inches were recorded. Several local governments and schools were closed for more than a week. The blizzard was followed by another storm, which blanketed the entire state with at least one foot of snow. To compound matters, heavy snowfall piled on top of this storm’s accumulations in the next week, which kept snowpack on the ground for an extended period. This snow was eventually thawed by higher temperatures and heavy rain that fell after this thaw resulted in severe flooding. Total damage between the blizzard and subsequent flooding exceeded $30 million.
- **Hurricane Fran in 1996 -** This September 6 hurricane resulted in a record number of customers without power and closure of 78 primary and 853 secondary roads. Rainfall amounts between eight and 20 inches fell over the mountains and Shenandoah Valley, leading to record-level flooding within this region. 100 people had to be rescued from the

floodwaters and hundreds of homes and buildings were damaged by the floodwaters and high winds. $350 million in damages.

- **The Christmas Ice Storm in 1998 -** This prolonged ice storm struck central and southeast Virginia in the days leading up to Christmas. Ice accumulations exceeded an inch, bringing down many trees and power lines within this region. 400,000 people were without power on Christmas Eve; outages extended for 10 days in some regions. Property damage from this storm was estimated to be around $20 million.
- **Wildfires of 1999 -** The Purgatory Mountain Fire in Botetourt County, one of the largest fires of the year, burned 1,285 acres and cost more than $166,000 to contain. A fire on Clinch Mountain in Southwest Virginia burned only 240 acres but containment costs exceeded $97,000 due to the mountainous terrain and extreme drought conditions. A total of 1,749 fires burned 12,118 acres, considerably exceeding the five-year annual average of 1,320 fires and 6,081 acres.
- **Hurricane Floyd in 1999 -** This large hurricane brought 10 to 20 inches of total rainfall over portions of southeast Virginia, with wind gusts up to 100 mph and storm surges approaching seven feet. These three elements combined caused storm damages of approximately $255 million. This disaster impacted the City of Franklin and Southampton and Isle of Wight Counties, as well as the other 44 Virginia jurisdictions included in the major disaster declaration. More than 8,900 homes, businesses and public facilities were either destroyed, significantly damaged, or sustained moderate impacts. In addition to direct property damage, lost business revenues were estimated at $13.1 million, with the City of Franklin losing nearly $2 million in tax revenues. Direct crop losses were estimated at $17 million.
- **Terrorist Attack in 2001 -** American Airlines Flight 77 was hijacked and flown into the Pentagon in Arlington County. The hijacking resulted in 150 fatalities when it crashed into the west side of the building.
- **Southwest Virginia Flooding, 2001-2004 -** A total of six federal disasters, primarily flooding and severe storms, were declared in Southwest Virginia from 2001-2004 (Disasters 1386, 1406, 1411, 1458, 1502, 1525 and 1570). The worse hit counties were Tazewell (all 6 disasters), Buchanan (5 disasters), and Russell (4 disasters). Dickenson, Lee, Smyth, and Wise Counties were also declared in half of these disasters. Many of these disasters have storm tracks along the mountain valleys, producing excessive localized flooding. Catastrophic flooding was experienced in rural settlements as well as in Bluefield, Hurley, Appalachia, Pennington Gap, Norton, Dante and Wise.
- **Hurricane Isabel in 2003 -** Hurricane Isabel entered Virginia September 18 after making landfall along the North Carolina Outer Banks. The Commonwealth sustained tropical storm winds for 29 hours with maximum sustained winds recorded at 69 mph. The hurricane produced storm surge of five to eight feet along the coast and in the Chesapeake Bay with rainfall totals between two and 11 inches along its track. Rainfall of 21 inches was measured near Waynesboro Virginia. Damage due to wind, rain, and storm surge resulted in flooding, electrical outages, debris, transportation interruptions, and damaged homes and businesses. At the height of the incident, approximately 6,000 residents were housed in 134 shelters and curfews were imposed in many jurisdictions. Further damage

occurred when a series of thunderstorms and tornadoes came through many of the designated areas in the southeast portion of Virginia on September 23. There was a total of 36 confirmed fatalities. More than 93,000 individuals, families and businesses registered for federal assistance. Residential impacts included 1,186 homes reported destroyed and 9,110 with major damage, 107,908 minor damage; losses estimated to exceed $590 million. Of the 1,470 businesses involved, 77 were reported destroyed, 333 suffered major damage and 1,060 businesses suffered minor or casual damage, with losses exceeding $84 million. Public assistance exceeded $250 million. More than two-thirds of households and businesses within the Commonwealth were without power. Remote locations did not have power restored for three weeks.

- **Hurricane Gaston in 2004 -** Tropical Depression Gaston (renamed Hurricane Gaston) moved into Virginia from the south during the morning of Monday, August 30, 2004. Although forecasts called for accumulations of one to three inches in Central Virginia, the system stalled over the Richmond metropolitan area resulting in 14 inches of rain. Homes, apartments, and businesses in low-lying areas of the Greater Richmond Metropolitan area were flooded. I-95, I-64, and I-195 were closed for flooding or damage. The Office of the Chief Medical Examiner confirmed nine deaths directly linked to Tropical Depression Gaston. The hurricane caused $130 million in damages.
- **Tropical Depression Ernesto in 2006 –** Briefly a hurricane in the Caribbean, Tropical Depression Ernesto moved into Virginia on September 1. The system slowed over coastal and eastern Virginia, causing rainfall accumulations of up to 10 inches of rain in the cities of Hampton, Poquoson and Newport News. Serious flooding and shoreline damage occurred in Northern Neck with damages most significant in Northumberland, Lancaster and Westmoreland Counties. With an estimated $118 million in damages, a public assistance disaster declaration provided aid to the Commonwealth and 25 local governments.
- **November Nor'easter and Tropical Depression Ida in 2009 -** A combination of a nor’easter and the remnants of Tropical Depression Ida led to significant rainfall which caused flooding and damage amounting to approximately $388 million, $25 million of which was in Norfolk alone. The areas affected were Hampton, Newport News, Norfolk, Virginia Beach, Chesapeake, Poquoson, Portsmouth, James City County, and York County[2].
- **Severe December Winter Storm in 2009 -** A nor’easter that formed over the Gulf of Mexico developed into a winter storm affecting much of the East Coast. The highest single day snowfall associated with this storm was 27 inches reported at the weather station in Buchanan.
- **Severe February Winter Storm in 2010 -** A nor’easter developed into a winter storm that produced significant snowfall affecting northern Virginia. The highest single day snowfall associated with this storm was 34 inches reported at the weather station near Purcellville in Loudoun County.
- **Hurricane Irene in 2011 -** Hurricane Irene was a large tropical cyclone affecting the Caribbean and East Coast of the US. Hurricane Irene was initially announced as an emergency declaration, but was declared a major disaster, resulting in federal funding. The

Commonwealth experienced the second highest number of power outages ever with 2.5 million citizens without power after the storm. Irene is ranked as the seventh costliest hurricane in US history, costing approximately $15.8 billion[3].

- **Mineral Earthquake in 2011 -** On August 23, 2011, a 5.8 magnitude earthquake occurred approximately seven miles from Mineral, Virginia close to Louisa County. Hundreds of aftershocks were felt for several days. Some of these aftershocks were recorded at a 4.5 magnitude[4]. Louisa County received over $6.6 million in Individual Assistance as well as $1.6 million in low-interest loans to individuals and businesses through the Small Business Administration[5].
- **Tropical Storm Lee in 2011 -** Tropical Storm Lee caused heavy rain and flooding in Virginia on September 8 and 9, 2011. Caroline, Essex, Fairfax, King and Queen, King George, Prince William, and Westmoreland Counties, and the City of Alexandria were approved for federal disaster assistance. The heavy rain caused significant damage to neighborhoods and businesses in Fairfax and Prince William Counties. Approximately 500 individuals were displaced from their homes in Prince William County[6].
- **Derecho in 2012 -** Severe thunderstorms and straight-line winds exceeding 80 mph impacted Virginia on the evening of June 29 and the morning hours of July 1. Fifteen storm-related deaths were reported[7]. A large portion of the Commonwealth lost power for several days, during a significant heat wave.
- **Hurricane Sandy in 2012 -** Hurricane Sandy was declared a major disaster in Virginia on November 26, 2012, following damage assessment surveys. The declaration included Individual Assistance for Accomack County, Public Assistance for 25 counties and three independent cities, and Hazard Mitigation Assistance for all jurisdictions in the commonwealth. Damage assessments found that approximately 245 residential structures were affected, and that the primary impact was damage to utilities. $10.5 million was obligated under the Public Assistance Program for affected jurisdictions[8].
- **Severe Winter Storm and Snowstorm in 2016 -** The Commonwealth was impacted by a severe winter storm on January 22 and 23, 2016, resulting in a Presidential Disaster Declaration. The declaration authorized reimbursement for emergency protective measures for 25 jurisdictions, resulting in more than $47 million obligated to impacted jurisdictions[9].
- **Hurricane Matthew in 2016 -** Hurricane Matthew impacted a large swath of the eastern seaboard in 2016, including Virginia. The governor requested and received Individual Assistance for seven cities and two counties, and Hazard Mitigation Assistance for the entire commonwealth; the declaration was later amended to include Public Assistance. The Preliminary Damage Assessment found that 2,306 residential structures were impacted by Matthew. More than $10 million in Individual Assistance funding was obligated, along with $6.1 million in Public Assistance funding[10].
- **Hurricane Florence in 2018 -** On October 3, the governor requested a major disaster declaration due to Hurricane Florence during the period of September 8-21, 2018. Public Assistance was requested for 20 counties and six independent cities as well as Hazard Mitigation assistance for the entire Commonwealth. The declaration authorized Public Assistance reimbursement for emergency protective measures totaling over $34 million.

- **Hurricane Michael in 2018 -** On December 5, the Governor requested a major disaster declaration due to Hurricane Michael during the period of October 9-16. The governor requested a declaration for Public Assistance for 25 counties and two independent cities and Hazard Mitigation for the entire Commonwealth. Beginning on October 5, 2018, joint Federal, Commonwealth, and local government Preliminary Damage Assessments were conducted for 27 counties in Virginia resulting in $37 million in damages.
- **Virginia COVID-19 Pandemic, 2020 -** On March 30, Virginia requested a major disaster declaration due to the Coronavirus Disease 2019 (COVID-19) pandemic beginning on January 20. The governor requested a declaration for the Individuals and Households Program, Crisis Counseling Program, Disaster Unemployment Assistance, Disaster Legal Services, and Disaster Case Management under the Individual Assistance program for the entire commonwealth; emergency protective measures (Category B), including direct Federal assistance and Transitional Sheltering Assistance under the Public Assistance program for the entire Commonwealth; and Hazard Mitigation for the entire Commonwealth. This event was of the severity and magnitude that the need for supplemental Federal assistance was granted prior to the completion of joint Federal, Commonwealth, and local government Preliminary Damage Assessments.
- **Severe Winter Storms in 2021 -** On April 15, Virginia requested a major disaster declaration due to severe winter storms during the period of February 11-13, 2021. The governor requested Public Assistance for 31 counties and Hazard Mitigation for the entire commonwealth. During the period of March 22 to April 19, 2021, joint federal, commonwealth, and local government Preliminary Damage Assessments were conducted in the 31 counties requested. More than $24 million in Public Assistance funding for damage to utilities was estimated.

3.4.2 Federal Disaster Data Compilation

Federally Declared Disaster data from previous hazard mitigation plans were used as the starting point to update the records. Once the data from the new sources was compiled and all available missing data were filled in using FEMA's Declared Disasters webpage, the data were ready to be processed into HIRA categories. Descriptions of the disasters can vary quite dramatically; thus, they needed to be grouped into broad hazard type categories for comparison. **Table 3-7** shows how the declared disaster categories were grouped into the HIRA hazard categories.

Table 3-7 - FEMA disasters declarations to align with the HIRA hazards

HIRA Category	General Categories Included
Drought	Drought
Flood	Flood Flood / Tornado Hurricane Thunderstorm / Flood Thunderstorm / Flood / Landslide Winter Storm / Flood
Non-Tornadic Wind	Hurricane Thunderstorm / Flood Thunderstorm / Flood / Landslide Thunderstorm / Tornado / Flood Thunderstorm / Tornado Tropical Storm
Hurricane	Hurricane / Flood / Landslide Tornado
Tornado	Flood / Tornado Thunderstorm / Tornado / Flood Thunderstorm / Tornado
Winter Weather	Winter Storm Winter Storm / Flood
Wildfire	Wildfire
Landslide	Thunderstorm / Flood / Landslide
Impoundment Failure (flooding)	NA

Since many of these disaster declarations have multiple events and cover large geographic areas, there is the possibility that a municipality has received funding for a disaster that did not occur in that municipality. For example, an event that included severe storms, flooding, and tornadoes, could have only had a tornado in one county, while disaster assistance was provided to multiple counties. Early disaster records have significantly less information and detail than modern records, preventing a thorough breakdown of multi-jurisdictional declarations.

In order to visualize the number of different disaster types that have impacted Virginia, the maps showing the individual federally declared disasters have been double counted when different hazards have occurred during a single event. For example, the storm in July 2006 (DR- 1655) was classified by FEMA as Severe Storms, Tornado, and Flooding. To show these as separate events each designated county was given a score of one for each of the event types for this one declared disaster. Each declared disaster is represented from the assigned FEMA categories. This may result in some categories not being represented to their fullest.

The total number of declared disasters (Figure 3-9) does not double count these events; the total number of individual hazard events for each county combined will not equal the total number of declared disasters. In addition, contiguous communities may have been added for communities declared for disasters.

Figure 3-9 - Total number of declared disasters 1969 through March 2022.

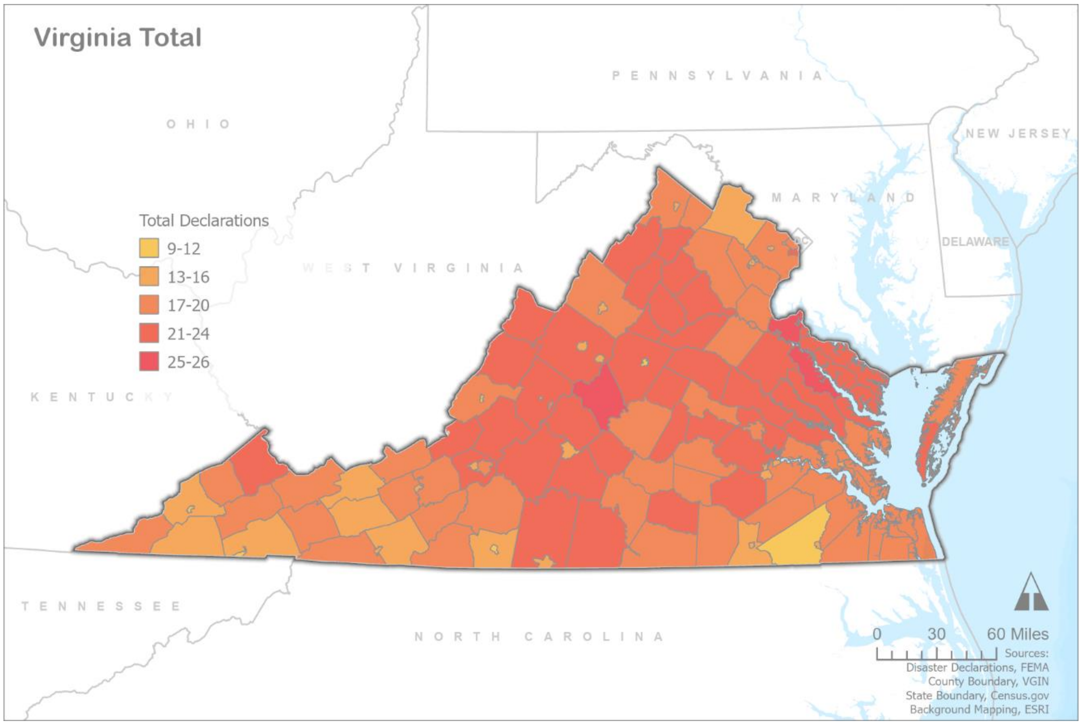


Figure 3-10 through Figure 3-18 show the number of declared disasters, by jurisdiction, for the individual hazard HIRA categories between 1969 and January 2022. Flood, hurricane, and non-tornadic wind represent most of the Presidential Disaster Declarations in Virginia. Drought, earthquake, extreme cold/winter weather, landslide, pandemic, tornado, and wildfire are hazards with a relatively lower number of presidential disaster declarations in Virginia. Erosion, extreme heat, karst (sinkholes), land subsidence, impoundment failure, and space weather have been considered in this plan, but do not have any federally declared disasters; this does not imply that these hazards have not occurred or have not occurred in conjunction with another federally declared disaster.

The following jurisdictions have experienced 24 or more declared disasters from 1969 through January 2022:

- Bedford County
- Chesterfield County
- Essex County
- Greene County
- King and Queen County
- King George County
- Lancaster County
- Louisa County
- Nelson County
- Northumberland
- Rappahannock
- Westmoreland

Figure 3-10 - Number of Presidential Declarations in Virginia for Drought.

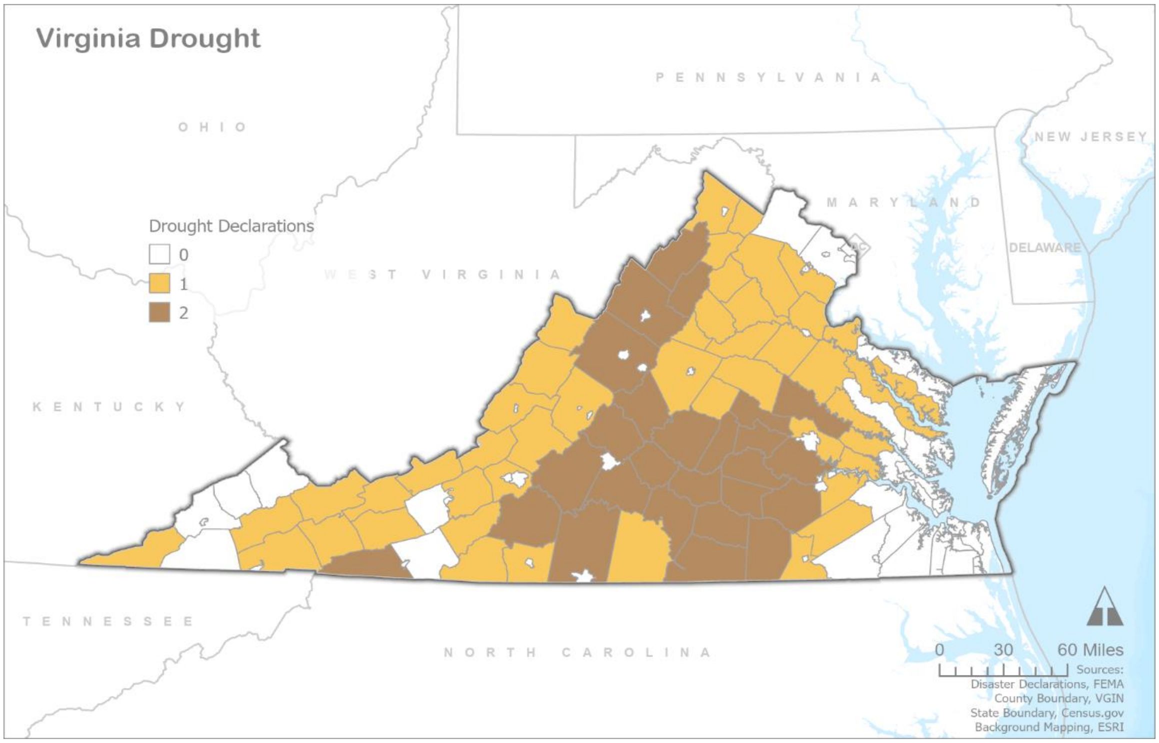


Figure 3-11 - Number of Presidential Declarations in Virginia for Earthquake.

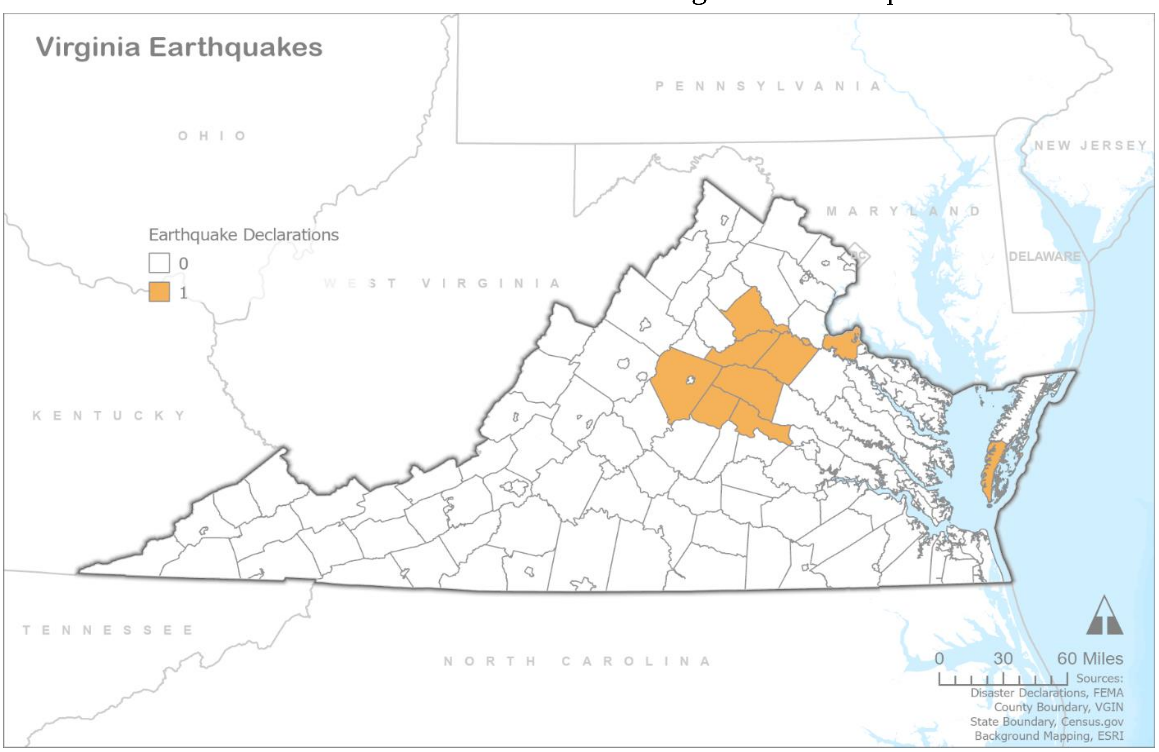


Figure 3-12 - Number of Presidential Declarations in Virginia for Extreme Cold/Winter Weather.

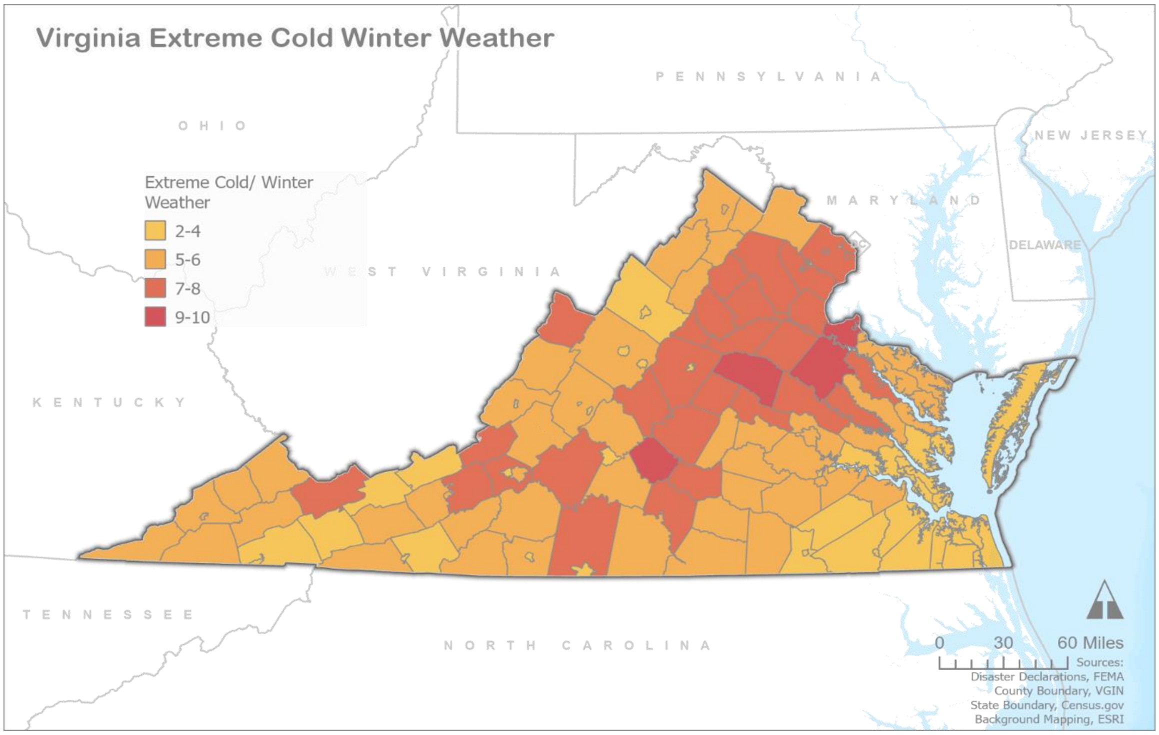


Figure 3-13 - Number of Presidential Declarations in Virginia for Flooding.

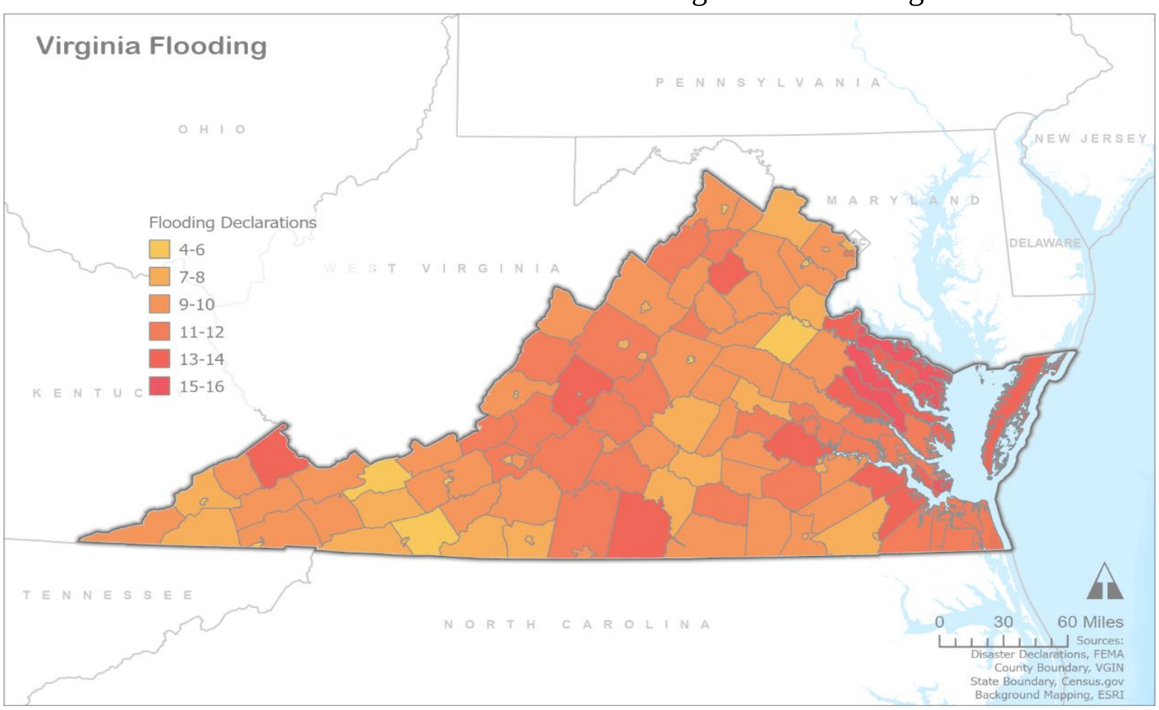


Figure 3-14 - Number of Presidential Declarations in Virginia for Hurricane.

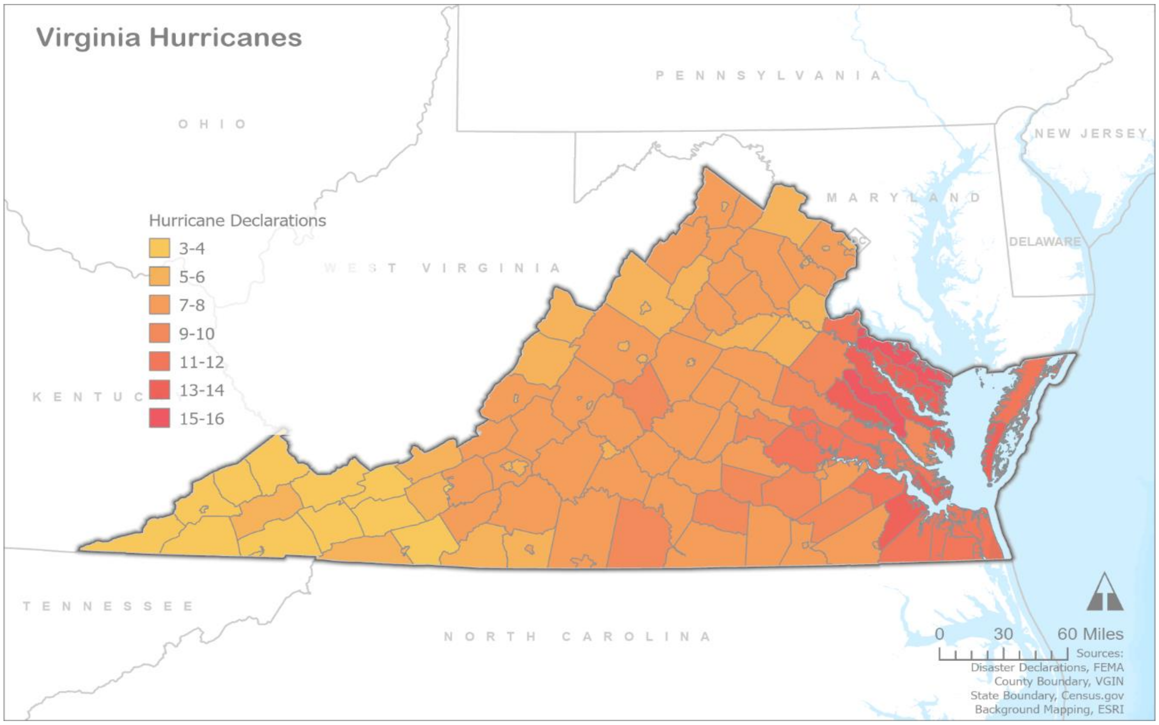


Figure 3-15 - Number of Presidential Declarations in Virginia for Landslide.

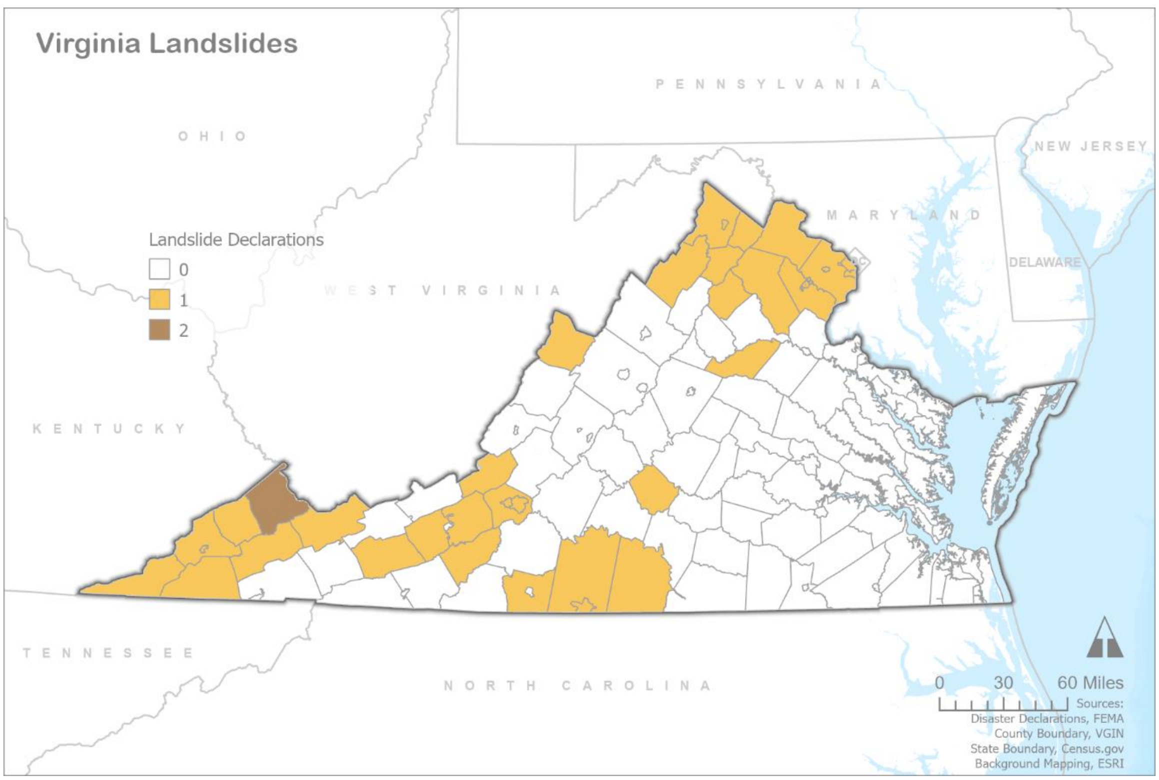


Figure 3-16 - Number of Presidential Declarations in Virginia for Non-Tornadic Wind.

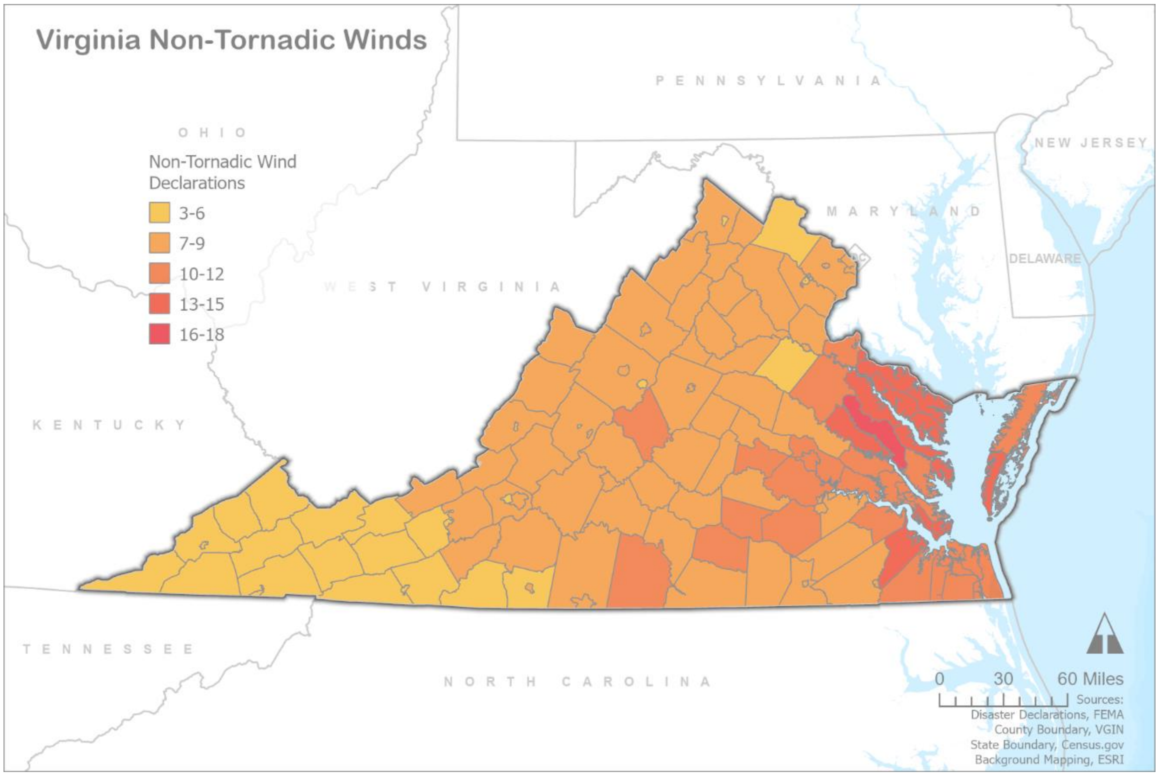


Figure 3-17 - Number of Presidential Declarations in Virginia for Tornado.

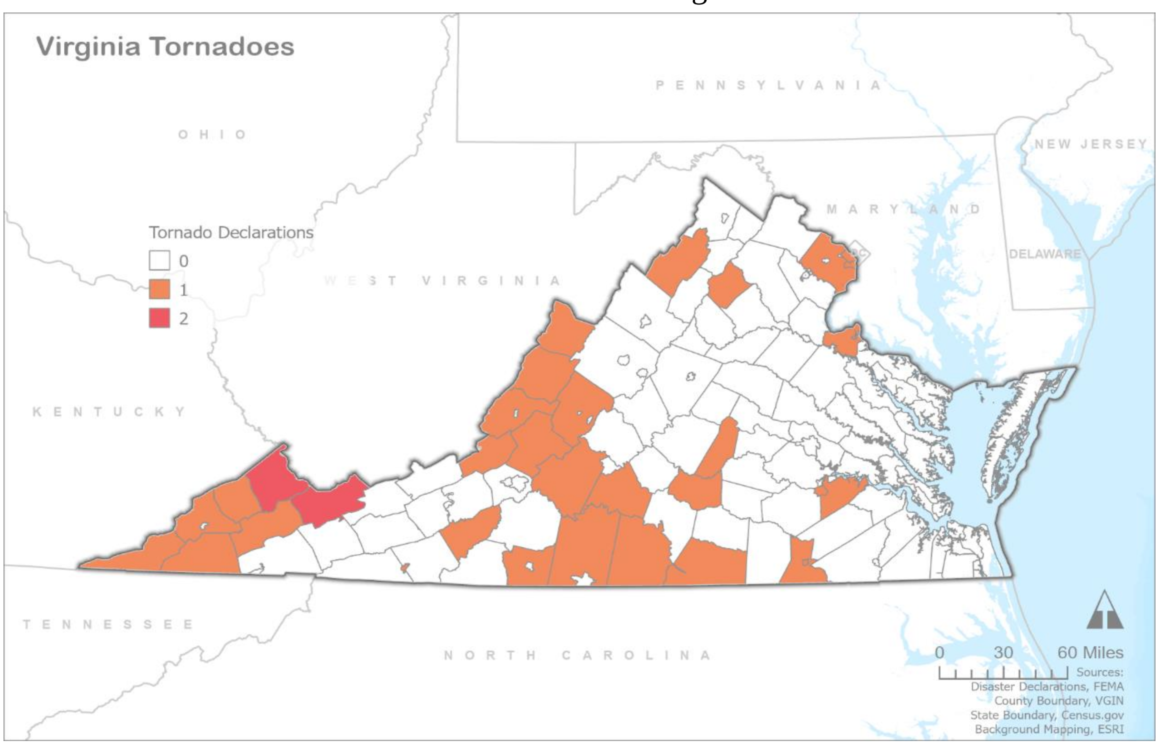
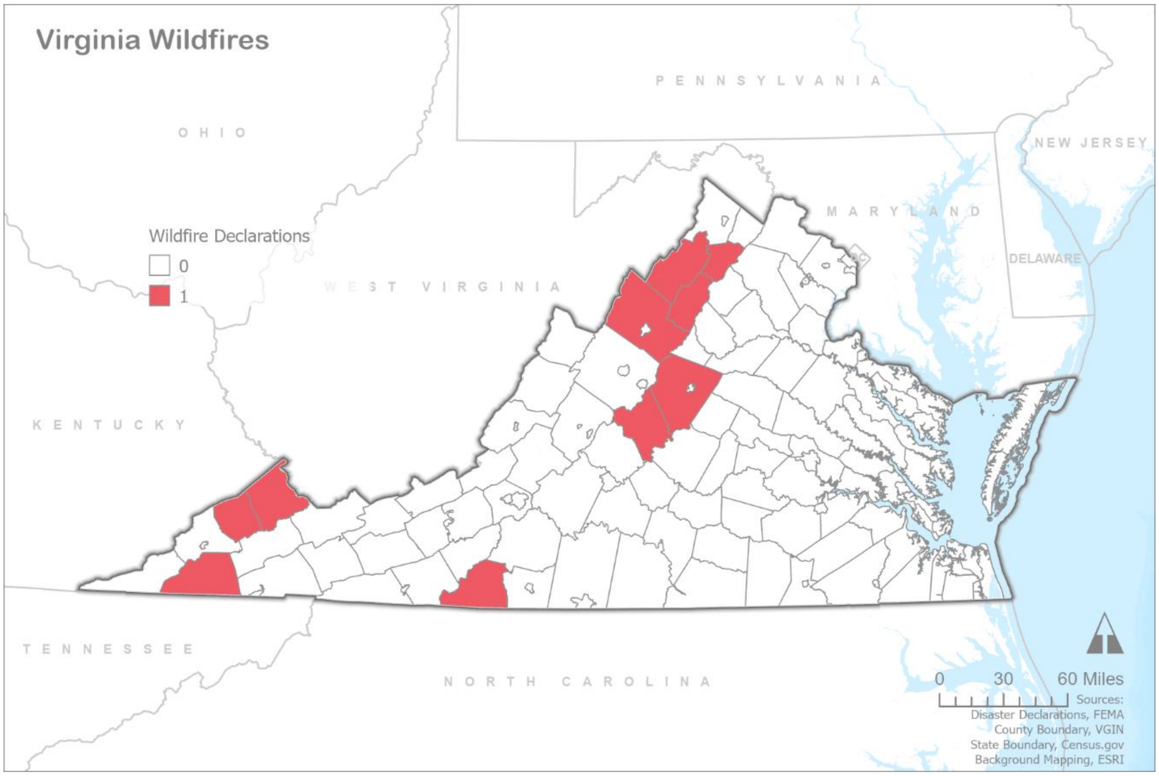


Figure 3-18 - Number of Presidential Declarations in Virginia for Wildfire.



3.5 National Centers for Environmental Information Storm Events Database

3.5.1 Storm Data Background

The National Centers for Environmental Information (NCEI) *Storm Events Database* is published by the National Oceanic and Atmospheric Administration (NOAA). The *Storm Events Database* contains information on storms and weather phenomena that have caused loss of life, injuries, significant property damage, and/or disruption to commerce. Efforts are made to collect the best available information, but information may be unverified by the National Weather Service (NWS). The NWS does not guarantee the accuracy or validity of the information. Although NWS issues guidelines for preparation of event descriptions, the historical records often vary widely in their level of detail[12].

For this update, VDEM collected *Storm Events Database* records containing information about significant weather events from January 1, 1950, through December 31, 2021. Records for most weather event categories were reported starting in 1993, except for tornado (1951), thunderstorm winds (1955), and hail (1955).

NCEI data are relatively unreliable with regard to geological hazards (i.e., earthquake, landslide, karst). NCEI records for these events under-represent events in Virginia, yet still represent the best history and damage estimates available. The NCEI database provided the county or city in which the event occurred in one of two methods:

- County/City Name – Event listed as individual record for each county or city in which it occurred.
- Zone – Event listed by the zone or multiple zones, which contain multiple counties and cities. Some individual rows in NCEI data could include every county and city in Virginia.

3.5.2 Normalizing Data

Table 3-8 provides the normalized sum of hazard events, by type, for all jurisdictions in Virginia. In this table, the damages, injuries, and deaths due to each hazard type have not been annualized to account for their varying periods of record. Each event in this table represents a storm event affecting a single jurisdiction.

Table 3-8 - Jurisdictional analysis of NCEI Hazard Events

Hazard Type	Timeframe	Years of Record	Number of Episodes	Property Damage ($million)	Crop Damage ($million)	Direct Injury	Indirect Injury	Direct Deaths	Indirect Deaths
Drought	1996-2022	26	69	0.00	668.49	0	0	0	0
Excessive Heat	1996-2022	26	107	0.00	0.00	142	17	4	5
Flood	1996-2022	26	1,687	1,063.49	96.70	18	0	60	0
Hurricane	1996-2022	26	30	1,169.12	165.60	34	0	12	0
Landslide	1996-2022	26	6	0.90	0.00	0	0	0	0
Non-Tornadic Wind	1955-2022	67	3,238	288.28	39.86	415	18	39	5
Tornado	1951-2022	71	105	1,079.53	2.89	943	0	38	1
Wildfire	1996-2022	26	26	12.60	2.96	4	0	0	0
Winter Storm Count	1996-2022	26	1,115	71.10	45.48	25	32	19	13
Totals			**6,383**	**3,685.02**	**1,021.98**	**1,0581**	**67**	**172**	**24**

3.5.3 Inflation Computation

The damages entered in the NCEI *Storm Events Database* portray how much estimated damage was incurred in the year of the event. Due to inflation and the changing value of money, the values of damages incurred have been adjusted to reflect 2021-dollar value.[iii] This calculation utilized the US Bureau of Labor Statistics 2021 yearly index of Consumer Prices divided by the index value in occurrence year.

3.5.4 Data Compilation

Because the NCEI *Storm Events Database* uses detailed event categories, the reported storm events were summarized in simplified classifications to correspond to the major hazard types considered in this HIRA. **Table 3-9** shows how the NCEI categories were grouped into the

HIRA hazard categories. Section 3.7 on ranking methodologies also explains how the NCEI data were used in ranking the hazards against each other.

Table 3-9 - NCEI categories to align with hazards addressed in the HIRA

HIRA Category	NCEI Categories Included
Drought	Drought
Flood	Coastal Flood Flash Flood Flood Heavy Rain Storm Surge
Non-Tornadic Wind	Marine High Wind Marine Strong Wind Marine Thunderstorm Wind Strong Wind Thunderstorm Wind Tropical Depression Tropical Storm
Hurricane	High Wind Hurricane (Typhoon)
Tornado	Funnel Cloud Tornado Waterspout
Winter Weather	Avalanche Blizzard Cold/ Wind Chill Extreme Cold/Wind Chill Freezing Fog Frost/Freeze Ice Storm Sleet Winter Storm Winter Weather
Wildfire	Dense Smoke Wildfire
Landslide	Debris Flow

Table 3-8 shows the number of NCEI hazard events for the Commonwealth. High wind and winter storm events make up more than 90% of the events for those jurisdictions with 600 or more NCEI recorded events for flood, non-tornadic wind, and winter storm, which include:

- Fairfax County
- Loudoun County
- Fauquier County
- Albemarle County
- Prince William County
- Franklin County
- Pittsylvania County
- Shenandoah County
- Frederick County
- Augusta County
- Halifax County

Flood, non-tornadic wind, and winter weather represent most of the documented weather-related events in Virginia. Extreme cold, earthquakes, erosion, land subsidence, pandemic, space weather, karst (sinkholes), and impoundment failure are hazards that have been considered for the Commonwealth but currently do not have NCEI events associated with them. Figure 3-19 shows the total number of NCEI hazard events by jurisdiction.

Figure 3-19 - Total number of NCEI hazard events by jurisdiction for Virginia.

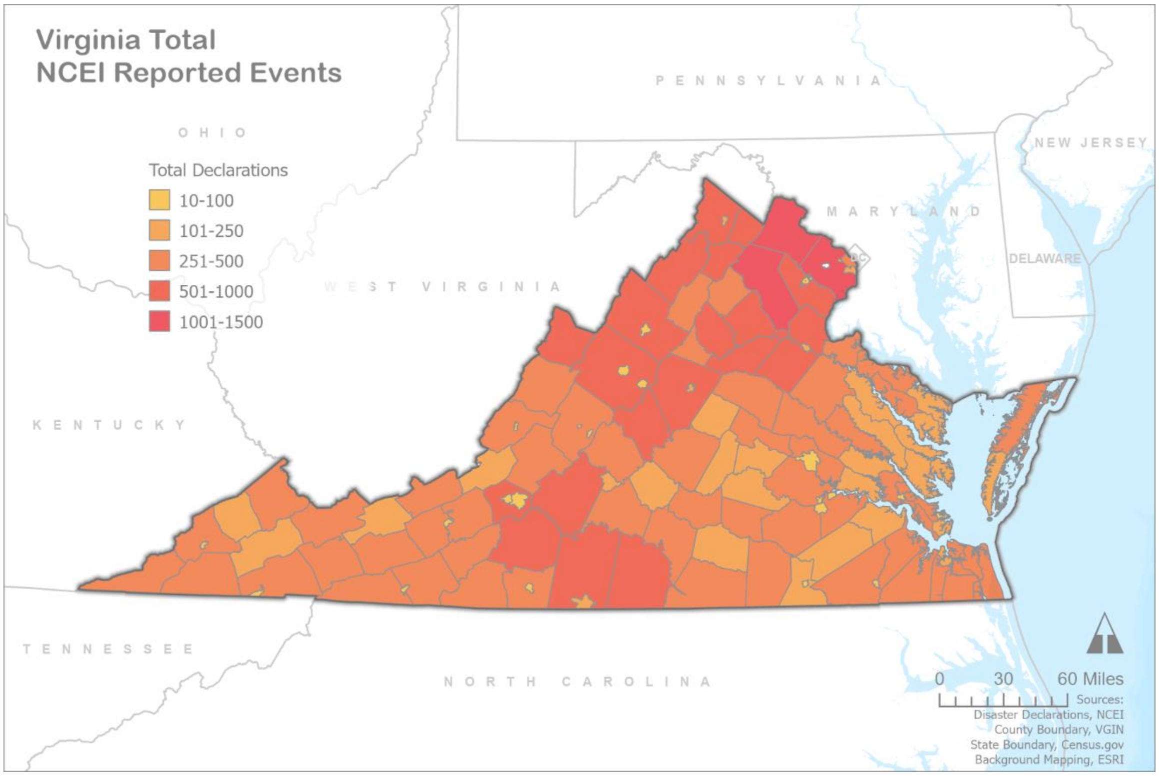


Figure 3-20 through **Figure 3-28** show the number of NCEI recorded events, by jurisdiction, for the individual hazard categories for this HIRA. Unlike the Federally declared disasters, the individual hazard maps do not double count events. To be consistent with the NCEI data, only the dominant hazard type is shown, as described in the above sections.

Figure 3-20 - Number of NCEI Drought Events in Virginia.

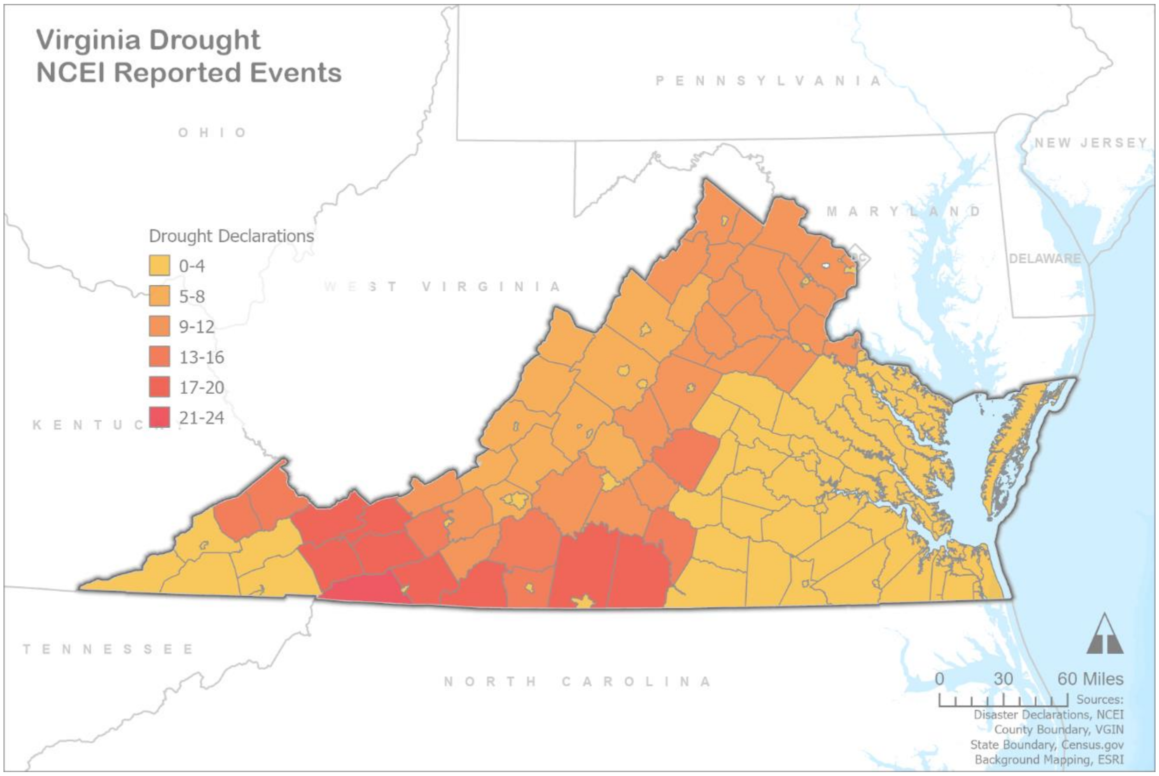


Figure 3-21 - Number of NCEI Excessive Heat Events in Virginia.

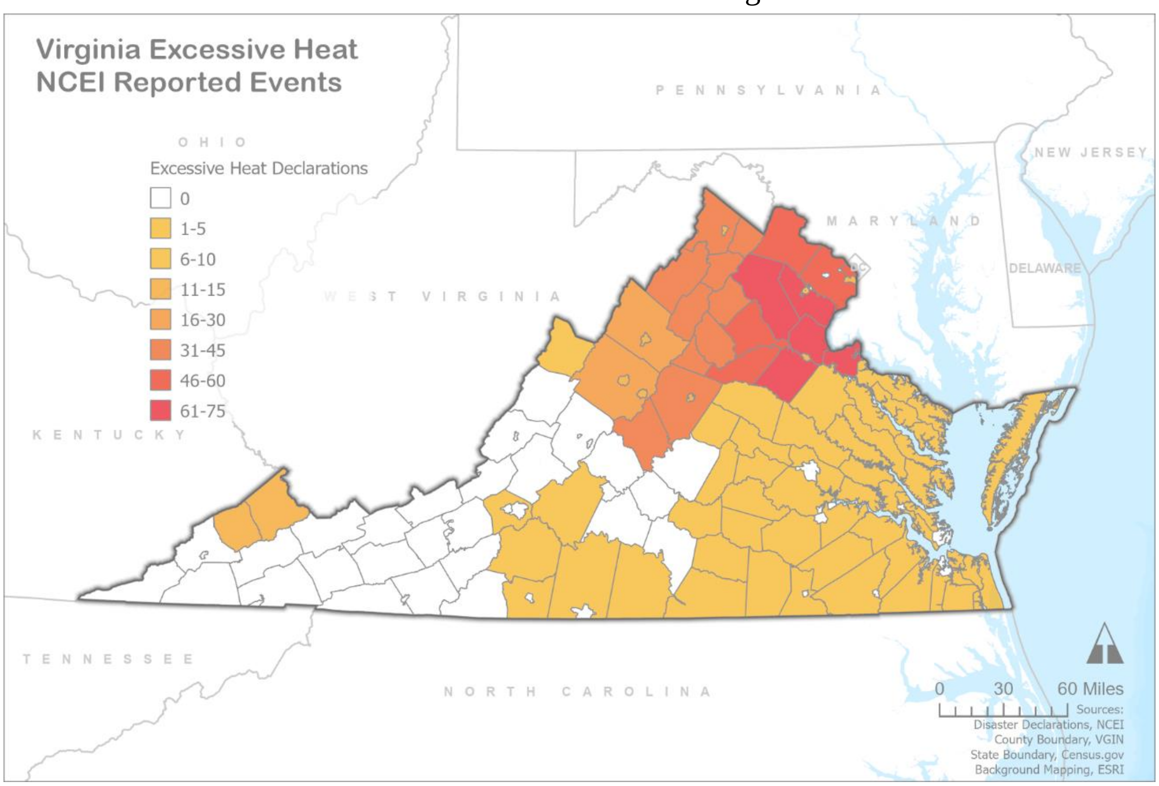


Figure 3-22 - Number of NCEI Winter Weather Events in Virginia.

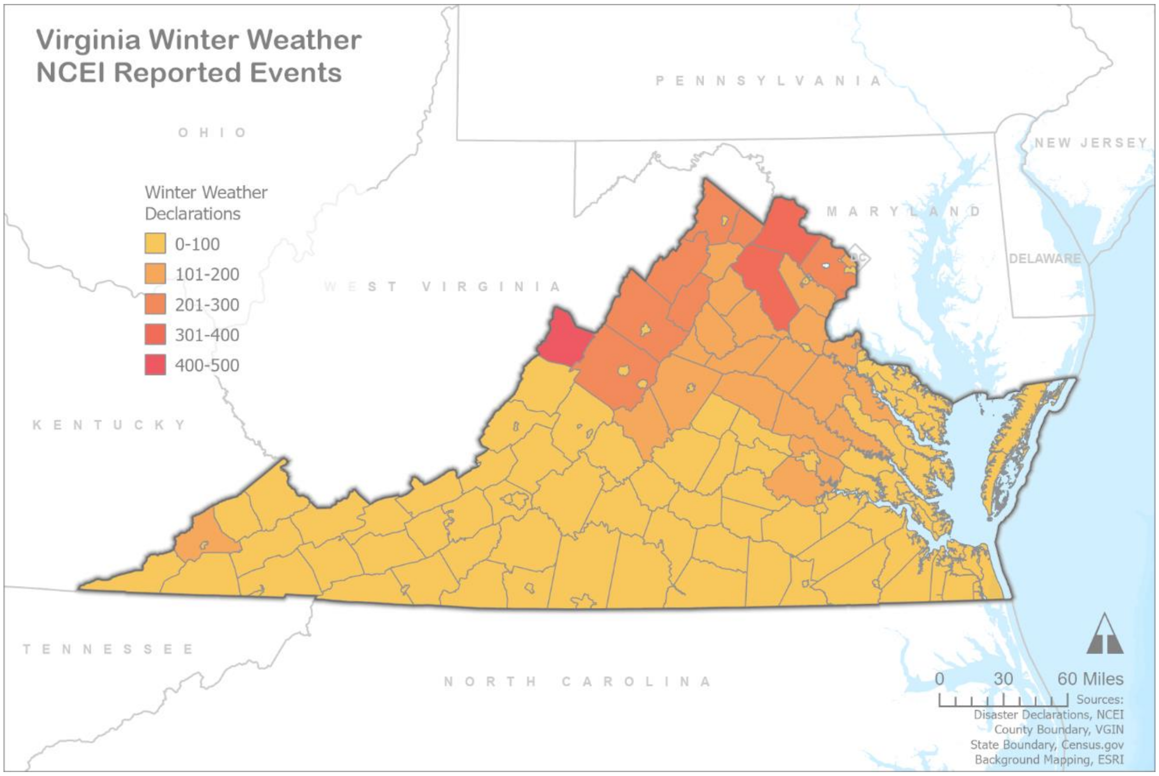


Figure 3-23 - Number of NCEI Flooding Events in Virginia.

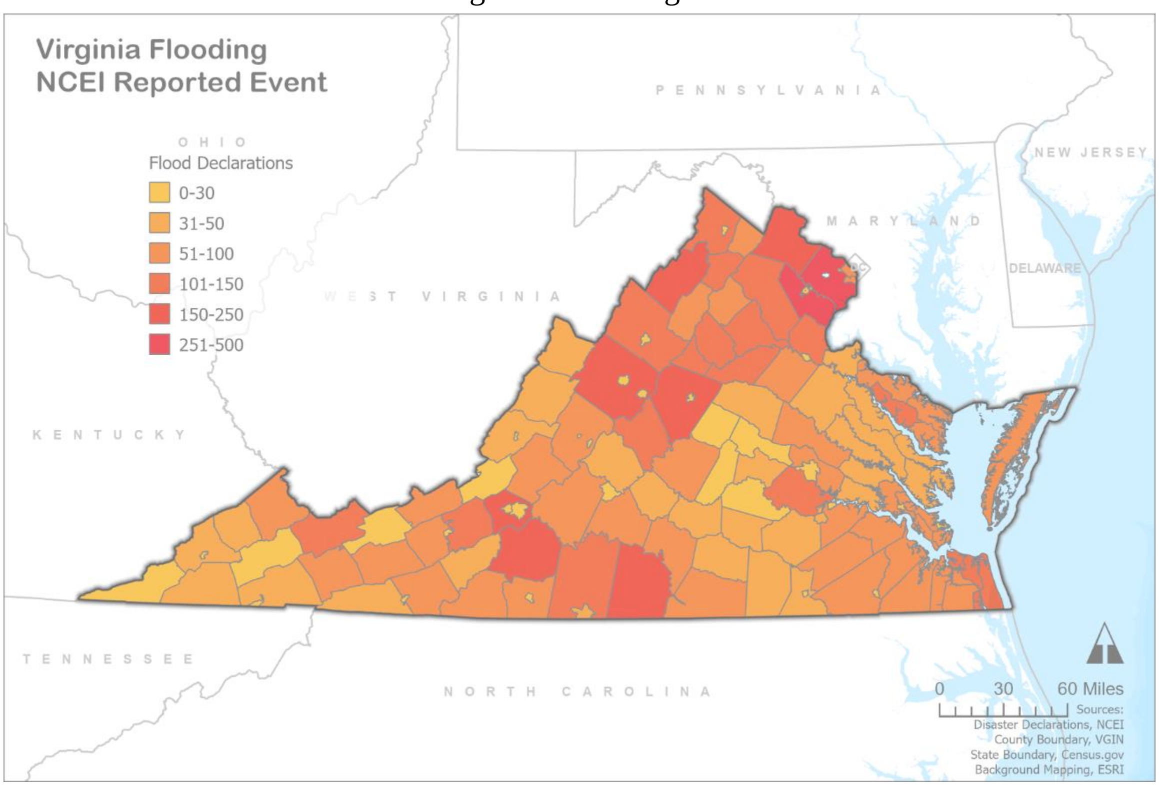


Figure 3-24 - Number of NCEI Hurricane Events in Virginia.

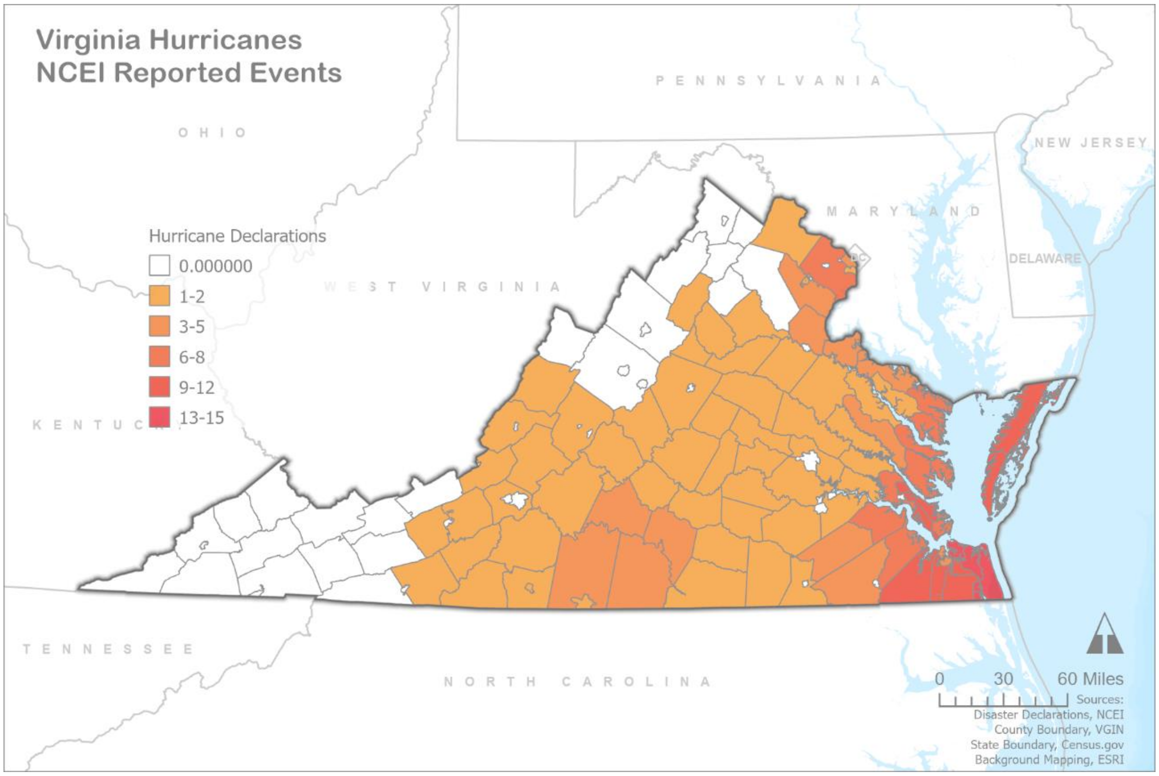


Figure 3-25 - Number of NCEI Landslide Events in Virginia.

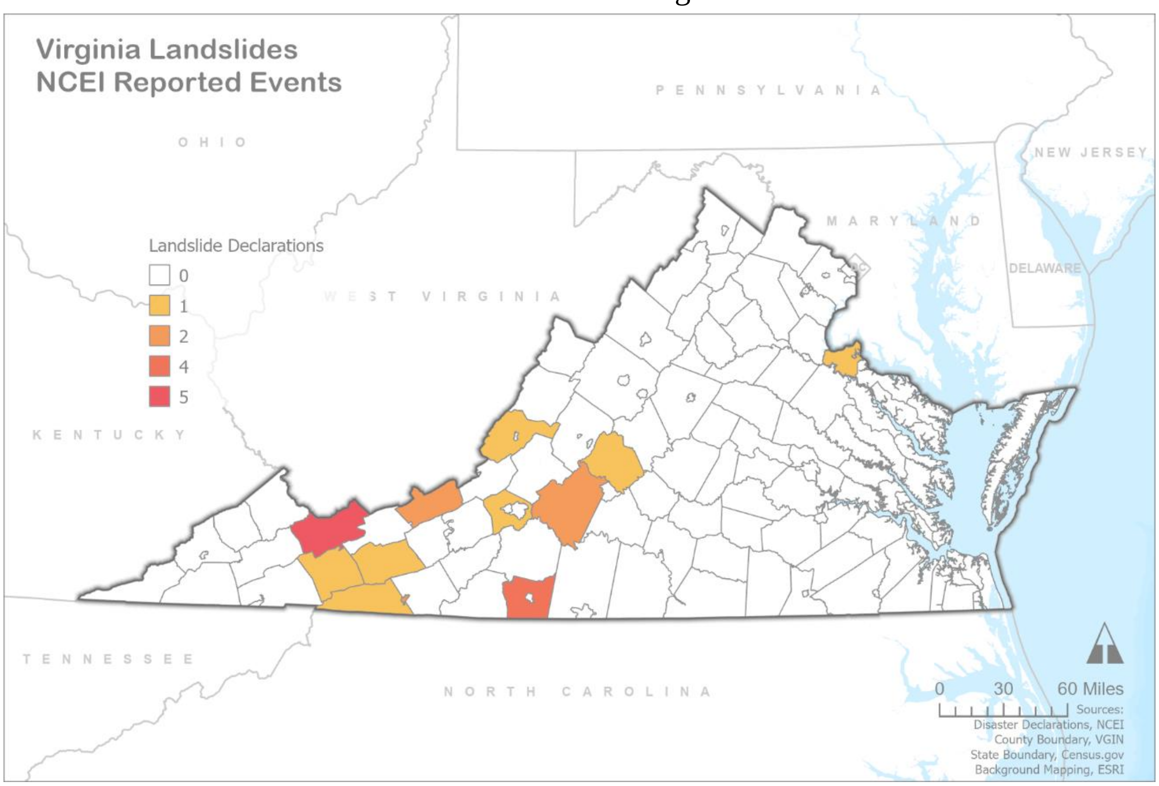


Figure 3-26 - Number of NCEI Non-Tornadic Wind Events in Virginia.

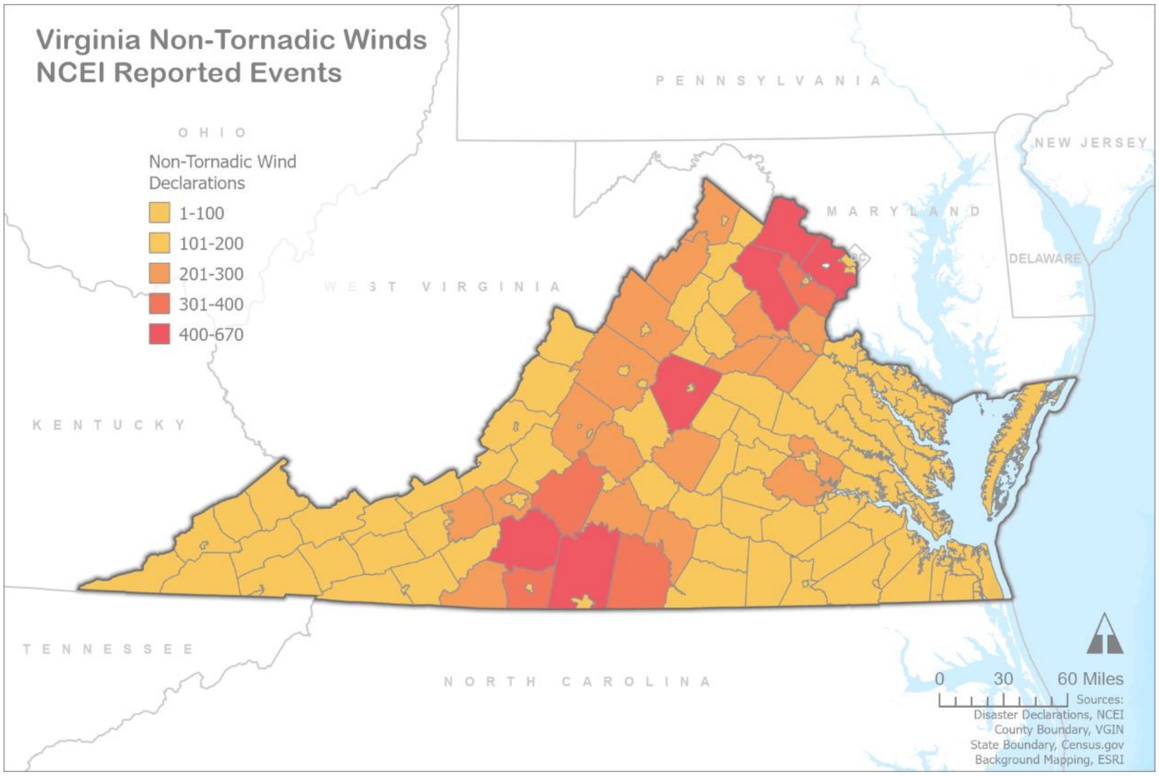


Figure 3-27 - Number of NCEI Tornado Events in Virginia.

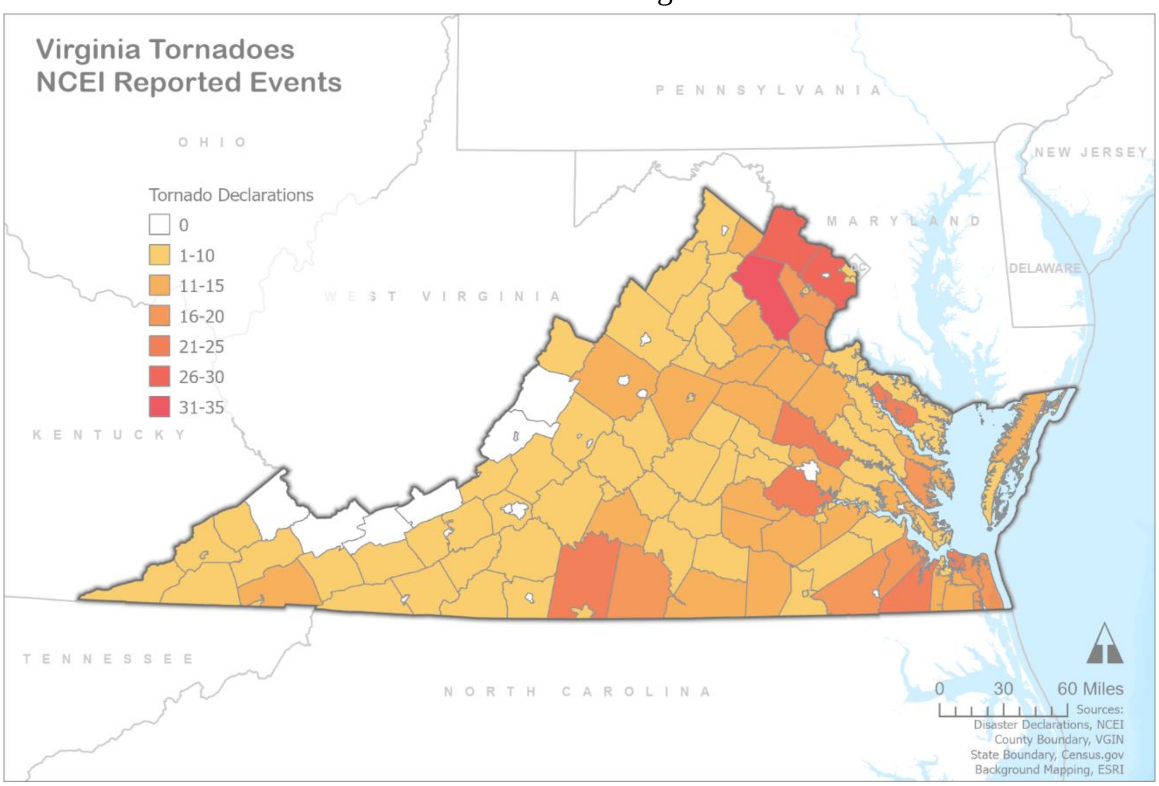
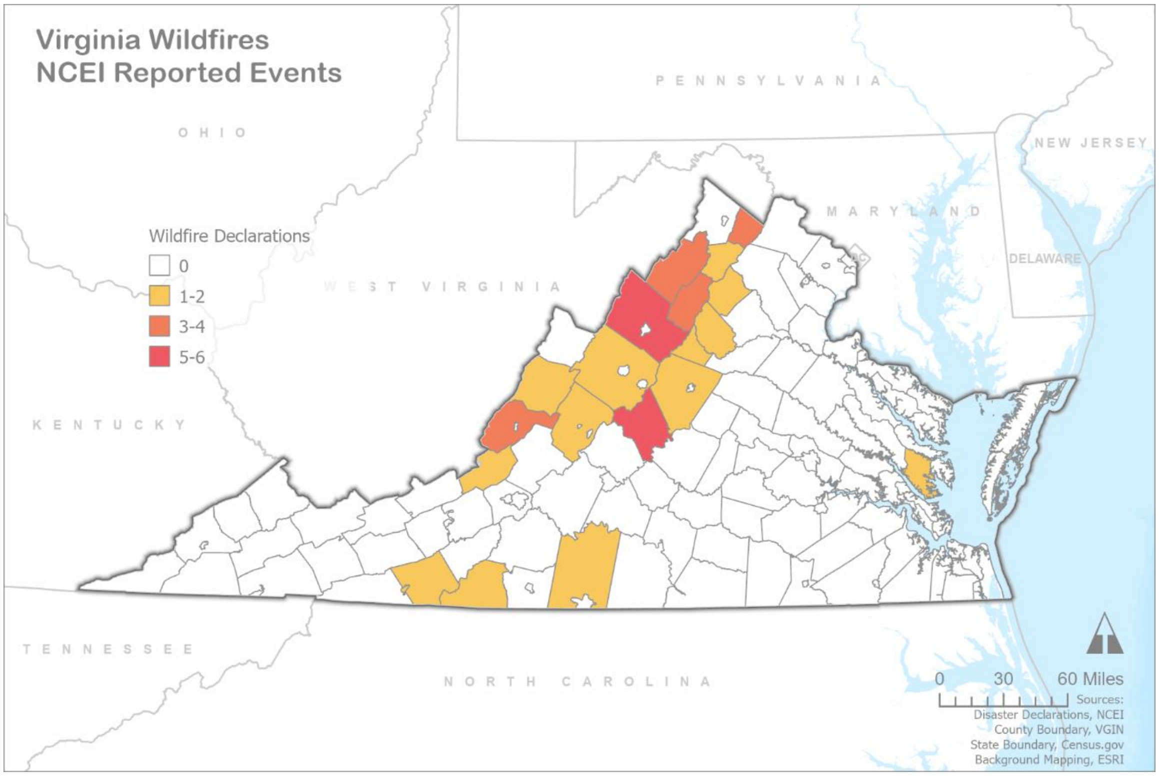


Figure 3-28 - Number of NCEI Wildfire Events in Virginia.



3.6 State Facilities, Critical Facilities, and Energy Pipelines Analysis

In addition to examining vulnerability by governmental jurisdiction, the HIRA also considers state facility and critical facility vulnerability. The HIRA does not generally include local mitigation plan assessment of this information; although local plan data were evaluated, inconsistencies between the plans prevented consistent incorporation of local analysis.

All state facility data were gathered by VDEM for this HIRA update. The HIRA examined two major sources of facility data: asset data provided by the Virginia Department of General Services (DGS) for state owned, leased, or managed facilities; and Federal Homeland Security Infrastructure (HSIP) Freedom geodatabase for critical facilities data. The facility data contained detailed location information for most assets but did not contain any asset valuation information. The original dataset received also contained several non-improved land holdings; these were removed from the original dataset and excluded from analysis.

Many of the buildings in the Virginia Agency Property System (VAPS) database might be considered critical to disaster preparedness and response, but not all critical facilities are in the VAPS database. For example, many privately-owned buildings and structures (e.g., hospitals, power plants, certain industrial facilities, etc.) may be considered critical during certain natural disasters. As such, the critical facilities data collection has been used to represent a broader array of critical facilities than would be available through VAPS.

Additional types of linear infrastructure may also qualify as critical facilities but were not assessed in this plan due to data and scope limitations. Historical road closure and condition reports were considered for use in this plan (as with the previous plan), but the format of the data posed challenges that limited its use.

3.6.1 State Facilities

The original VAPS dataset obtained for this update contained information for over 13,800 locations for 247 state agencies, including public universities and colleges in Virginia. For the purposes of the risk assessment, the term "state-owned facilities" is used to refer to both state-owned and state-operated facilities. The dataset contained spatial location information for most assets; this information, when available, was used to intersect state assets with identified hazard zones. However, the dataset did not contain extensive attributes about each building or structure, such as basic structural information, construction type, building value, square footage, number of floors, year built, or sprinkler system characteristics. A second dataset was later identified that did contain at least one valuation for each asset but did not contain any location information. There was not a common identifier between the two datasets; as these data sets could not be merged, no valuation estimate could be determined for state facilities.

After the initial data processing, all remaining assets were assigned a category of use based on the primary function. These categories allowed for ease of developing and displaying relevant maps. **Table 3-10** provides these categories and the number of facilities identified in each category.

Table 3-10 - State Facilities and Numbers

State Facilities Categories	Total
Agriculture	317
Airfield	13
Animal Health	27
Armory	39
Barn	178
Childcare	10
Communications	76
Conference Center	15
Education	1,225
EMS	3
EOC	1
Fire Service	36
Food Service	88
Fuel	516
Hazmat	433
Historic	19
Housing	1,656
Library	29
Livestock	143
Medical Facility	125

State Facilities Categories	Total
Military	3
Museum	20
Office	1,260
Other	1,360
Parking	148
Public Safety	200
Readiness Center	30
Recreational	794
Research	178
Special Population	25
Storage	2,344
Student Services	53
Support	698
Toll	11
Utility	128
Visitors Center	46
Wastewater	68
Water	455
Closed	33
Total Facilities	**12,803**

3.6.2 Critical Facilities

The Commonwealth does not currently have a statewide critical facility dataset. Instead, various plans appear to use different datasets, based upon the geographic and subject-matter scope of each plan. The 2023 HIRA uses the Homeland Infrastructure Foundation-Level Data (HIFLD) open dataset to identify critical facilities in the Commonwealth. Critical facilities are grouped into six broad categories: law enforcement facilities, educational facilities, emergency response, transportation, and public health. The HIFLD dataset contains general location information for each facility, but it does not contain attribute information such as building valuation, age, or size.

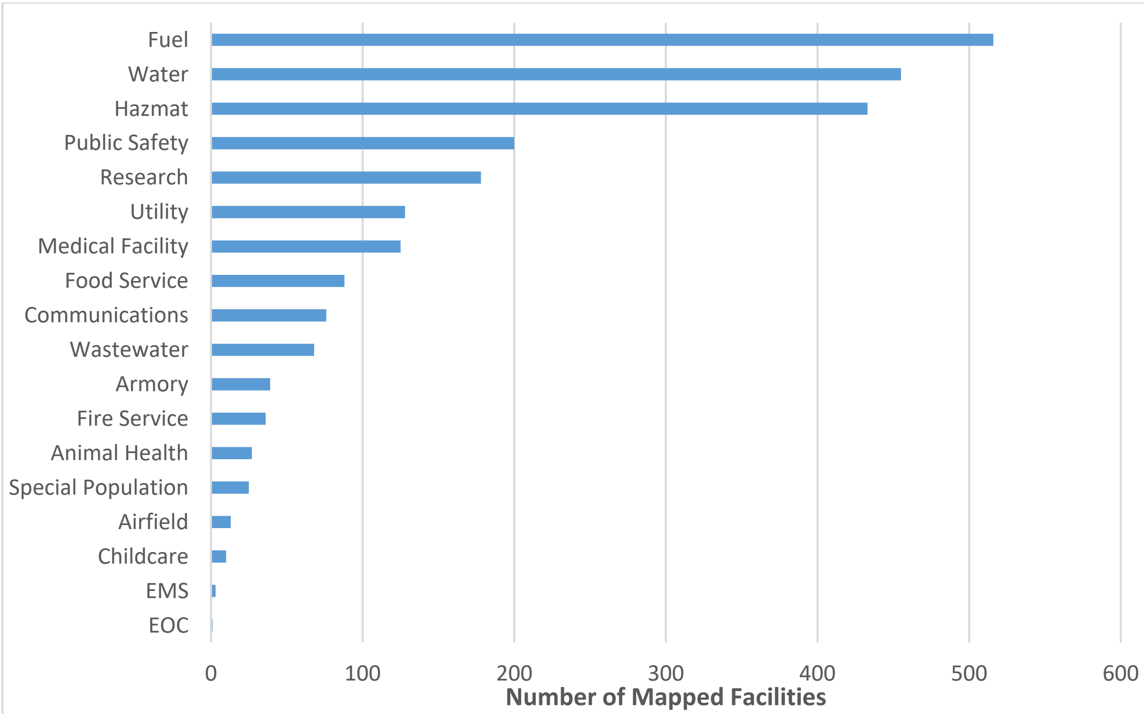
All critical facilities data for this plan update were determined from the VAPS state dataset. State assets were grouped into similar categories. Once asset categories were determined, some were further identified as critical. This version of the plan identifies the following broad types of critical facilities:

- Law Enforcement Facilities
- Special Populations Facilities
- Emergency Response
- Fuel Facilities
- Food Distribution/Service
- Utilities

The Commonwealth VAPS is the best available dataset since it is maintained at the state level. However, this dataset has similar issues to the HIFLD dataset, with lack of building valuation data and building size data.

Although not a complete representation of all the possible types of critical facilities, this data is a good representation of facility types in the state. The database contains over 2,400 critical facilities within the six categories. Facilities are represented only as geographic points, so the full spatial extent of larger facilities is not considered. Figure 3-29 shows the number of facilities located in each critical facility category.

Figure 3-29 - Critical Facility Type and Number of Mapped Facilities



3.6.3 Energy Pipelines

Transmission and distribution pipelines are used to transport liquids and gases such as petroleum products, natural gas, and other chemicals across long distances. Virginia's economy and security benefits from the products transported via pipeline; this includes refined petroleum to fuel transportation systems, and natural gas to heat homes and generate power. However, these fluids are often hazardous to human health and/or to the environment, and so the operation of transmission pipelines is regulated to ensure public safety.

Applicable federal laws are found in US Code, Title 49, Subtitle VIII, Chapter 601; regulatory activity occurs in accordance with Title 49 of the Code of Federal Regulations (CFR), Parts 190-199, and are carried out by the US Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA). In Virginia, the State Corporation Commission's (SCC) Division of Utility and Railroad Safety is also responsible for regulating certain operators, in coordination with PHMSA. The SCC is an independent state agency and an appellate level court whose decisions can be appealed only to the Virginia Supreme Court.

Risks associated with transmission pipelines result from accidental releases of the transported products, which can impact public safety, the environment, national security, and the economy.

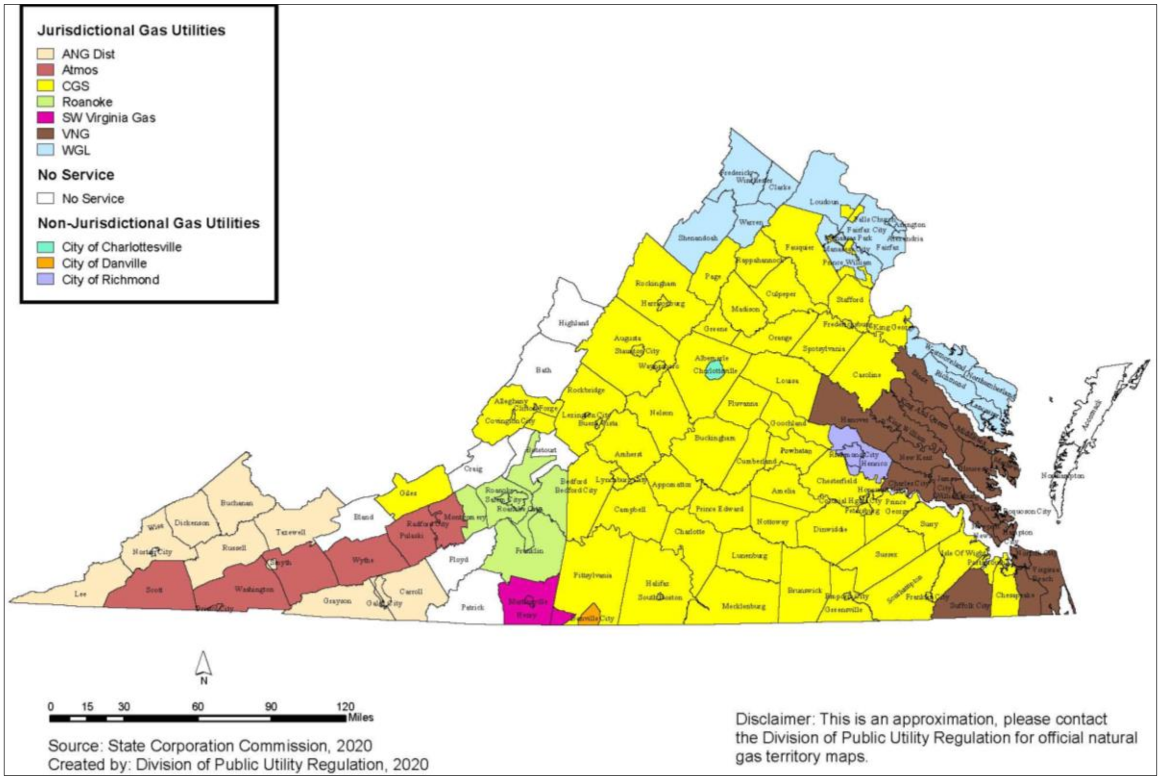
Accidental releases can result in injuries or fatalities from fires or explosions caused by ignition of the released product, as well as from possible toxicity and asphyxiation effects. Economic impacts may result from business interruptions, damaged infrastructure, and loss of fuel supplies.

Pipelines may be impacted by natural hazards in direct and indirect ways. An example of a direct impact would be erosion or shifts in the supporting soil resulting in pipeline collapse. Indirect impacts are those that affect the infrastructure that supports pipeline operations. An example of an indirect impact would be severe storms causing a general power or communication systems failure which, while not impacting the structural integrity of the pipeline, could disrupt the pipeline operator’s ability to operate the pipeline safely and the pipeline may be required to be shutdown. Hazard-specific summaries of pipeline impacts are included in the individual hazard sections, where applicable.

The Pipeline and Hazardous Materials Safety Administration (PHMSA) maintains the National Pipeline Mapping System (NPMS), a nationwide GIS database of transmission energy pipelines with attribute information such as the pipeline operator (typically a private business) and the type of material transported. The database does not include detailed valve, facility, or operational details, nor does it include distribution or gathering pipelines. Map features in the NPMS typically have an accuracy of +/- 500 feet, so the database is useful for a general assessment rather than engineering work like excavation planning for pipelines. The Pipeline Safety Improvement Act of 2002 required pipeline operators to begin submitting geospatial data to the NPMS. Due to security concerns, the distribution of NPMS data is limited to federal, state, and local government agencies. The NPMS Public Map Viewer allows the public to view maps of transmission pipelines, liquid natural gas plants, and breakout tanks in one selected county[iv].

Figure 3-30 represents only the seven natural gas distribution companies regulated by rate making and the three municipal distribution operator’s areas as a reference by the Division of Public Utility Regulation. The SCC’s Safety oversight through the Division of Utility and Railroad safety covers approximately 78 pipeline operators from small distribution systems to large intrastate pipelines.

Figure 3-30 - Jurisdiction of Natural Gas Utilities, Virginia (SCC, 2020)



PHMSA also tracks significant pipeline incidents such as breaks or spills; PHMSA defines "significant incidents" as those incidents reported by pipeline operators when any of the following specifically defined consequences occur (

Table 3-11)[v]:

- Fatality or injury requiring in-patient hospitalization
- $50,000 or more in total costs, measured in 1984 dollars
- Highly volatile liquid releases of 5 barrels or more or other liquid releases of 50 barrels or more
- Liquid releases resulting in an unintentional fire or explosion.

Table 3-11 - Significant Pipeline Incidents Caused by Natural Hazards in Virginia (2001-2021)[vi].

Year	Location	Operator	Property Damage	Sub-Cause
2001	City of Richmond	Richmond Dept. of Public Utilities	$124,418	Earth Movement
2007	City of Richmond	TransMontaigne Product Services Inc.	$1,086	Lightning
2010	Charlotte Courthouse	Colonial Pipeline Co.	$123,396	Temperature
2012	Carolina County	Virginia Natural Gas	$0	Earth Movement

Year	Location	Operator	Property Damage	Sub-Cause
2021	City of Newport News	Virginia Natural Gas	$337,225	Earth Movement

As of this plan update, the pipeline infrastructure subject to SCC oversight includes:

- 22,314 miles of distribution main,
- 19,837 miles of services,
- 40 miles of jurisdictional gathering,
- 506 miles of intrastate gas transmission,
- 2,692 miles of interstate gas transmission,
- 1,132 miles of interstate hazardous liquids pipelines,
- 9.2 miles of intrastate hazardous liquids pipelines and
- 72 hazardous liquids breakout tanks

3.6.4 Analysis

The results of the risk assessment for state facilities, critical facilities, and energy pipelines are included in the risk assessment section of each individual natural hazard. Facilities were intersected with the hazard's Geographic Extent (GE) layer to determine the building's risk zone. The analysis methodology is described in full detail in the individual hazard sections; tables are used to represent the number of facilities in each risk category.

Potential dollar loss to state facilities was completed for some of the hazards. Total exposed building value has been denoted for all the addressed hazards. Agencies with a large quantity of structures or building value in the high-risk hazard areas are noted in each of the sections. These agencies and buildings are an excellent starting point for assessing the need for specific mitigation action items, however detailed analysis could not be completed for the critical facilities because of the lack of building specific data.

A quantitative assessment of wind and earthquake impacts to state facilities, critical facilities and pipelines involved the use of Hazards US Multi-Hazard (Hazus) software, a GIS-based loss estimation tool available from FEMA, along with a statistical risk assessment methodology for hazards outside the scope of Hazus. For the flood hazard, the quantitative assessment incorporated a detailed GIS-based approach. When combined, the results of these vulnerability studies formed an assessment of potential hazard losses (in dollars) along with the identification of specific state or critical assets that are deemed at-risk.

Originally designed for the analysis of earthquake risks, FEMA has expanded the program to include the analysis of flood and wind events. By providing estimates on potential losses, Hazus facilitates quantitative comparisons among hazards and may assist in the prioritization of hazard mitigation activities. Hazus uses a statistical approach and mathematical modeling of risk to predict the frequency of occurrence and estimated impacts of a hazard based on recorded or historic damage information. The Hazus risk assessment methodology includes distinct hazard specific and inventory parameters. For example, wind speed and building type were modeled using the Hazus software to determine the impact (damages and losses) on structures.

This plan update utilized Hazus results produced during the previous update in 2018 to provide regional profiles and estimated losses for hurricane wind hazards. Hazus was used to generate probabilistic ‘worst case scenario’ events to show the maximum potential extent of damage. Those events of less severe magnitude which could occur would likely result in fewer losses than those calculated here. In addition, in 2018 a statewide scenario for earthquakes was developed and is included in the risk assessment for this plan update. Note that the damage assessment for this plan update will consider inflation in the damage assessment over the past 5 years.

3.7 Hazard Assessment and Ranking Methodology

This subsection further describes the concepts underlying the hazard identification and risk assessment process, and the methods used to rank hazards by relative risk. These concepts underlie the individual hazard chapters that follow. The Advisory Committee and the Working Group reviewed the process used to identify the hazards during the Advisory Committee Workshop in April 2022 and validated the methodology as acceptable for this plan update.

The risk assessment is structured to provide the following information for relevant hazards:

- Geographic Area Affected
- Historical Occurrences
- Probability of Future Events
- Vulnerable Populations

Maintaining clear terminology in the 2023 SHMP revision process was a priority. To improve consistency, the following discussion identifies working definitions and expanded meanings of key terms as found in references consulted during the update.

Probability - In this plan, probability is the odds (or chance) of a certain event, of a certain magnitude, occurring in each period. In the strictest sense, probability must be expressed with a quantitative statement of chance. However, when the exact probability has not been studied, a qualitative statement of risk must suffice. Two primary methods exist for determining the probability of a hazard’s occurrence: statistical analysis of historical occurrences; and models of probable occurrence.

Statistical analysis of historical occurrences can be applied to large databases. These databases may include the time, intensity, location, and damage caused by an event. Examples of such databases include weather conditions, wildfire occurrences, and sinkhole reports. Determining the historic frequency of occurrence of certain events may be sufficient to estimate future rates of occurrence if the event occurs at a relatively steady rate. However, a major drawback to this method of probability estimation is that errors, biases, and incomplete reporting in the historical database can lead to inaccurate projections.

In contrast to pure statistical analysis, models of probable occurrence predict hazard probability based on a more theoretical basis. While many models are often calibrated to historical data, they have the capability to predict occurrences that would not be otherwise observed, due to the lack of witnesses for extremely rare events. Examples of such models include flood maps depicting 1-percent and 2-percent annual chance floodplains (1-percent and 0.2-percent-annual-chance flood), storm surge inundation models, karst susceptibility maps based on geologic conditions, fire risk, and many others.

The desired result of a probability analysis is the creation of a dataset that communicates not only the probability of occurrence, but also the spatial extent and intensity. A statement of probability alone, without some associated intensity, is not always useful if the hazard in question occurs frequently, and with widely varied intensity.

Vulnerability may be defined as the degree to which a certain receiving body may be damaged by a hazard event. Jurisdictional vulnerability is often directly related to the number and type of people in certain hazard-prone areas. Facility vulnerability, on the other hand, may be directly related to structural capacity, fire suppression systems, and other reinforcements against hazards.

Within jurisdictional vulnerability, special attention may be paid to social vulnerability as certain members of society are more vulnerable to disaster events. Several studies outline methods to consider socioeconomic status when calculating the overall vulnerability of a certain geographic location. One promising analysis method creates a social vulnerability index using readily available US Census data and has been used in several other hazard risk assessments. Description of social vulnerability indexing used for this HIRA is described in Section 3.7.

This report analyzes both jurisdictional and facility-specific vulnerability. Jurisdictional vulnerability includes population and other demographic factors, aggregated building values, and the net numbers of local critical facilities impacted by a potential hazard. Facility-specific vulnerability is the result of the physical properties of a facility: the construction type, standards, and age; elevation and number of stories; fire suppression; and various other factors. Ultimately, vulnerability is often summarized in the form of an intensity-damage relationship developed from an analysis of historical hazard impacts.

Impact may be defined as the actual effect of a hazard event on a certain receiving body. Jurisdictional impact could be quantified as the number of people affected by an event, or other measures of the effect of the hazard on the jurisdiction. Facility impact could be the financial losses that occur because of damage to the facility by a well-defined hazard event.

For many hazards, impact is difficult to predict. Usually, historical data is analyzed to assess quantified damages, deaths, and injuries that result from specific events of specific intensities. This analysis may result in intensity-damage relationships that can be used to estimate the impact of specific hazard scenarios in the future. Hazus, for example, can use depth-damage curves to calculate the projected impact to specific buildings if elevation information and building valuation data are available.

Risk - Risk is “the estimated impact…[and]…the likelihood of a hazard event…” Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage above a threshold. It also can be expressed in terms of potential monetary losses associated with the intensity of a hazard[2].

The risk associated with a certain hazard can also be described as the probability of that hazard’s occurrence multiplied by its impact. When probability is expressed as annual chance, risk may be calculated as annualized loss. For many hazards, different probabilities may be associated with varying intensities. In these cases, the combined risk due to a certain hazard is equal to the sum of the risk associated with each intensity level.

3.7.1 Ranking Methodology

To compare the risk of different hazards, and prioritize which are more significant, requires a system for equalizing the units of analysis. Under ideal conditions, this common unit of analysis would likely be ‘annualized dollars’ from damage and human life. However, such an analysis requires reliable probability and impact data for all the hazards to be compared. As this is often not the case, many hazard prioritization methods are based on scoring systems, which allow greater flexibility and more room for expert judgment.

VDEM developed a standardized methodology to compare different hazards’ risk on a jurisdictional basis. As some of the hazards assessed in this plan did not have precisely quantifiable probability or impact data, a semi-quantitative scoring system was used to compare all the hazards. This method prioritizes hazard risk based on a blend of quantitative factors from the available data. Several parameters have been considered in this methodology, all of which could be derived from the NCEI database:

- History of occurrence;
- Vulnerability of people in the hazard area;
- Probable geographic extent of the hazard area; and,
- Historical damages, in terms of crop and property.

The ranking methodology tries to balance these factors for which reliability varies from hazard to hazard due to the nature of the underlying data. Each parameter was rated on a scale of one (1) through four (4). The exact weights are highly debatable, but the conclusion was that the population vulnerability and density would each be weighted at 0.5 and geographic extent at 1.5, relative to the other parameters. These scores are summed at a jurisdictional level for each hazard separately, permitting comparison between jurisdictions for each hazard type. A summation of all the scores from all hazards in each jurisdiction provides an overall, ‘all-hazards’ risk prioritization. The following sections provide an overview of the six parameters that were used in ranking the hazards that impact Virginia.

NCEI data are incomplete; these data were used for the ranking because of the standardized collection of many of the hazards of interest. The data only partially represents the geological hazards and thus the ranking can only characterize the current form of the data. As other data sources become available, the ranking will need to be reassessed to make sure the parameters are still valid for ranking the hazards.

3.7.1.1 Population Vulnerability and Density

Population vulnerability and density are simple, yet important factors in the risk ranking assigned to a jurisdiction. In general, a hazard event that occurs in a highly populated area has a much higher impact than a comparable event that occurs in a remote, unpopulated area. Two population parameters were used, accounting for jurisdictions with high populations and jurisdictions with densely populated areas. Each parameter was given a weighting of 0.5 to avoid overwhelming the overall ranking methodology with pure population data.

Population vulnerability was calculated as the percent of the total population of Virginia present in each jurisdiction. The 2020 US Census population estimate for each jurisdiction was divided by the total population for the state; a value between one and four was assigned based on a geometric breaks pattern. By ranking jurisdictions this way, those cities and counties with significantly larger populations have effectively been given extra weight. **Table 3-12** describes the breaks and assigned scores for population vulnerability.

Table 3-12 - Population Vulnerability as the percentage of people that will be affected by the occurrence of the hazard

Population Vulnerability	
Rank	**Definition**
1	<= 0.229 % of the total population of the state
2	0.230% - 0.749% of the total population of the state
3	0.750% - 2.099% of the total population of the state
4	> = 2.100% of the total population of the state

Population density was based on the population per square mile for each jurisdiction. Census 2020 population estimate data for each jurisdiction were divided by the total area of a jurisdiction; a value between one and four was assigned based on geometric intervals. By ranking jurisdictions this way, those cities and counties with densely populated areas have effectively been given extra weight. **Table 3-13** describes the breaks and assigned scores for population density.

Table 3-13 - Population Density as the number of people per square mile that will be affected by the occurrence of the hazard

Population Density	
Rank	**Definition**
1	<= 60.92 people/sq mi
2	60.93 – 339.10 people/sq mi
3	339.11 - 1,743.35 people/sq mi
4	>= 1,743.36 people/sq mi

3.7.1.2 Geographic Extent

Probable geographic extent (GE) would ideally be measured consistently for each hazard; however, the available data sources vary widely in their depiction of hazard geography. Thus, one uniform ranking system could not be accomplished. For this HIRA, each hazard was assigned individual category break points based on the available hazard data. In the overall scoring system, geographic extent was given a 1.5 weighting relative to the other parameters, as geographic extent was deemed to be critically important, and more reliable than some of the other parameters. GE data sources, ranking criteria, and category breaks are summarized in **Table 3-14**.

Table 3-14 - Geographic Extent as the percentage of a jurisdiction impacted by the hazard.

Geographic Extent			
Hazard	Description	Category Breaks	
		Rank	Definition
Flood	Percent of a jurisdiction that falls within FEMA Special Flood Hazard Area (SFHA). *Data: FEMA Floodplains (DFIRMs)*	1	<=2.99%
		2	3.00-4.99%
		3	5.00 -9.99%
		4	>=10.00%
High Wind/ Hurricane	Average maximum wind speed throughout the entire jurisdiction. *Data: Hazus 3-second Peak Gust Wind Speeds*	1	<= 59.9
		2	60.0 - 73.9
		3	74.0 - 94.9
		4	>= 95.0
Wildfire	Percent of jurisdiction that falls within a “high” risk. *Data: VDOF Wildfire Risk Assessment*	1	<= 9.9%
		2	10.0% - 19.9%
		3	20.0% - 49.9%
		4	>= 50.0%
Karst	Percent of jurisdiction where the risk is “high” for karst related events. *Data: USGS Engineering Aspects of Karst*	1	<= 24.9%
		2	25.0% - 49.9%
		3	50.0% - 74.9%
		4	>= 75.0%
Landslide	Percent of jurisdiction where a high landslide risk exists. *Data: USGS Landslide Incidence and Susceptibility*	1	<= 24.9%
		2	25.0% - 49.9%
		3	50.0% - 74.9%
		4	>= 75.0%
Earthquake	Average 2500-year return period max percent of gravitational acceleration (PGA). *Data: Hazus 2500-year PGA*	1	<= 0.069
		2	0.070 - 0.159
		3	0.160 - 0.299
		4	>= 0.300
Winter Storm	Average annual number of days receiving at least 3 inches of snow, calculated as an area- weighted average for each jurisdiction. *Data: NWS snowfall statistics*	1	<= 1.49
		2	1.50 - 1.99
		3	2.00 - 2.99
		4	>= 3.0
Tornado	Annual tornado hazard frequency (times one million), calculated as an area-weighted average for each jurisdiction. *Data: NCEI tornado frequency statistics*	1	<= 1.24
		2	1.25 - 9.99
		3	10.00 - 99.9
		4	>= 100.00

3.7.2 Annualizing the Data for Analysis

Data from the NCEI database were annualized to be able to compare the results on a common system. In general, this was completed by taking the parameter of interest and dividing by the length of record for each hazard. The annualized value should only be used as an estimate of what can be expected in each year. Property and crop damage were annualized in this fashion. A summary of the parameters and the period of record used for each hazard can be found in Section 3.5, which further describes the use of NCEI data.

3.7.2.1 Annualized Fatalities and Injuries

Fatalities and injuries are also an important factor to evaluate when determining risk ranking. Using NCEI data, past deaths and injuries were computed for drought, flood, high wind, tornado, wildfire, and winter storm. The remaining hazards have no reported deaths or injuries in this database and thus were assigned a ranking of one (1). The combined injury/death values were annualized over the period of record for each event category and scored, using natural breaks (Table 3-15). A summary of deaths/injuries and the period of record used for each hazard can be found in Section 3.5 which describes the NCEI data.

Table 3-15 - Annualized Fatalities and Injuries

Annualized Fatalities and Injuries	
Rank	**Definition**
1	<= 1.019 fatalities and/or injuries per year
2	1.020 – 6.279 fatalities and/or injuries per year
3	6.280 – 13.199 fatalities and/or injuries per year
4	>= 13.200 fatalities and/or injuries per year

3.7.2.2 Annualized Crop and Property Damage

Crop damage and property damage were also analyzed separately to give each jurisdiction a score of one (1) to four (4). These data were obtained from the NCEI storm events database and annualized according to the period of record for each event category (Table 3-16**)**.

The period of record in NCEI varies dramatically by hazard type. A summary of crop and property damages and the period of record used for each hazard can be found in Section 3.5 which describes the NCEI data.

Table 3-16 - Annualized Crop and Property Damage as the estimated damages that a hazard event will likely cause in each year

Annualized Crop and Property Damage		
Rank	**Definition: Crop Damage**	**Definition: Property Damage**
1	<= $25,711 per year	<= $ 136,129 per year
2	$25,712 – $100,270 per year	$136,130 - $432,555 per year
3	$100,271 - $291,384 per year	$432,556 - $1,111,067 per year
4	>= $291,385 per year	>= $1,111,068 per year

3.7.2.3 Annualized Events

While each hazard may not have a comprehensive database of past historical occurrences, the record of historical occurrences is still an important factor in determining where hazards are likely to occur in the future. Annualizing the NCEI storm events data yields a rough estimate of the number of times a jurisdiction might experience a similar hazard event in any given year. To do this, the total number of events in the NCEI database, for each specific hazard in each jurisdiction, was divided by the total years of record for that hazard to calculate an annualized events value. A summary of events and the period of record used for each hazard can be found in Section 3.5 which describes the NCEI data.

It should be noted that data are not collected for land subsidence (karst), earthquake, and landslide in NCEI; thus, the events for these hazards all received a default rank of one (1). Table 3-17 describes the annual frequency breaks for events.

Table 3-17 - Annualized Events as the number of times that a hazard event would likely happen in each year

Annualized Events	
Rank	**Definition**
1	<= 0.09 events per year
2	0.10 – 0.99 events per year
3	1.00 – 4.99 events per year
4	>= 5.00 events per year

3.7.2.4 Overall Hazard Ranking

The scores from each of these categories were added together for each hazard to estimate the total jurisdictional risk due to that hazard. As discussed previously, the population parameters were each given a weighting of 0.5 (for a total of 1.0 for all population parameters), and Geographic Extent was given a weighting of 1.5 relative to the other factors. The total scores were broken into five categories to better illustrate the distribution of risk scores. Those jurisdictions with scores from 0 to 1.5 were determined to have a low risk in that hazard category, scores 1.60 through 2.49 were considered medium-low risk, between 2.50 and 3.59 medium risk, between and 3.99 were considered medium-high risk; and jurisdictional hazard scores greater than 4.00 were given a high rating.

In addition to this quantitative rating system described above, a qualitative assessment was used that relies less on technology and more on historical and anecdotal data, community input, and professional judgment regarding expected hazard impacts. The Working Group used a scoring matrix to summarize risk by placing each hazard in order of importance for this planning effort. This type of risk level ranking was based on historical and anecdotal data, as well as lived experiences of Working Group members. The Working Group also provided feedback on which hazards were of most concern from a climate change and social vulnerability standpoint. This ranking was done collaboratively in Working Group Workshop #1 for each hazard; results are found at the end of this section.

While the quantitative assessment focuses on using best available data, computer models, and GIS technology, this qualitative ranking system relies more on historical data, local knowledge, and the consensus of the State HMP Advisory Committee, as discussed in more detail in Section 2, describing the Planning Process. The results allow all hazards of concern, including those not tracked by NCEI, to be ranked against one another. Using both the qualitative and quantitative analyses to evaluate the hazards that impact the state provided committee members with a dual-faceted review of the hazards. This allowed officials to recognize those hazards that may potentially be costly, but also to plan and prepare for hazards that may not cause much monetary damage but could put a strain on the local resources needed to recover, or on those citizens least able to recover.

3.7.2.5 Assessing Social Vulnerability

The National Risk Index (NRI) is a relatively new dataset and online application from FEMA that identifies communities most at risk to various natural hazards. For each of the 18 natural hazards explored in the NRI, risk is calculated as follows:

Risk = Expected Annual Loss x Social Vulnerability x (1/Community Resilience)

Source data for the social vulnerability component are derived from the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) Social Vulnerability Index (SoVI). SoVI is a location-specific assessment of social vulnerability that utilizes 29 socioeconomic variables that contribute to a community's reduced ability to prepare for, respond to, and recover from hazards as shown in Table 3-18.

Table 3-18 - Variables used in the HVRI Social Vulnerability Index

Socioeconomic Variables
Median gross rent for renter-occupied housing units
Median age
Median dollar value of owner-occupied housing units
Per capita income
Average number of people per household
Community hospitals per capita (County SoVI only)
% Population under 5 years or age 65 and over
% Civilian labor force unemployed
% Population over 25 with <12 years of education
% Children living in married couple families
% Female
% Female participation in the labor force
% Households receiving Social Security benefits
% Unoccupied housing units
% Families with female-headed households with no spouse present
% Population speaking English as second language (with limited English proficiency)
% Asian population
% African American (Black) population
% Hispanic population
% Native American population
% Housing units with no car available
% Renter-occupied housing units
% Families earning more than $200,000 income per year
% Employment in service occupations
% Employment in extractive industries (e.g., farming)
% Population without health insurance (County SoVI only)
% Population living in mobile homes
% Population living in nursing facilities

Community resilience is the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. A Community Resilience score represent the relative level of a community's resilience compared to all other communities at the same level. A Community Resilience score is inversely proportional to a community's risk. A higher Community Resilience score results in a lower Risk Index score.

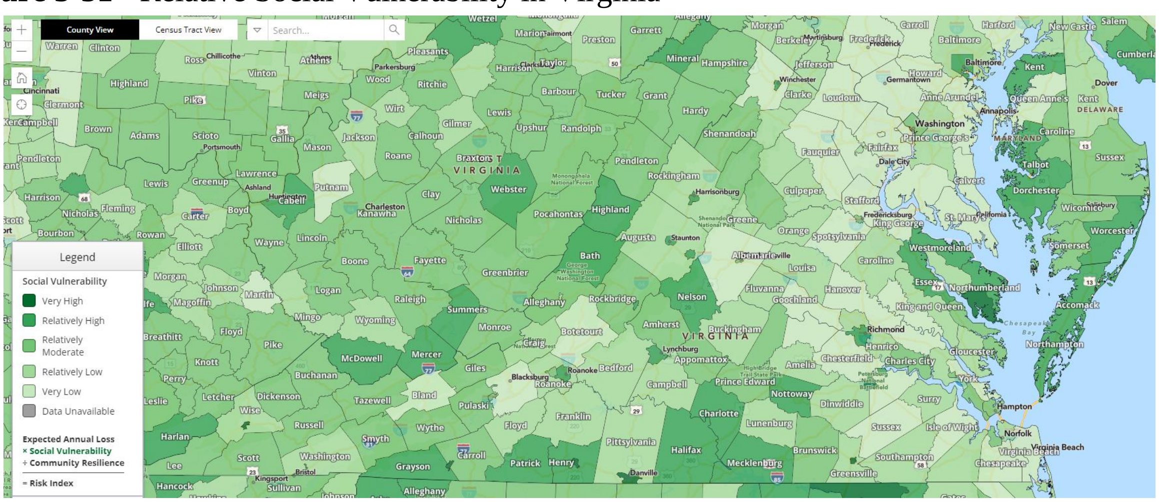
SoVI Metrics[vii] take into account 28 variables aggregated below into 8 components; based on census data from 2010-2014.

These 8 components explain 78% of the variance in the data.

- Wealth
- Race (Black) and Social Status
- Age (Elderly)
- Ethnicity (Hispanic) and lack of Health Insurance
- Special Needs Populations
- Service Sector Employment
- Race (Native American)
- Gender (Female)

Note: Resilience and SoVI scores are not dependent on hazards. This means the NRI risk score is a function of the Expected Annual Loss. The relative social vulnerability uses the factors above for the Commonwealth, without analysis of resilience or loss data for a particular hazard. This map is used in the HIRA to interpret social vulnerability for hazards not specifically addressed in the NRI such as Flooding Due to Impoundment Failure. The map data were also used in the plan to rate mitigation actions addressing those hazards. This plan update uses the NRI dataset to produce summaries of relative social vulnerability to the prominent natural hazards, including flooding, hurricane, and tornado. Figure 3-31 shows NRI relative social vulnerability for Virginia.

Figure 3-31 - Relative Social Vulnerability in Virginia



Source: FEMA and SoVI, 2021

3.7.3 Summary of Planning Efforts

Virginia currently has 19 local hazard mitigation plans (Richmond Regional and Crater PDCs are combined for the most recent update) that have been submitted and approved by VDEM and FEMA Region 3. The following section addresses local hazard identification, vulnerability and potential losses based on estimates provided in local risk assessments. In this revision of the plan, these results were not compared in detail to the statewide risk assessment because of data inconsistencies.

In addition to FEMA requirements for risk assessments, VDEM has additional requirements for local plan risk assessments. The local plans must include maps for the flood hazard. This typically involves an overlay of the Special Flood Hazard Area (SFHA) over demographic data to determine what infrastructure and populations lie within the floodplain. The second requirement is for local risk assessments to include maps of known high hazard areas. Chapter 6 of this plan discusses the steps VDEM uses for review and approval of local plans and how the state coordinates with the local planning efforts.

3.7.4 Local Hazard Identification

The most significant hazards identified in the local hazard mitigation plans were flood, non-rotational wind, and winter weather, the same top three hazards that are identified in this revision of the statewide analysis. Local plans identified a variety of distinct hazards. Table 3-19 classifies these based on an assessment of how most localities ranked the hazard, whether as High, Medium-High, Medium, Medium-Low, Low, and Not Assessed. For example, flooding was given an overall ranking of high for comparison in this plan. Of the 20 plans, 17 plans ranked flooding as high, two ranking flooding as medium, and one plan ranked flooding as low, resulting in an overall locality ranking of high. In addition to the hazard summarized in this report, local plans also assessed other hazards of local concern.

Table 3-19 - Summary of local plan hazard ranking

High	Medium	Low	Not Assessed by Majority
Flood	Tornado	Earthquake	Man-Made
Non-Tornadic Wind	Drought	Flooding due to Impoundment Failure	Technological
Winter	Wildfire	Erosion	Biological
Hurricane	Extreme Heat	Karst	Terrorism
Extreme Cold		Landslide	
		Space Weather	

Localities used a variety of approaches, ranging in complexity, to rank the hazards they identified as impacting their regions. Some plans used a blend of various techniques and discussions to arrive at their final ranking. Several of the major ranking/scoring techniques used in the local plans included:

- Quantitative scoring (based on available historical data, i.e., NCEI);
- Qualitative judgment/knowledge of locality;

- Numerical scoring worksheets (based on criteria, i.e., FEMA 386-2 worksheets); and
- Interactive activities with steering committee members.

FEMA guidance indicates that the jurisdictions at greatest risk to specific hazards should be identified, considering both the characteristics of the hazard and the jurisdictions' degree of vulnerability. A variety of analysis methods may be sufficient to meet these goals; FEMA does not mandate a specific analysis method. As a result, many local Virginia hazard mitigation planners have developed their own ranking system.

None of the ranking techniques used in the local plans are incorrect, as there is no standard way to rank hazards that impact specific jurisdictions. Lack of available data for each hazard is often a driving factor in the ranking method's degree of subjectivity. The numerical rankings were frequently performed by different planning contractors, thus different data processing methodologies were used. The variability in the ranking systems made it difficult to compare local hazard rankings to the state risk assessment. Table 3-20 shows how each of the local plans ranked the hazards identified in their plans. Some modifications have been made to this table to be able to compare localities to the state plan. The local plans identified 37 hazards. Careful review determined that many of these hazards were not unique hazards; rather, they were simply variations in terminology or additional hazards that are not defined within this HIRA. In addition, not all jurisdictions used 'low, medium, and high' for their ranking terminology. Some allowed for hybrid rankings, such as 'medium-high'. To account for this, each ranking was assigned a number; in some cases, these numbers were decimals. The rankings were numerically averaged, and then converted back to the standard terms of 'low, medium, and high.'

The top three hazards identified by the local PDC's are:

- Flooding (20 out of 20 PDCs).
- Tornado (20 out of 20 PDCs); and,
- Winter Storm (19 out of 20 PDCs).

Table 3-20 - Local Plan Hazard Ranking Summary

	Flooding	Hurricane, Tropical Storm, Cyclone, Nor' easter	Coastal Erosion/Shoreline	Non-rotational wind	Severe wind	Thunderstorm/ Hailstorms	Lightning	Winter storm/weather	Ice storm	Wildfire	Communicable Disease/Pandemic/Infection	Landslide	Karst/subsidence	Tornado	Drought	Earthquake	Dam/levee Failure	Extreme Heat	Extreme Cold	Terrorism, Active Threat	HazMat, Biological Hazard	Space Weather	Technology (Power, Pipelines, Communication)
Richmond Regional and Crater PDCs (15 and 19)	H		L		H	M		M		L	L			H	M	L	L	M					
Southside PDC (13)	H	H			H	H	M	H		M		L		M	H	L	M	H	M				
Commonwealth Regional Council (14)	M	H				H		H		M				H	H			H					
Northern Shenandoah Valley PDC (7)	H	H	L		H	M	M	H	H	M		L	L	H	M	L	M	M	H		M		M
Rappahannock-Rapidan RC (9)	H	M				H		H		M		L	L	H	M	L	L	M					
Thomas Jefferson PDC (10)	H	H			H		L	M		L		L		L	L	L	L	L					
George Washington Regional Commission (16)	H	H	H	H				H		H		L	L	H	M	L	L	M					
Cumberland Plateau PDC (2)	H				M	M		M		M		M	L	L	M	M	M	L					
Lenowisco PDC (1)	H			H	M	M		H		H	M	M	M	M	M	M	L						
Mount Rogers PDC (3)	H	L			M	L	L	H	H	M		L	L	L	M	L	L						
Accomack-Northampton PDC (22)	H		H		H						H			L						L	M		L
Hampton Roads PDC	H	H						M		L	L		H	M		L	L				M		
Northern Neck PDC (10)	H	H	M		M	M		L		L				H	L	L							
Middle Peninsula PDC (18)	H	H	M	H	M		M	H	H	M	H		L	M	L	L	L	M	M		M		
West Piedmont PDC (12)	H	H	H		H	H	H	H		M		L		H	M	M	M			M	H		M
Central Virginia	H	M				M		M		M	L	M	L	M	H	L	M	M	M	L	M	L	
New River Valley PDC (4)	H				H			M	M	M		L	L	L	M	L			H	M	M		
Roanoke Valley-Allegheny PDC (5)	H	H		H				H		M		M		M		L							
Central Shenandoah PDC (6)	H	H		M				H	H	M		L	M	M	H	L	H	H		L	L		L
Northern Virginia RC (8)	H				H			H		M		L	L	H	M	M	L	H	H				
Overall	**H**	**H**	**M**	**H**	**H**	**M**	**M**	**H**	**H**	**M**	**M**	**L**	**L**	**M**	**M**	**L**	**L**	**M**	**H**	**L**	**M**	**L**	**M**

3.7.5 Addressing Uncertainty in Hazard Identification

Table 3-21 provides an outline of what types of events fall within the designated HIRA hazard categories. For this risk assessment the following hazards were evaluated: Drought, Earthquake, Erosion, Extreme Cold, Extreme Heat, Flooding, Hurricane, Impoundment Failure, Karst (Sinkholes), Landslide, Land Subsidence, Non-Tornadic Wind, Pandemic, Tornado, Space Weather, Wildfire, and Winter Weather. Committee discussions centered on how to determine the categorization of certain events. Hurricanes are one of the Commonwealth's most costly hazards; however, the events can cause damage from both wind and flood. Since the impacts of high wind, excluding tornadoes and hurricane, are the same whether it be from a derecho or a severe thunderstorm, it was decided wind events not categorized as tornado or hurricane should be grouped together in a non-tornadic wind category.

Table 3-21 - Summary of hazard events by HIRA category hazards

Flood	Non-Tornadic Wind	Winter Weather	Tornado	Drought	Hurricane
Riverine	Heavy Wind	Snow	Tornado Winds	Drought	Hurricane Wind
Coastal storm surge	Thunderstorm	Ice			Tropical Storm Wind
Tsunami	Derecho	Extreme cold			
Nor'easter		Nor'easter with snow, ice			
Sea level rise					

Earthquake	Karst (Sinkholes)	Landslide	Impoundment Failure	Extreme Cold	Extreme Heat
Earthquake	Karst (Sinkholes)	Landslide	Dam failure Levee failure	Extreme Cold	Extreme Heat

Erosion	Space Weather	Land Subsidence	Pandemic	Wildfire
Erosion	Space Weather	Land Subsidence	Pandemic	Wildfire
	Solar Storm		Disease	Dense smoke

3.7.6 Assessment of Local Vulnerability and Potential Losses

Local hazard rankings have made strides in recent years to decrease the variability in criteria to develop monetary loss values; however, the methodology remains inconsistent across the local hazard mitigation plans. This variability does not lend itself to being able to compare relative loss values for each hazard in the statewide plan. Annualized loss values were pulled out of the local plans and brought into this plan for comparison. Flood, tornado, non-tornadic wind, and hurricane were the dominant hazards that had annualized loss values associated with them.

Table 3-22 illustrates the wide range in annualized loss estimates that have been pulled from the local plans. Some plans provided total loss estimates for a specific flood or hurricane event but did not provide annualized losses. In these instances, "-"was listed in the table. Without proper documentation and data, these values cannot be compared in their current form. Some of the local plans used FEMA's Hazus software for this analysis, while others may have used a combination of past event damages and years of record.

Table 3-22 - Local Hazard Mitigation plan annualized loss estimates

Jurisdiction / PDC	Hurricane	Tornado	Flood	Earthquake	Non-tornadic Wind	Drought	Wildfire	Winter Weather
Richmond-Crater	$1,436,741	$1,488,825	$95,063	$4,167,000	$9,704,000	$1,765,040	$231,896	$40,411
Southside	$18,760,000	-	$35,451,000	-	$18,760,000	$4,130,000	-	-
Commonwealth	-	-	-		-	$1,193,181	-	$5,590
Northern Shenandoah Valley	-	-	-	-	-	-	-	-
Rappahannock-Rapidan	$491,000	$262,527	$17,515,000	$360,000	$491,000	$1,535,000	$42,522	$135,425
Thomas Jefferson	$832,000	$5 - $7 M	$1,400,000	-	$816,000	$5 - $15 M	-	-
George Washington	-	-	-	-	-		-	-
Cumberland Plateau	-	-	-	-	-		-	-
Lenowisco	-	-	-	$47,436	$73,247		-	-
Mount Rogers	-	-	-	-	-	-	-	-
Accomack-Northampton	-	-	-	-	-	-	-	-
Hampton Roads	$86,913,000	$24,300,000	$44,261,424	$1,100,000	$86,913,000	-	$36,860	$805,800
Northern Neck	$292,888	$173,366	$1,317,887	-	$360,275	$943,399	-	-
Middle Peninsula	$2,766,673	-	$40,909,000	-	-	-	-	-
West Piedmont	$29,468,177	$2,481,050	$379,594	$29,468,177	$970,498	$2,987,923	$400,352	$214,958
Central Virginia	$760,000	-	-	$307,000	-	$515,380	-	-
New River Valley	-	-	-	$781,183	$374,000	-	-	-
Roanoke Valley-Allegheny	-	-	-	-	-	-	-	-
Central Shenandoah	$399,000	-	$66,991,000	-	-	-	-	-
Northern Virginia	$6,500,000	$209,662	$255,477	$1,490,000	$6,500,000	-	-	-

3.8 Hazards

In the past, the picture of climate change in the Southeastern United States was obscured by being one of the few regions in the world with relatively little overall warming in daily maximum temperatures since 1900[viii]. More recent analysis, captured by the Fourth U.S. National Climate Assessment for the Southeast region and Virginia-specific analyses of temperatures, precipitation, and sea level rise[ix,x,xi], make it clear that Virginia's climate is changing, and future hazard mitigation plans in the Commonwealth need to consider the range of changes in frequency, intensity, and duration of hazards connected to climate change. Commonwealth-wide, temperatures have risen more than 1.5°F since the beginning of the 20th century[1]. The amount of warming varies by season and by location, with the greatest changes in temperature from 1986-2016 relative to the 1895-2000 average coming in winter and spring[2]. However, since 2005 average temperatures in the summers have been the warmest on record[3].

The total annual precipitation for the Commonwealth has been trending upward slightly since 2000, and the observed number of extreme precipitation events of 2" storm total or greater is highly variable but overall exhibiting an upward trend as well, with the number of events from 2015-2020 exceeding the previous record of such events from 1995-1999[3]. Some events have been significantly higher, including the 8.4 inches of rain received at Washington Dulles International Airport from Tropical Storm Lee in 2011 and rainfall totals of 3-4 inches in Northern Virginia during a convective rainfall event July 8, 2019[4]. Due to the combined impact of sea level rise and land subsidence, coastal Virginia also experiences among the highest rates of relative sea level rise in the United States, with over 18 inches of relative sea level rise in the past 100 years recorded at the National Oceanic and Atmospheric Administration's tide gauge in Sewells Point[4]. Over time, the combination of rising sea levels and rainfall events are exacerbating flooding in coastal Virginia, with flooding leading to loss of marsh buffers and increased stress on stormwater infrastructure.

Relevant to hazard mitigation planning, continued warming temperatures are anticipated to impact the transmission of some vector borne diseases, increase long term heat stress due to the projected increase in number of warm nights per year, increase heat stress due to extreme high temperatures impacting outdoor workers (particularly in agriculture), alter air quality, and shift historical patterns of wildfire[1]. Sea level rise and increased rainfall will also affect critical infrastructure and the flooding of homes and businesses. The Commonwealth of Virginia has adopted the National Oceanic and Atmospheric Administration's intermediate-high scenario as the future sea level rise curve recommended for planning purposes[4]. This curve now indicates that the Sewell's Point, VA tide gauge in Norfolk 1.21 feet of sea level rise by 2040, 1.67 ft by 2050, and 5.61 ft by 2100[xii]. Storm surges and high tides would be superimposed on top of this amount of sea level rise, meaning that a storm the magnitude of Hurricane Isabel in 2003 would produce a storm surge 5 feet above NAVD88 in 2050[xiii]. The Virginia Coastal Resilience Master Plan was published in 2021 and includes hazard analysis and planning guidance for building resilience to sea level rise and coastal flooding for the Commonwealth through 2100[xiv]. Future iterations of this plan will also incorporate new projections of increased rainfall, duration, and intensity curves that have been developed for the Commonwealth of Virginia[xv] which are now available through a web tool that provides 2-year through 100-year change factors to precipitation based on the current NOAA Atlas 14 IDF curves for both low and high emissions scenarios through 2100 (https://midatlantic-idf.rcc-acis.org/). Approved April 11, 2022, Virginia Senate Bill 551 also requires Virginia's Department of Conservation and Recreation (DCR) to update the Virginia Coastal Resilience Master Plan regularly and to develop a statewide Virginia Flood Protection Master Plan[xvi]. These plans will be available for the 2028 update of the Commonwealth of Virginia Hazard Mitigation Plan and will continue to improve the ability to incorporate climate change conditions into hazard mitigation planning at the Commonwealth and regional levels.

3.8.1 Drought

3.8.1.1 Background

Drought is a natural climatic condition caused by an extended period of limited rainfall beyond that which occurs naturally in a broad geographic area. High temperatures, high winds, and low humidity can worsen drought conditions and make areas more susceptible to wildfire. Human demands and actions can also hasten drought-related impacts.

Droughts are frequently classified as one of the following four types: meteorological, agricultural, hydrological, or socio-economic. Meteorological droughts are typically defined by the level of "dryness" when compared to an average or normal amount of precipitation over a given period. Agricultural droughts relate common characteristics of drought to their specific agricultural-related impacts. Emphasis tends to be placed on factors such as soil water deficits, water needs based on differing stages of crop development, and water reservoir levels. Hydrological drought is directly related to the effect of precipitation shortfalls on surface and groundwater supplies. Human factors, particularly changes in land use, can alter the hydrologic characteristics of a basin. Socio-economic drought is the result of water shortages that limit the ability to supply water-dependent products in the marketplace.

Economic impacts include loss of income for farmers dependent on crop harvests, irrigation costs for farms and gardens, higher costs of feed and water for farm animals, and impacts to farm supply businesses such as tractor sales. Wildfire resulting from drought can impact timberland. Water utilities may have additional costs to treat and provide limited water supplies, and food prices in general may be driven higher. Environmental impacts may include loss or destruction of fish and wildlife habitat, and lack of food or drinking water for wild animals and resultant disease in those populations, migration of wildlife, and poor soil quality which may lead to soil erosion. Social impacts may result from changes in lifestyle associated with chronic drought and associated water restrictions. Severe drought may cause health problems related to poor water quality and fewer recreational activities if drought continues and water supplies are curtailed.

Current drought conditions in Virginia are tracked by the Drought Monitoring Task Force (DMTF), an interagency group made up of representatives from both state and federal agencies. The Task Force's status reports integrate information from various state and federal organizations to provide a complete picture of current and near-term drought conditions[xvii].

Current drought conditions nationwide are tracked by the US Drought Monitor, a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, federal, and state environmental and climatologic organizations. The US Drought Monitor blends a variety of drought indicators to produce a weekly drought condition status map for the nation[xviii].

Droughts are typically quantified based on indices that consider rainfall, temperature, stream flow, groundwater, and/or other factors. One of the most cited drought measures is the Palmer Drought Severity Index (PDSI), first documented in a 1965 paper by Wayne Palmer, which uses temperature and precipitation information for a location in a formula to quantify dryness. A Palmer index value of zero indicates normal conditions, with increasingly negative values indicating increasing drought severity. PDSI is specifically intended to measure long-term droughts. Other drought indices, such as the crop moisture index (CMI) use different methods and formulas to quantify dryness, and may be more appropriate for specific applications, including measuring short-term droughts. The US Drought Monitor uses a variety of drought indices, including the Palmer index, to produce an overall drought severity classification.

The drought severity classification table (Table 3-23) shows the ranges for Palmer Drought Severity Index (PDSI) for each dryness level. Other indicators are also used, such as USGS weekly streamflow data and a standardized precipitation index. Short-term drought indicator blends focus on 1 to 3-month precipitation totals. Long-term blends focus on 6 to 60 months of precipitation data.

Table 3-23 - Palmer Drought Severity Index[xix]

Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	-1.0 to -1.9
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	-2.0 to -2.9
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	-3.0 to -3.9
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	-4.0 to -4.9
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less

Figure 3-32 provides a look at the national average percent of D3-D4 conditions from 2000-2022.

Figure 3-33 shows the PDSI summary map for the US from 1895 to 1995. PDSI drought classifications are based on observed drought conditions and range from -0.5 (incipient dry spell) to -4.0 (extreme drought). As can be seen, the Eastern US has historically not seen as many significant long-term droughts as the Central and Western regions of the country.

Figure 3-32 - National average percent of D3-D4 conditions, including Virginia, 2000-2022.

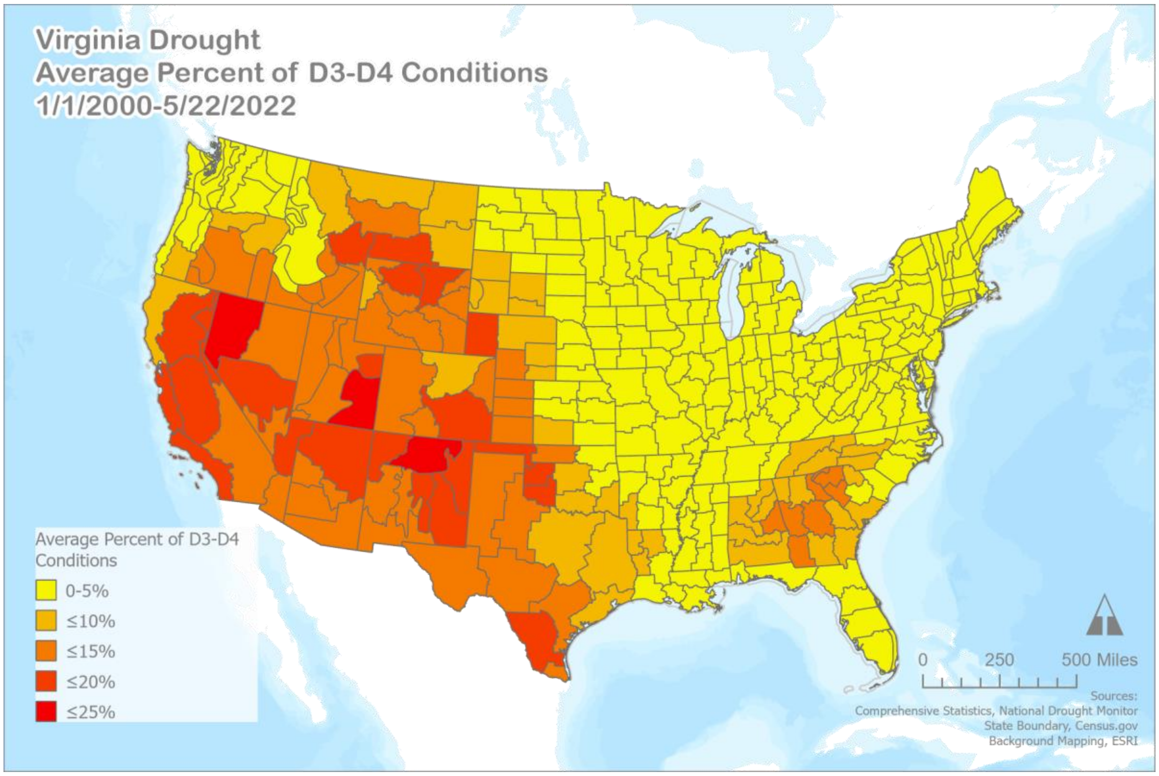
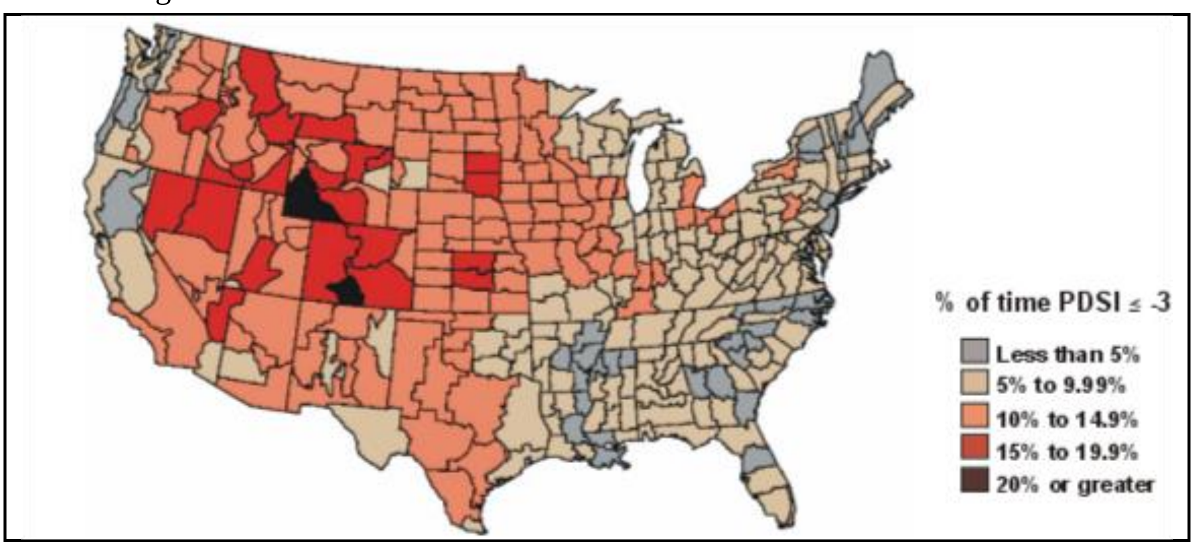


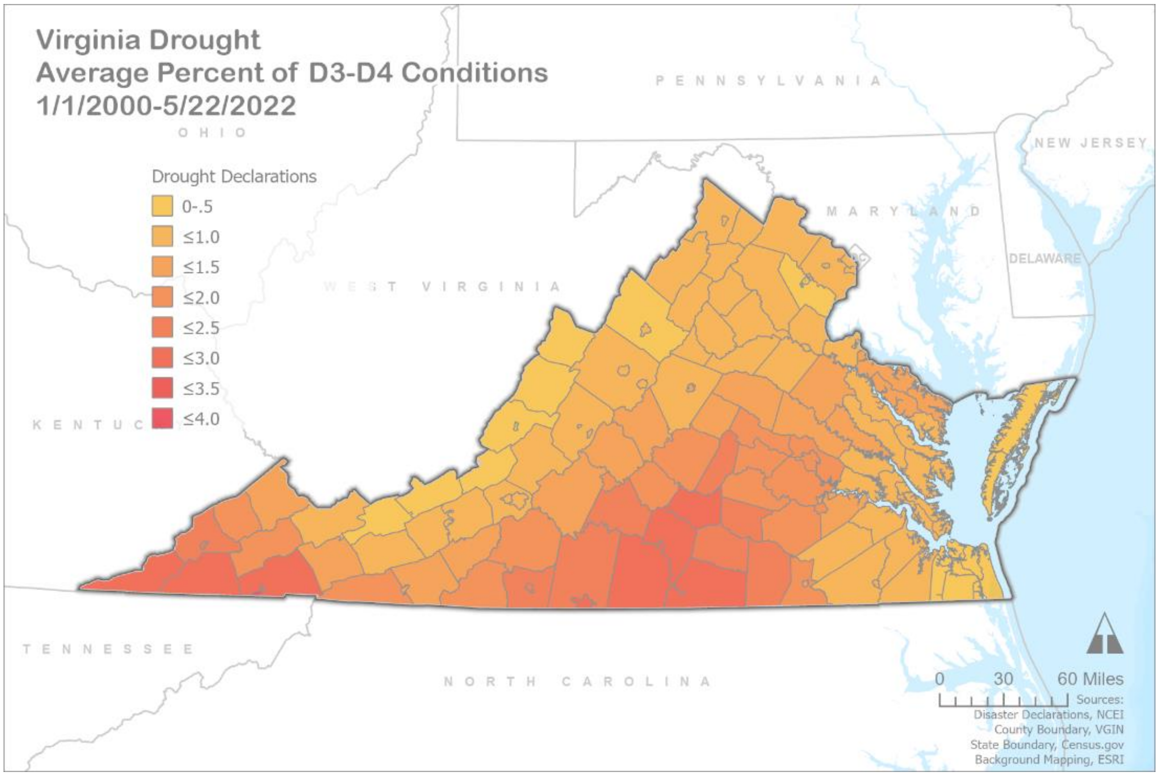
Figure 3-33 - Palmer Drought Severity Index, 1895-1995 Percent of Time in Severe and Extreme Droughtxx



3.8.1.2 Location and Spatial Extent

Drought typically impacts a large area that cannot be confined to geographic boundaries; however, some regions of the US are more susceptible to drought conditions than others. According to Figure 3-34, Virginia is in a zone representing 5 percent to 9.99 percent of the time with PDSI less than or equal to -3 (-3 indicating severe drought conditions). Drought conditions typically do not cause significant damage to the built environment. Agricultural areas are more likely to be impacted by drought, especially in the early stages. As water restrictions are put in place because of acute water shortages, impacts on urban consumers increase (use restrictions, drinking water supply effects and saltwater intrusion). Figure 3-34 indicates that Virginia has had a maximum of 4 drought declarations per county between January 2000 and May 2022.

Figure 3-34 - Virginia Drought – Average D3-D4 Conditions Statewide



3.8.1.3 Significant Historical Events

The drought of record for Virginia occurred in 1931 when the statewide average rainfall amount was 7.64 inches compared to an average mean rainfall amount of 17.89. This drought was during the period that also saw the Great Dust Bowl that contributed to the Great Depression.

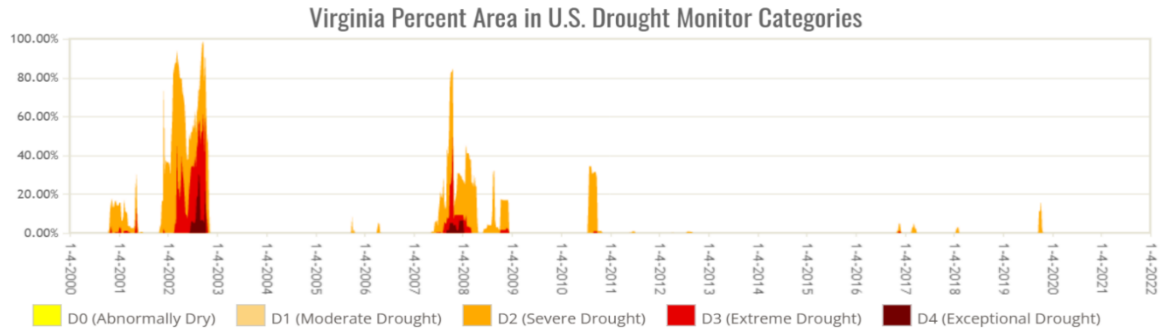
Table **3-24**, based on available records from VDEM, local plans, and the National Weather Service (NWS) describes some of the major recorded droughts in Virginia's history.

Table 3-24 - Selected Droughts in Virginia's History[xxi]

Date of Occurrence	Details
1607	An extended drought threatened Jamestown; many did not survive.
1930	The Virginia Piedmont counties of Loudoun, Fauquier, and Culpeper registered less than 21 inches of rain for the year – about half of the normal amount. From July through November of 1930, no rain gauge in the Piedmont registered more than 1.6 inches of rain[xxii].
1962-1971	The cumulative stream flow deficit was the largest because of its duration; however, it was not as severe as the 1930 drought.
1985-1988	Severe drought in the entire southeast US.
1993	Hot, dry weather affected 23 Virginia counties and was responsible for an estimated $75 million in crop damages.
1995	City of Suffolk was declared a Drought Disaster Area, with an estimated $13.3 million in crop damages.
1997	Drought conditions resulted in crop damages estimated at $73.8 million in central, eastern, and northern Virginia.
1998	Drought conditions resulted in crop damages estimated at $66.5 million in the Eastern Piedmont and Northern Neck regions of Virginia.
1999	Drought conditions resulted in crop damages estimated at $83 million in Northern Virginia.
2000s	Throughout most of the early and mid-2000s, the entire southeastern US was in varying levels of drought, including Virginia. In November 2002, 45 counties were approved for primary disaster designation by the US Secretary of Agriculture, while 36 requests were still pending. This dry period led to water conservation restrictions throughout the state and exacerbated water supply infrastructure problems, especially in rural communities.
October 2005	The Town of Big Stone Gap experienced a water shortage due to a combination of drought-like conditions and construction activities on a new dam for the Big Cherry Reservoir. A state of emergency was declared, and about $1.3 million in state funding was used to help offset the costs of local emergency water supply operations.
2007	Seventeen counties fell into severe drought status as over $10 million in crop damages occurred in southwest Virginia.
June 2007	In the Town of Goshen, a pump failure caused water pressure to drop, and many older pipes (circa 1930), which were already in fragile condition, cracked and caused major leaks. The water system was forced to shut down for repairs. A state of emergency was declared, and water was shipped in and distributed with assistance from the National Guard, volunteer organizations, and church groups.
2010	The summer of 2010 was hot and dry. Most of the state suffered from moderate to severe drought conditions, and some jurisdictions were placed under water restrictions.
2012-2013	La Nina conditions produced extreme and exceptional drought conditions throughout much of the US, Canada, and Mexico. Peak drought conditions in July resulted in more than 80% of the country with at least abnormally dry conditions. Much of Virginia was classified as either abnormally dry or as experiencing moderate to severe drought conditions.
2021-2022	NCEI reports Pittsylvania, Charlotte, and Halifax Counties experienced drought conditions for 3 months.

Figure 3-35 provides a time series of US Drought Monitor Categories since 2000 for the Commonwealth of Virginia, highlighting times when Virginia was in Extreme, Severe or Exceptional drought categories.

Figure 3-35 - Virginia Drought History, 2000-2021[xxiii]



As of early 2022, precipitation totals have been below the watch indicator for many areas of the state. The DMTF issued a Drought Watch Advisory for the Northern Virginia and Northern Piedmont regions, which means that precipitation levels are low enough to warrant further monitoring of these areas for the development of drought conditions[xxiv].

3.8.1.4 Probability of Future Occurrence

The future incidence of drought is highly unpredictable and may be localized, which makes it difficult to assess the probability of drought. Near-term conditions can be extrapolated from past trends. Some form of drought affects Virginia every year, and so the real challenge is to assess the exact timing, location, and severity of drought conditions. Any assessment of historical or future drought conditions must also define the measures of drought to be tracked, a non-trivial task.

No sources of information on long-term historic frequency of drought or future probability of drought were identified for inclusion in this plan. This may be a result of multiple definitions resulting in inconsistent reporting. As a result, while the future probability of some type of drought may be estimated at 100%, the exact severity of future drought cannot be quantified at this time.

3.8.1.5 Impact and Vulnerability

Virginia has extensive agricultural operations throughout the state, many of which are vulnerable to shortages in rainfall. As of 2017, there were approximately 43,225 farms in the state, and approximately 33% of the state's land was held in farms (7.8 million acres)xxv. Because of the significant amount of cropland and agricultural operations in the state, drought is a hazard of concern. Precipitation at reliable, predictable times in the growing cycle of any crop is essential for the success of that crop, as every crop has a predictable growing season.

Evapotranspiration is the evaporation of water from plant leaves. The rate of evaporation varies widely depending on weather conditions (temperature, humidity, sunlight intensity, precipitation, wind, etc.). During dry periods – including droughts - transpiration can contribute to the loss of moisture in the soil, which can impact vegetation and crops.[xxvi]

Figure 3-36 illustrates the distribution of cultivated lands in Virginia. Cultivated lands are defined by the USDA Census of Agriculture as land from which crops were harvested and hay was cut, and land used to grow short-rotation woody crops, land in orchards, citrus groves, Christmas trees, vineyards, nurseries, and greenhouses[xxvii].The USDA Census of Agriculture is updated on a 5-year cycle. The last update was done in 2017 and the 2022 update is ongoing. Therefore, the data shown in the figure below is based on the 2017 Census of Agriculture. The top five counties with the greatest acreage of cropland, and therefore high exposure to drought impacts, are listed in Table 3-25.

Table 3-25 - Acreage of Cropland by Jurisdiction for the Top Five Countiesxxviii

County	Cropland Acreage
Rockingham County	107,355
Augusta County	95,603
Southampton County	91,803
Fauquier County	68,423
Pittsylvania County	66,556

Short-term droughts occurring in sync with the growing season may have a significant impact on agricultural productivity but may have little impact on public drinking water supply. Long-term hydrologic drought can impact public water supplies, forcing local governments to enact water conservation restrictions. The cost of such restrictions has not been analyzed in this plan due to lack of reliable data. Jurisdictions which have invested in water supply and distribution infrastructure are less vulnerable to drought.

In addition to the primary impacts of drought, there are also secondary impacts that can increase the potential for other hazards to occur. Extended periods of drought can increase the risk of wildfire occurrences. Wildfire occurrences can lead to an increase of burned woody debris that could increase the potential for landslides or mudflows. Drought conditions may also increase the number of trees impacted by high wind events.

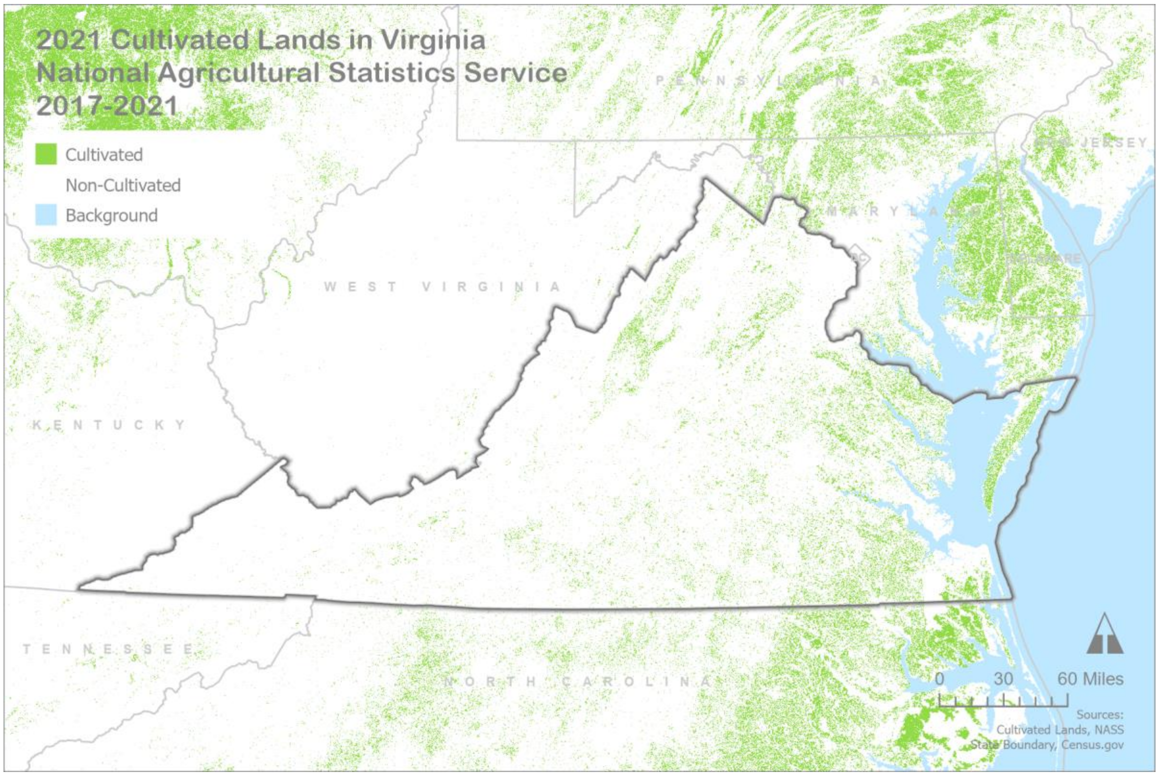
Risk

The risk associated with drought in Virginia has not been formally quantified due to the difficulty in assessing the rate of incidence, and the lack of complete data on drought impacts. There is low risk of property damage due to drought in Virginia. Droughts can typically occur in every part of the state. Risk to structures should be considered uniform across the Commonwealth.

Crop damages due to drought are uncertain, as agricultural productivity often varies with growing conditions from year to year. However, the NCEI Storm Events Database does report an annualized average of about $27.0 million of crop damages due to drought in the 25 years from 1997 and 2022. Other than crops, the NCEI database does not report any property damages due to drought.

Figure 3-36 highlights cultivated lands in Virginia which provides an idea of where critical facilities could potentially be impacted.

Figure 3-36 - Cropland in Virginia



State Facility Risk

Droughts generally do not impact state structural assets so the risk to state-owned assets is extremely low. Some state agencies and education facilities operate farms or have other agriculture-related research functions and drought could conceivably impact these operations; however, the risk is to the agricultural output, not the agency structures. The value of those agricultural production assets could not be quantified for the purposes of this report; however, future versions of this plan may be improved through the collection of these data. This list is not known to be exhaustive because it was compiled through original research for the purposes of this plan and it does not include all equestrian and golf recreational facilities on all state-owned lands that could be impacted by drought. Additional investigations with DHR, DCR, the Virginia Department of Game and Inland Fisheries, Institutions of Higher Education and DOC are advised to collect a more thorough list of state-owned and operated working farm acreages. Affected facilities may include the following:

- DOC - Beaumont Correctional Center Farm in Beaumont
- DOC – Coffeewood Correctional Center Farm in Mitchells
- DOC – Culpeper Correctional Facility for Women Farm in Mitchells
- DOC – Dinwiddie Correctional Unit Farm on Cox Road
- DOC – Farm Facilities at Powhatan Correctional Center in State Farm
- DOC – Farm Facilities at James River Correctional Center in State Farm
- DOC – Farm Facilities at Greensville Correctional Center in Jarratt
- DOC – Farm Facilities at Halifax Correctional Unit in South Boston

- DOC – Farm Facilities at Baskerville Correctional Center in Baskerville
- DOC – Farm Facilities at Nottoway Correctional Center in Burkeville
- DOC – Farm Facilities at Chatham Diversion Center in Chatham
- DOC – Farm Facilities at Beaumont Correctional Center in Beaumont
- DOC – Farm Facilities at Southampton Correctional Center in Capron
- DOC – Farm Facilities at Deerfield Correctional Center in Capron
- DOC - Farm Facilities at Wise Correctional Unit at Coeburn
- Virginia Outdoors Foundation – Hayfiles Farm in McDowell
- Frontier Culture Museum of Virginia – Farm Facilities in Staunton
- DHR – Clermont Farm in Berryville
- VDOF – Game Farm in Cumberland
- DCR – Farm Facilities at Sky Meadows State Park in Delaplane
- DCR - Farm Facilities at Chippokes Plantation State Park
- Virginia Military Institute Bushong Farm - In 1964, the Bushong Farm and surrounding property was deeded to VMI, creating the first act of Civil War battlefield preservation in the Shenandoah Valley.

Virginia Tech Agricultural Research and Experiment Centers (ARECs)—About 3,900 acres of land at 12 agricultural research stations and laboratories throughout the state are used for agricultural, forestry, seafood, and aquaculture research. Some of the land is leased; the remainder is owned by the university. These stations, the number of acres owned, the year operations began, and the location of each are Hampton Roads AREC, 70 acres, 1920, Virginia Beach; Middleburg AREC, 420 acres, 1949, Middleburg; Northern Piedmont, 43.18 acres, 1940, Orange; Eastern Shore AREC, 226 acres, 1913 (moved to current location in 1956), Painter; Alson H. Smith Jr. AREC, 134 acres, 1921, Winchester; Shenandoah Valley AREC, 634 acres, 1954, Steeles Tavern (includes the Cyrus McCormick Farm); Tidewater AREC, 325 acres, 1914, Holland; Southwest Virginia AREC, 208 acres, 1929, Glade Spring; Eastern Virginia AREC, 54 acres, 1912, Warsaw (started in Williamsburg; moved to current location in 1950); Southern Piedmont AREC, 1,184.16 acres (efforts underway to increase acreage to a total of 3,829 acres), 1906 (two experiment stations in Chatham and one in Charlotte Court House consolidated in 1972 to form this AREC), Blackstone; Virginia Seafood AREC, 1 acre, 1975, Hampton; and Reynolds Homestead Forest Resources Research Center, 710 acres, 1969, Critz (site includes the Reynolds Homestead. The Southwest Virginia Aquaculture Research and Experiment Center, which opened in 2000 in Saltville was closed as an AREC in the winter 2009-2010 and is now used as a department research laboratory.

Virginia Tech Cyrus McCormick Farm—In 1954 the heirs of Cyrus McCormick gave the college the 634-acre farm Walnut Grove, where McCormick had demonstrated his first successful reaper. The property, located between Steele’s Tavern and Raphine in Rockbridge County, was used to establish the Shenandoah Valley Agricultural Research and Extension Center, dedicated in 1958. A five-acre memorial plot, which is a designated National Historic Landmark, includes a museum converted from a blacksmith shop, a gristmill, and a manor house that are open to visitors.

Virginia Tech Reynolds Homestead—In 1969 Nancy Susan Reynolds donated the Reynolds Homestead, birthplace and boyhood home of tobacco manufacturer R.J. Reynolds, to the university, followed in 1980 by an additional gift of land. Total acreage: 723.99 acres. The site includes a two-story brick home, known as the Rock Spring Plantation House, which was built in 1843 and is a historic landmark; several outbuilding, family and slave cemeteries, a continuing education center, and the Reynolds Homestead Forest Resources Research Center. In 2007, the Virginia Tech Foundation purchased an additional 32.40 acres; cost $107,500; followed in 2008 by the purchase of 28.07 acres; cost $149,500, both purchases for use in forestry research. The plantation home is open to the public.

Virginia Tech College Farm Operation—Formed in 1990. Six tracts of land, including Whitethorne Farm, totaling 3,200 acres in Blacksburg area. Crops produced on 1,937 acres used to support livestock in research and teaching programs. Field plot and livestock grazing research conducted on 400 acres. Additional 660 acres devoted to wildlife, forestry, conservation management, demonstrations, and other educational activities.

Virginia Tech Corporate Research Center—Development started in 1985 to attract industrial research and development operations to locate in the park and interact with university research programs. Located south of the main campus and adjacent to the Virginia Tech/Montgomery Executive Airport. Dedicated September 25, 1987. 33 completed buildings on 230+ acres of land with 1.2+ million square feet of space. The park is home to 180+ companies currently employing 3,000+. The VTCRC has plans to construct another 16 buildings (870,000 square feet) to house a total of around 5,000 employees in the future.

Virginia Tech Fries, Va., Textile Mill—Donated by Robert Pamplin with the understanding that it would be sold, and proceeds used to support the Pamplin College of Business. The mill and milldam, which made the generation of electricity possible, was sold around 1990 to a company that buys small generation plants and sells the electricity to large utilities.

Heth Property—Acquired 2001 when Heth family sold and gifted 326 acres of property worth approximately $15.2 million to the university. Located adjacent to Virginia Tech. Most of the property intended for eventual use and growth of the university. Some property currently used by Biological Sciences for stream restoration research on Stroubles Creek; other parts of the property have been used by the College of Agricultural and Life Sciences.

Kentland Farm and Historic District—Acquired in 1985 as part of Whitethorne Farm (see below); 350-acre area that includes an antebellum manor house, hexagonal brick smokehouse, overseer’s house, 19th-century grist mill, Kent-Cowan cemetery, and slave cemetery. Recognized by Virginia Board of Historic Resources and placed on National Register of Historic Places in 1991. Includes Kentland Manor, constructed 1834-35, a two-story, five-bay, Flemish-bond brick home with Federal and Greek Revival detailing. The historic district includes five Native American utilization areas dating to Late Woodland period (AD 800-1600). Revitalization project commenced 2003 to preserve and develop the historic district.

Virginia Tech Marion DuPont Scott Equine Medical Center—Constructed in 1981 in Leesburg and operated by Virginia Tech’s Virginia-Maryland Regional College of Veterinary Medicine.

Funding for the facility, which provides diagnostic and treatment services and on-site training for equine veterinary medicine and surgery students, came from Marion duPont Scott and the Virginia Tech Foundation. The Westmoreland Davis Memorial Foundation provided the 198-acre site for the center. New barn dedicated April 17, 2009; named for Paul R. Fout, a horse breeder and trainer. Founding director of equine center was Dr. G. Frederick Fregin.

Virginia Tech Moore Farm—Approximately 246.90 acres. Located off Price’s Fork Road. Acquired in 1950 from Alma Flanagan Moore and Lawrence W. Moore. Consists of observatory, several houses, several barns and sheds, and other buildings. Astronomy-teaching observatory constructed 1974; 410 sq. ft. Contains a 16 1/2 ft. dome and 12 1/2 inch, electronically controlled Newtonian telescope.

Virginia Tech Whitethorne Farm—Acquired by the university in 1985 in a deed exchange between the university and Jay D. and Lorraine B. Nicewonder and The Buchanan Bottoms Land Company, a Virginia corporation. Includes 1,750 acres of land and several agriculture-related buildings, and the Kentland Farm and Historic District. In 1986 the Virginia Tech Foundation purchased an additional 95 acres; cost $187,000. University leases the land from the Foundation. Farmland used by College of Agriculture and Life Sciences for research.

UVA Panorama Farms - Panorama Farms is a privately owned farm of 850 acres located off Earlysville Road, approximately six miles from the Grounds of the University of Virginia. The property has nine miles of cut grass trails and 30 miles of wooded mountain bike trails. There are two different 5K courses, as well as a 6K, an 8K and a 10K course each with a common starting line and finish line. The courses are laid out entirely on rolling grass fields that are maintained year-round. The courses are exceptionally spectator friendly. The home of the Virginia cross country teams, Panorama Farms was the site of the 2006 and 2007 ACC Cross Country Championships and the 2013, 2015, 2016, 2017 and 2019 NCAA Southeast Regional Championships.

UVA Morven Farm - current acreage includes forty-three buildings and a core property to be held in perpetuity. The gift also includes the renowned Formal Gardens, circa 1930, and the Japanese Garden constructed in the mid-1990s. Provides a collaborative environment for both local initiatives and global convening for pressing environmental issues. Includes a kitchen garden and the First Lady’s Food Lab.

UVA - The Virginia Forest Research Facility (VFRF) is part of the Pace/Steger teaching/research site located in nearby Fluvanna County. This field site, representing a secondary growth, mixed deciduous forest and associated riparian zones in the Piedmont of central Virginia, has a 40-m meteorological tower for measuring trace gas exchanges as well as facilities and equipment used primarily for undergraduate and graduate teaching purposes.

UVA Blandy Farm - Focus of ecological research is centered on the 700 acre Blandy Experimental Farm located near Front Royal, VA. Blandy contains cropland, fields, and forest, office and dormitory buildings, and is home to the Orland E. White State Arboretum of Virginia. Faculty and students also conduct research at the Mountain Lake Biological Station, a research and teaching facility located in the deciduous hardwood forest of the Allegheny Mountains of southwestern Virginia and administered by the Biology Department at UVA.

Radford University Farm at Selu - a farming-based living history museum on a replicated 1930s homestead on Radford University's 380-acre Selu conservancy.

Critical Facility Risk

Droughts typically do not impact infrastructure. Cropland is the asset that is most at risk from drought, but crops are not considered critical facilities. Drinking water reservoirs may experience service interruptions during drought conditions in some parts of the US; however, this risk has been successfully managed in Virginia in the past and the reservoirs in Virginia are primarily owned and operated by non-state entities.

Drought Risk to Energy Pipelines

The risks associated with expansive soils – including those posed to buried pipelines – may be exacerbated by prolonged drought followed by soil-saturating precipitation[xxix]. Severe drought conditions can cause soil to shift, which may cause brittle pipelines to break. Soils that are prone to changes in volume with changing moisture content are called expansive soils. The capacity of soil to shrink and swell is dictated by the clay minerals present in those soils, particularly montmorillonite, which can cause swelling of up to 15 times the dry volume and exert pressure of more than 30,000 pounds per square foot. Seasonal changes in soil moisture can increase the shrink/swell behavior of expansive soils. Expansive soils may be recognized by large cracks that form during droughts.

National Risk Index

The National Risk Index (NRI) includes three components: a natural hazards component (Expected Annual Loss), a consequence enhancing component (Social Vulnerability), and a consequence reduction component (Community Resilience). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for drought are reviewed for each community (county tract).

As shown in Figure 3-37, drought is of greatest risk to areas within the south central and southeastern portions of the Commonwealth.

Table **3-26** highlights the highest risk communities to drought in Virginia.

Figure 3-37 - Drought Risk

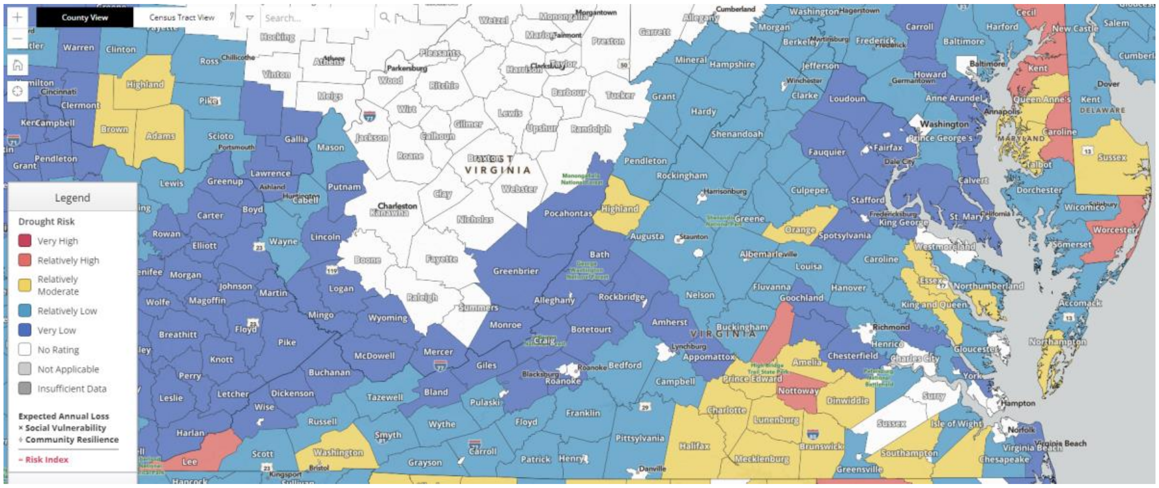


Table 3-26 - Communities With Highest Risk Index Rating for Drought

Locality	NRI Risk Index Rating
Lee County	Relatively High
Cumberland County	
Nottaway County	

Source: NRI

Future Conditions

Information provided by the Governor's Climate Commission indicates that Virginia is "moving towards more widespread impacts under the driest conditions." While the data is not yet conclusive that chronic or increased drought conditions already have or will evolve in Virginia, there is sufficient evidence to cause concern and to monitor future drought conditions. In addition to concerns regarding livestock, croplands, and people, the 808,000 acres of freshwater wetlands in Virginia are also at risk during prolonged drought conditions[xxx]. Fuel transport by rail and barge is susceptible to increased interruption and delay during more frequent periods of drought that affect water levels in rivers and ports.

The 2017 National Climate Assessment describes increased temperatures and more frequent droughts because of climate change[xxxi]. It reports that the annual average temperature of the contiguous US has risen since the start of the 20th century[xxxii]. Assuming a "business as usual" emissions scenario is maintained, NASA's Langley Research Center predicts that a nine degree increase in average temperatures in Virginia could be reality by 2100[xxxiii]. This would mean that most of Virginia would be warmer than parts of Texas are currently. NASA has also confirmed that since 1880, when official record keeping began, the past eight years collectively have been the warmest, with 2020 and 2016 being the hottest[xxxiv]. NASA stresses that the important consideration in these figures is that this is not a single or a handful of years that are warmer – this is decade after decade of increases in temperatures. The report confirmed that "heat and precipitation extremes will be five times more likely by 2100 in Virginia, with a once-in-20-year-event occurring every four years".

Based on climate assessments from the US Global Change Research Program, the Intergovernmental Panel on Climate Change, and the EPA's Climate Change Indicators in the US, changes in the drought pattern in Virginia will have both positive and negative impacts on farming, agriculture, and people. Higher temperatures generally reduce productivity in livestock, and can lead to reduced yields of crops, including corn. But higher concentrations of atmospheric carbon dioxide can increase crop yields, which may offset the harmful effects of high temperatures on cotton, soybeans, wheat, and peanuts. These potentially higher yields, however, are reliant on the availability of water for irrigation. Rising temperatures will increase both the need for irrigation and the amount of water needed. If sufficient water for irrigation is not available, severe, or prolonged droughts will result in reduced crop yields[xxxv].

Jurisdictional Risk

The hazard ranking for drought is based on parameters reported in the NCEI Storm Events Database. No geographic extent data were available for drought probability estimation; each jurisdiction was assigned a value of low (1) for ranking purposes. Annualized injuries, deaths, and property damages were also given a low ranking for the state because of the limited events in the NCEI storm events database. The reporting of drought occurrence, and of drought- related crop damages, is shown to be generally higher in Northern, South-Central, and Southwestern parts of the state.

Local Risk Assessment

Local plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

After review of the local and regional plans, 17 of the 20 provided a risk rank for drought. Most of these plans provided a general description of drought and its impact on their region. Four plans used Census data to report the percentage of people on public and private wells. In addition, two plans included past regional water supply problems and complaints. A few local plans also discussed the types of crops and farmland in their regions. Six local plans provided annualized loss values based on the NCEI storm events database; this is the same data that was used for the statewide analysis. Two plans considered the NCEI data and annualized loss estimates, with results that showed negligible amounts of annualized losses. Table 3-27 shows the annualized loss values from the local plans. Local plans discussed the inability to calculate loss due to the lack of detailed record keeping of historical events, probability, and drought not having a physical impact on structures in terms of damage to structures. The local plan ranking average was medium for drought. The 2023 statewide analysis has ranked drought as medium risk.

Table 3-27 - Local Mitigation Plans – Annualized Crop Losses for Drought

PDC/Jurisdiction	Local Plan Annualized Crop Loss
Richmond-Crater	$1,765,040
Southside	$4,130,000
Commonwealth	$1,193,181
Northern Shenandoah Valley	*
Rappahannock-Rapidan	$1,535,000
Thomas Jefferson	$5 - $15 M
George Washington	*
Cumberland Plateau	*
Lenowisco	*
Mount Rogers	*
Accomack-Northampton	**
Hampton Roads	*
Northern Neck	$943,399
Middle Peninsula	*
West Piedmont	$2,987,923
Central Virginia	$515,380
New River Valley	*
Roanoke Valley-Allegheny	**
Central Shenandoah	*
Northern Virginia	*

* Not reported in HMP
** Not identified as hazard in HMP

3.8.1.6 Changes in Development

Most 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. In some cases, agricultural vulnerability was discussed as a part of the overall development trends section. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Most of the damages due to drought are not related to infrastructure. Communities with large amounts of agricultural land have some water supply related mitigation action items.

Table 3-28 - Drought Hazard Ranking Parameters and Risk

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Low	High	Medium	Low	Medium-Low
Albemarle	Medium-High	Medium	Low	Low	High	Medium-High	Low	Medium
Alexandria, City of	Medium-High	High	Low	Low	Low	Medium-High	Low	Medium-Low
Alleghany	Low	Low	Low	Low	Low	Medium	Low	Low
Amelia	Low	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Amherst	Medium	Medium	Low	Low	Low	Medium	Low	Medium-Low
Appomattox	Low	Low	Low	Low	Low	Medium	Low	Low
Arlington	High	High	Low	Low	Low	Medium-High	Low	Medium
Augusta	Medium-High	Medium	Low	Low	High	Medium-High	Low	Medium
Bath	Low	Low	Low	Low	Low	Medium	Low	Low
Bedford	Medium-High	Medium	Low	Low	Low	Medium	Low	Medium-Low
Bland	Low	Low	Low	Low	High	Medium	Low	Medium-Low
Botetourt	Medium	Medium	Low	Low	Low	Medium	Low	Medium-Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Brunswick	Medium	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Buchanan	Medium	Low	Low	Low	Low	Medium-High	Low	Medium-Low
Buckingham	Low	Low	Low	Low	Low	Medium	Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Campbell	Medium	Medium	Low	Low	High	Medium	Low	Medium
Caroline	Medium	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Carroll	Medium	Medium	Low	Low	High	Medium-High	Low	Medium
Charles City	Low	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Charlotte	Low	Low	Low	Low	High	Medium	Low	Medium-Low
Charlottesville, City of	Medium	High	Low	Low	High	Medium-High	Low	Medium
Chesapeake, City of	High	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Chesterfield	High	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Clarke	Low	Medium	Low	Low	High	Medium-High	Low	Medium-Low
Colonial Heights, City of	Medium	High	Low	Low	Low	Medium	Low	Medium-Low
Covington, City of	Low	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Craig	Low	Low	Low	Low	Low	Medium	Low	Low
Culpeper	Medium	Medium	Low	Low	Medium-High	Medium-High	Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Cumberland	Low	Low	Low	Low	High	Medium	Low	Medium-Low
Danville, City of	Medium	Medium-High	Low	Low	High	Medium	Low	Medium
Dickenson	Low	Low	Low	Low	Low	Medium-High	Low	Low
Dinwiddie	Medium	Low	Low	Low	High	Medium	Low	Medium-Low
Emporia	Low	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Essex	Low	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Fairfax	High	High	Low	Low	Low	Medium-High	Low	Medium
Fairfax, City of	Medium	High	Low	Low	Low	Medium-High	Low	Medium
Falls Church, City of	Low	High	Low	Low	Low	Medium-High	Low	Medium-Low
Fauquier	Medium-High	Medium	Low	Low	Low	Medium-High	Low	Medium-Low
Floyd	Low	Low	Low	Low	High	Medium	Low	Medium-Low
Fluvanna	Medium	Medium	Low	Low	Medium	Medium	Low	Medium-Low
Franklin	Medium	Medium	Low	Low	High	Medium	Low	Medium
Franklin, City of	Low	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Frederick	Medium-High	Medium	Low	Low	Medium	Medium-High	Low	Medium
Fredericksburg, City of	Medium	High	Low	Low	Low	Medium-High	Low	Medium-Low
Galax, City of	Low	Medium-High	Low	Low	High	Medium-High	Low	Medium
Giles	Low	Low	Low	Low	Low	Medium	Low	Low
Gloucester	Medium	Medium	Low	Low	Low	Medium	Low	Medium-Low
Goochland	Medium	Medium	Low	Low	Medium	Medium	Low	Medium-Low
Grayson	Low	Low	Low	Low	High	Medium-High	Low	Medium-Low
Greene	Medium	Medium	Low	Low	Medium	Medium-High	Low	Medium-Low
Greensville	Low	Low	Low	Low	Low	Medium	Low	Medium-Low
Halifax	Medium	Low	Low	Low	High	Medium	Low	Medium-Low
Hampton, City of	Medium-High	High	Low	Low	Low	Medium	Low	Medium-Low
Hanover	Medium-High	Medium	Low	Low	High	Medium	Low	Medium
Harrisonburg, City of	Medium	High	Low	Low	High	Medium-High	Low	Medium
Henrico	High	Medium-High	Low	Low	Medium	Medium	Low	Medium
Henry	Medium	Medium	Low	Low	High	Medium	Low	Medium
Highland	Low	Low	Low	Low	Low	Low	Low	Low
Hopewell, City of	Medium	High	Low	Low	Medium	Medium	Low	Medium
Isle of Wight	Medium	Medium	Low	Low	Medium-High	Medium	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
James City	Medium-High	Medium-High	Low	Low	Medium	Medium	Low	Medium-Low
King and Queen	Low	Low	Low	Low	High	Medium	Low	Medium-Low
King George	Medium	Medium	Low	Low	Medium	Medium-High	Low	Medium-Low
King William	Low	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Lancaster	Low	Medium	Low	Low	Medium-High	Medium	Low	Medium-Low
Lee	Medium	Low	Low	Low	Low	Low	Low	Low
Lexington, City of	Low	High	Low	Low	Low	Medium	Low	Medium-Low
Loudoun	High	Medium-High	Low	Low	High	Medium-High	Low	Medium
Louisa	Medium	Medium	Low	Low	Medium-High	Medium	Low	Medium-Low
Lunenburg	Low	Low	Low	Low	Low	Medium	Low	Low
Lynchburg, City of	Low	Medium-High	Low	Low	High	Medium	Low	Medium-Low
Madison	Low	Low	Low	Low	Medium-High	Medium-High	Low	Medium-Low
Manassas, City of	Medium	High	Low	Low	Low	Medium-High	Low	Medium-Low
Manassas Park, City of	Low	High	Low	Low	Low	Medium-high	Low	Medium-Low
Martinsville, City of	Low	Medium-High	Low	Low	High	Medium	Low	Medium-Low
Mathews	Low	Medium	Low	Low	Low	Medium	Low	Medium-Low
Mecklenburg	Medium	Low	Low	Low	Low	Medium	Low	Medium-Low
Middlesex	Low	Medium	Low	Low	Medium	Medium	Low	Medium-Low
Montgomery	Medium-High	Medium	Low	Low	High	Medium	Low	Medium
Nelson	Low	Low	Low	Low	Medium	Medium-High	Low	Medium-Low
New Kent	Low	Medium	Low	Low	Medium	Medium	Low	Medium-Low
Newport News, City of	High	High	Low	Low	Low	Medium	Low	Medium
Norfolk, City of	High	High	Low	Low	Low	Medium	Low	Medium
Northampton	Low	Medium	Low	Low	High	Medium	Low	Medium-Low
Northumberland	Low	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Norton	Low	Medium-High	Low	Low	Low	Low	Low	Low
Nottoway	Low	Low	Low	Low	Medium-High	Medium	Low	Medium-Low
Orange	Medium	Medium	Low	Low	High	Medium-High	Low	Medium
Page	Medium	Medium	Low	Low	High	Medium-High	Low	Medium
Patrick	Medium	Low	Low	Low	High	Medium	Low	Medium-Low
Petersburg, City of	Medium	Medium-High	Low	Low	Medium	Medium	Low	Medium-Low
Pittsylvania	Medium-High	Medium	Low	Low	High	Medium	Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Poquoson	Low	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Medium	Low	Medium-Low
Powhatan	Medium	Medium	Low	Low	High	Medium	Low	Medium-Low
Prince Edward	Medium	Medium	Low	Low	High	Medium	Low	Medium-Low
Prince George	Medium	Medium	Low	Low	Medium	Medium	Low	Medium-Low
Prince William	High	Medium-High	Low	Low	Low	Medium-High	Low	Medium
Pulaski	Medium	Medium	Low	Low	High	Medium	Low	Medium
Radford, City of	Low	Medium-High	Low	Low	High	Medium	Low	Medium-Low
Rappahannock	Low	Low	Low	Low	Medium-High	Medium-High	Low	Medium-Low
Richmond	Low	Low	Low	Low	Medium	Medium	Low	Medium-Low
Richmond, City of	High	High	Low	Low	Medium	Medium	Low	Medium
Roanoke	Medium-High	Medium-High	Low	Low	Low	Medium	Low	Medium-Low
Roanoke, City of	Medium-High	High	Low	Low	Low	Medium	Low	Medium-Low
Rockbridge	Medium	Low	Low	Low	Low	Medium	Low	Medium-Low
Rockingham	Medium-High	Medium	Low	Low	High	Medium-High	Low	Medium
Russell	Medium	Low	Low	Low	Low	Low	Low	Low
Salem, City of	Medium	High	Low	Low	Low	Medium	Low	Medium-Low
Scott	Medium	Low	Low	Low	Low	Low	Low	Low
Shenandoah	Medium	Medium	Low	Low	High	Medium-High	Low	Medium
Smyth	Medium	Medium	Low	Low	High	Medium-High	Low	Medium
Southampton	Low	Low	Low	Low	Low	Medium	Low	Low
Spotsylvania	Medium-High	Medium	Low	Low	Low	Medium-High	Low	Medium-Low
Stafford	Medium-High	Medium-High	Low	Low	Medium	Medium-High	Low	Medium
Staunton, City of	Medium	Medium-High	Low	Low	High	Medium-High	Low	Medium
Suffolk	Medium-High	Medium	Low	Low	Low	Medium	Low	Medium-Low
Surry	Low	Low	Low	Low	Low	Medium	Low	Low
Sussex	Low	Low	Low	Low	Low	Medium	Low	Low
Tazewell	Medium	Medium	Low	Low	High	Medium	Low	Medium
Virginia Beach, City of	High	High	Low	Low	Low	Medium	Low	Medium
Warren	Medium	Medium	Low	Low	Medium-High	Medium-High	Low	Medium
Washington	Medium	Medium	Low	Low	Low	Low	Low	Medium-Low
Waynesboro, City of	Medium	Medium-High	Low	Low	High	Medium-High	Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Westmoreland	Low	Medium	Low	Low	Medium-High	Medium	Low	Medium-Low
Williamsburg, City of	Low	Medium-High	Low	Low	Medium	Medium	Low	Medium-Low
Winchester, City of	Medium	High	Low	Low	Medium	Medium-High	Low	Medium
Wise	Medium	Medium	Low	Low	Low	Low	Low	Medium-Low
Wythe	Medium	Medium	Low	Low	High	Medium	Low	Medium-Low
York	Medium-High	Medium-High	Low	Low	Low	Medium	Low	Medium-Low

Table 3-29 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Local water supply distributions can be severely impacted if primary source of water for the area is compromised.
Health and Safety of Response Personnel	Limited impacts for response personnel unless water supply is compromised.
Continuity of Operations	Unlikely to execute Continuity of Operations Plan
Property, Facilities, and Infrastructure	Localized areas may experience moderate impacts from downed water utilities, property and infrastructure damages are expected to be minimal.
Delivery of Services	The ability to supply water to needed areas can be impacted if the water supply is low, or the utility line is damaged.
The Environment	Droughts can result in a lack of water, causing animals to relocate to possibly more populated areas. Drought can also increase the vulnerability to wildfire, and flooding if persistent heavy rains occur.
Economic and Financial Condition	Local economy could face moderate impacts for the duration of the drought, dependent on the abundance of a local water supply.
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.

Community Lifelines Impacted by Drought

FEMA developed the community lifelines construct to increase effectiveness in disaster operations reporting and better position the agency to respond to catastrophic incidents. Lifelines are the most fundamental services in the community that, when stabilized, enable all other aspects of society and when disrupted, require decisive intervention (e.g., rapid service re-establishment or employment of contingency response solutions). During initial response, priority efforts focus on stabilizing community lifelines.

Based on the hazard risk analysis and description of vulnerability and impacts of drought, the main community lifelines impacted by drought in Virginia are:

- Health and Medical
- Food, Water, Shelter
- Energy
- Safety and Security

3.8.2 Earthquake

3.8.2.1 Background

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Naturally occurring earthquakes result from crustal strain, volcanism, landslides, or the collapse of caverns but can also be triggered by mine blasts or collapse or nuclear testing. Earthquakes can affect hundreds of thousands of square miles; cause damage to property measured in the tens of billions of dollars; result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area.

Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site and regional geology and soil.

Earthquakes are caused by the sudden release of accumulated energy, resulting in the rupture of rocks along fault planes in the Earth's lithosphere. The areas of greatest tectonic activity occur at the boundaries of the Earth's slowly moving tectonic plates, as these locations are subjected to the greatest strain from plates traveling in various directions and speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength, a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, generating an earthquake.

Impacts from earthquakes can be severe and cause significant damage. Ground shaking can lead to the collapse of buildings and bridges and can disrupt utilities. Death, injuries, and extensive property damage are possible from earthquakes. Some secondary hazards caused by earthquakes may include fire, hazardous material release, landslides, flash flooding, avalanches, tsunamis, and dam failure.

Figure 3-38 - Louisa County August 2011[xxxvi]

Smaller earthquakes occur much more frequently than larger earthquakes. These smaller earthquakes are generally not felt by people and cause little or no damage. Very large earthquakes can cause tremendous damage and may be followed by a series of aftershocks occurring in the region for weeks after the event. Aftershocks generally have a smaller magnitude than the main shock but may still be powerful enough to cause additional damage.

Earthquakes can be measured in terms of their magnitude or intensity. Magnitude is the amount of energy that is released by an earthquake. There are several ways that magnitude can be measured but probably the most familiar is the Richter Scale (Table 3-30). The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology, as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of seismic waves recorded by seismographs. Adjustments are included for variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed as a dimensionless number from 0.0 to 10.0. For example, a magnitude 5.3 quake might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Even though the original calculations developed by Richter to estimate earthquake magnitude have gone out of favor, newer formulae still retain the familiar Richter reporting methodology as shown in Table 3-31. Currently, the moment magnitude scale (MMS) is the primary reporting method used by the USGS.[xxxvii]

Table 3-30 - Richter Scale[xxxviii]

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally, not felt but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0-7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

The effect of an earthquake on people and structures on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally, destruction. Although numerous intensity scales have been developed in the last several hundred years to evaluate the effects of earthquakes, the one currently used in the US is the Modified Mercalli Intensity Scale. It was developed in 1931 by American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals as shown in 9. The scale does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects.xxxix The lower numbers of the intensity scale indicate the way people perceive the earthquake. The higher numbers of the scale are based on observed structural damage. Structural engineers usually contribute information for assigning intensity values of VIII or above.

Table 3-31 - Modified Mercalli Intensity Scale for Earthquakes

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	<4.2
III	Slight	Felt by people resting; like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	<4.8
VI	Strong	Trees sway, suspended objects swing, objects fall off shelves	<5.4
VII	Very Strong	Mild Alarm; walls crack; plaster falls	<6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	<6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	<7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	<8.1
XII	Catastrophic	Total destruction, trees fall; ground rises and falls in waves	>8.1

Source: US Geological Survey

3.8.2.2 Location and Spatial Extent

Earthquakes in the central and eastern US, although less frequent than in the western US, are typically felt over a much broader region. East of the Rockies, an earthquake can be felt over an area as much as ten times larger than a similar magnitude earthquake on the west coast. A magnitude 4.0 eastern US earthquake typically can be felt at many places as far as 60 miles from where it occurred, and it infrequently causes damage near its source.[xl] A magnitude 5.5 eastern US earthquake usually can be felt as far as 300 miles from where it occurred, and sometimes causes damage out to 25 miles.

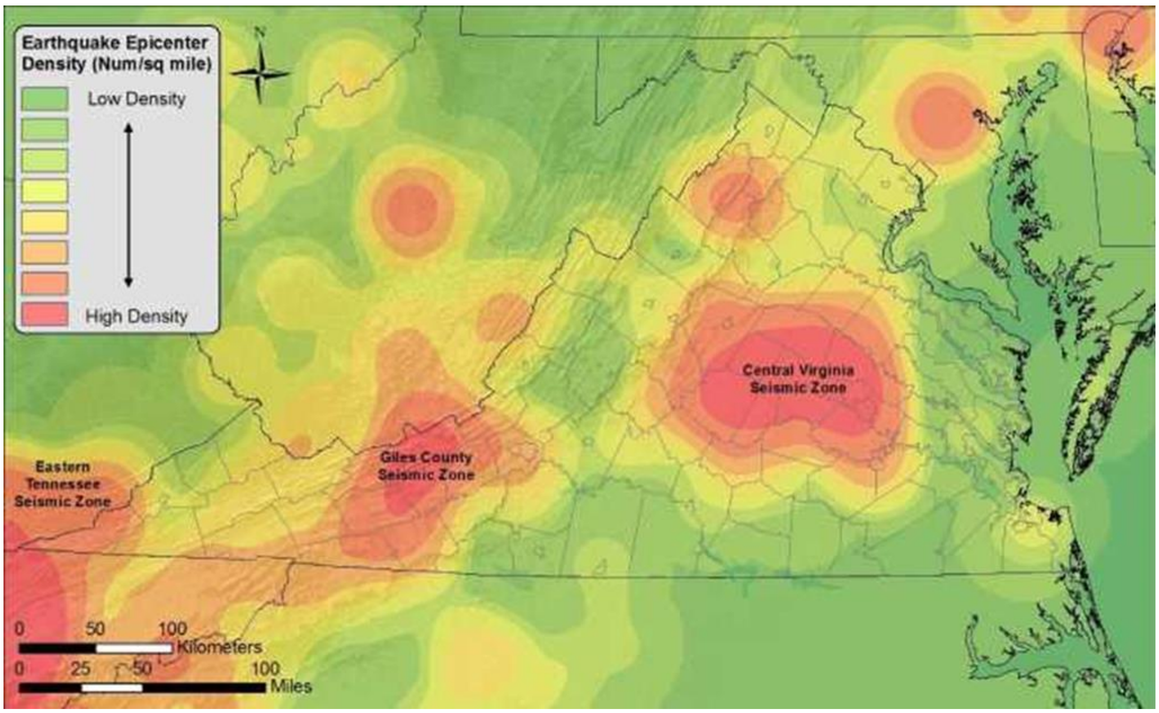
Earthquakes everywhere occur on faults within bedrock, usually several miles deep. Most bedrock beneath central Virginia was assembled as continents collided to form a supercontinent about 500-300 million years ago, raising the Appalachian Mountains. Most of the rest of the bedrock formed when the supercontinent rifted apart about 200 million years ago to form what are now the northeastern US, the Atlantic Ocean, and Europe.[xli]

At well-studied plate boundaries like the San Andreas fault system in California, scientists can often determine the name of the specific fault that is responsible for an earthquake. In contrast, east of the Rocky Mountains, this is rarely the case. The Central Virginia Seismic Zone is far from the nearest plate boundaries, which are in the center of the Atlantic Ocean. The seismic zone is laced with known faults but numerous smaller or deeply buried faults remain undetected. Even the known faults are poorly located at earthquake depths. Accordingly, few, if any, earthquakes in the seismic zone can be linked to named faults. It is difficult to determine if a known fault is still active and could slip and cause an earthquake. As in most other areas east of the Rockies, the best guide to earthquake hazards in the seismic zone is the earthquakes themselves.[xlii]

While it is important to identify historical earthquake occurrences within the Commonwealth, impacts can be felt within the Commonwealth from outside sources. Effects from intraplate earthquakes in other states are often felt in Virginia. The New Madrid fault is considered a major seismic zone for the Southern and Midwestern US. The New Madrid fault had a series of devastating earthquakes from 1811 through 1812, and intensities of V and VI on the Modified Mercalli Intensity Scale could be felt throughout Virginia. In September 1886, a magnitude 7.3 earthquake occurred in Charleston, South Carolina. Intensities of II-V on the Modified Mercalli Intensity Scale were felt throughout Virginia. While these events occurred in other states, they prove how the effects of earthquakes can be felt over a very broad region east of the Rockies.

Figure 3-39 shows the main three zones in Virginia that are more susceptible to earthquakes. These zones are believed to be sources of most magnitude 6 or greater earthquakes during the past 1.6 million years around Virginia, though there has never been a quake of that magnitude in Virginia's written historical record.

Figure 3-39 - Virginia Earthquake Epicenter Density Zones[7]



3.8.2.3 Significant Historical Events

Earthquake activity in Virginia has generally been, with a few exceptions, low magnitude but persistent. The first documented earthquake in Virginia took place in 1774 near Petersburg.[xliii] Historical data are supportive of the low risk assessment.

Figure 3-40 shows the epicenter locations of the 505 documented earthquakes in Virginia between 1774 and 2022 and Figure 3-41 documents the epicenters within the state and adjacent to it between 2017 and 2022.

Figure 3-40 - Virginia Earthquakes - 1774-2022[6]

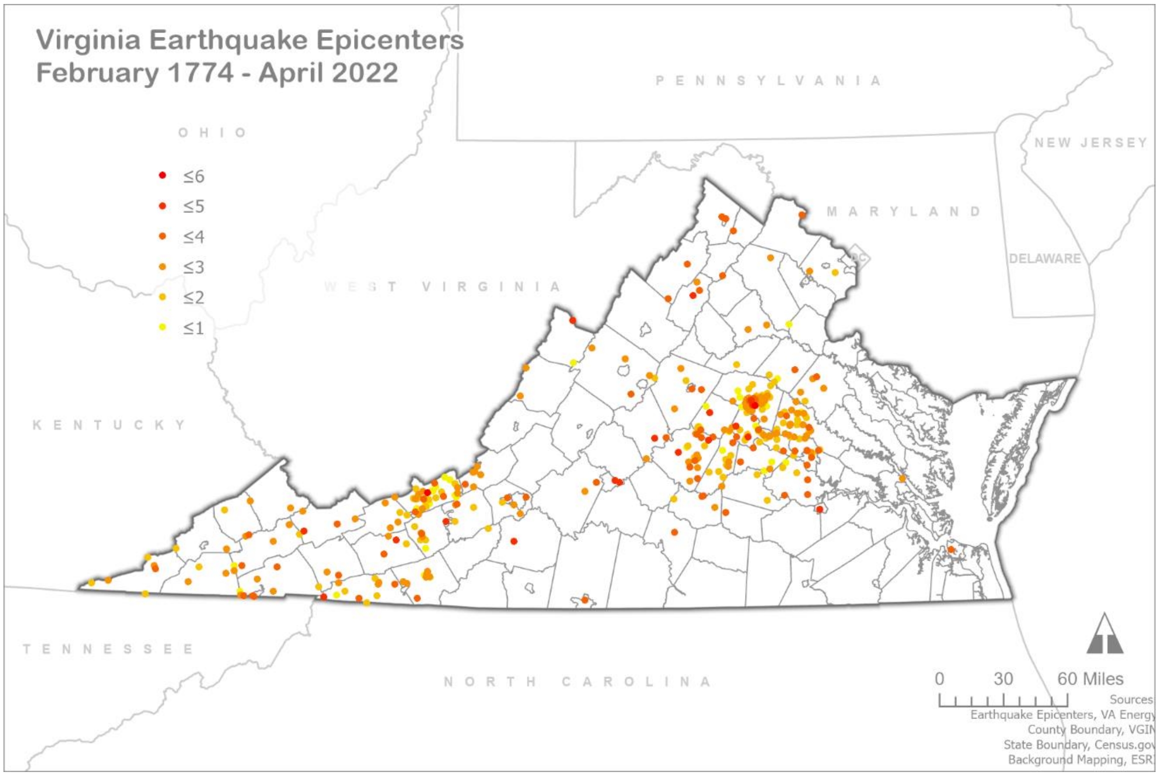
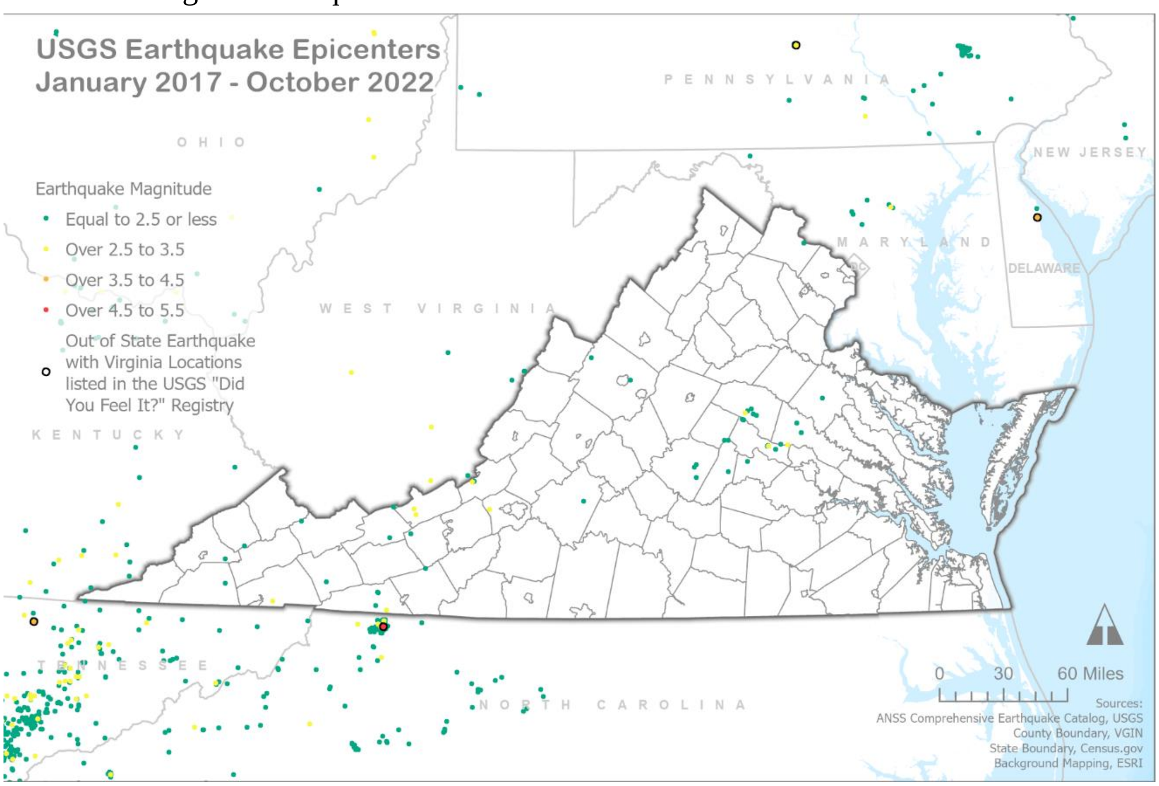


Figure 3-41 - Virginia Earthquakes - 2017-2022



On Tuesday afternoon, August 23, 2011, an earthquake with a moment magnitude of 5.8 occurred about 7 miles southwest of Mineral, Virginia, which is near Lake Anna in Louisa County. The earthquake was widely felt, with reports received from people as far away as Detroit, Atlanta, Boston, Toronto, and Montreal. Dozens of aftershocks up to magnitude 4.5 have been recorded, including a magnitude 4.2 aftershock approximately six hours after the main shock and a magnitude 4.5 aftershock about a day and a half later. The Washington Post reported that the North Anna Nuclear Generating Station's two reactors in Louisa County, 10 miles from the epicenter, shut down automatically when the quake hit. They lost power from the grid and switched to four diesel generators. The damage was greatest in Louisa County and several minor injuries occurred. Structural damage to buildings was significant in cities throughout central and eastern Virginia and Washington D.C., including damage to the Washington Monument and the Washington National Cathedral. Officials at Fort Monroe, in Hampton, Virginia, also reported some minor structural damage as a result of the quake. Earth movement associated with earthquakes can cause pipelines to shift and possibly rupture resulting in dangerous leaks. Older, more brittle pipelines would be more susceptible to damage as the result of abrupt earth movements. Columbia Gas confirmed that a gas leak in downtown Fredericksburg was related to this earthquake. Columbia Gas discovered the leak as part of a company emergency response pipeline safety survey that was conducted because of the earthquake. The survey showed that the natural gas was leaking into the storm and sanitary sewer system. This leak resulted in road closings and residence and other building evacuations until repairs were made[15].

The Daily Press and *Virginian-Pilot* newspapers reported a minor, but relatively rare, earthquake with its epicenter on the Peninsula August 3, 1995. According to the *Virginian-Pilot*, the quake measured 2.6 on the Richter scale. The Virginia Tech Seismological Observatory detected the quake with instrumentation in Goochland County west of Richmond, and in Blacksburg. The quake was centered under the York River near York River State Park. According to the *Daily Press*, people at Camp Peary in York County reported feeling the quake.

The Virginia Tech Seismological Observatory provides additional information on other recent events in Virginia, including a magnitude 4.0 shock that occurred on August 17, 1984. The epicenter was approximately 15 miles to the southeast of Charlottesville. The quake was felt from Washington, DC to the North Carolina border and from Staunton to Norfolk.

A magnitude 3.2 earthquake occurred Saturday, September 22, 2001, with the epicenter near Shadwell, just east of Charlottesville. The focal depth was within a few kilometers of the surface, and this produced a strong acoustic signal that local officials attributed to an aircraft in transonic flight. In fact, such explosive sounds are frequently associated with shallow earthquakes in eastern North America. Unlike in California, the rocks in the upper few kilometers of the Earth's crust in the east are extremely efficient transmitters of high frequency seismic energy, and a proportion of this energy is converted to ordinary sound waves when the seismic waves reach the Earth's surface.

In 2012, 2014, and 2015 there were earthquakes recorded within Virginia with magnitude of 3.1, but there is very little additional information available about these quakes. There have been no major earthquakes (over a 3.0) since 2015. Between 2017 and 2022, an additional 20 earthquakes originating from outside of the state could be felt in Virginia, the most notable of which was a 5.1 magnitude earthquake that occurred August 9, 2020, near Sparta, North Carolina. Table 3-32 includes information on all major earthquakes in Virginia between 1774 and 2022, while Table 3-33 provides data on all USGS-recorded earthquakes in Virginia since 2000.

Table 3-32 - Major Earthquakes in Virginia (1774-2022)[4]

Year	Month	Magnitude (Richter Scale)	Epicenter Location	Description
1774	21-Feb	4.5	Petersburg City Prince George County	A sharp earthquake that was felt over much of Virginia displaced houses "considerably off their foundations" at Blandford and Petersburg. Although the shock was severe at Richmond and terrified residents about 80 km north of Richmond at Fredericksburg, it caused no damage at those towns. Several "smart shocks" were reported in parts of Virginia from Feb. 20th to the 22nd. The main tremor rang bells at Salem (now Winston-Salem), N.C.
1833	27-Aug	4.5	Central Virginia Goochland County	A rather strong shock agitated walls of buildings at Lynchburg (west of Richmond, in southern Amherst County) and rattled windows violently. Fences along the road were shaken near the Louisa County Courthouse, northwest of Richmond. It was described as "severe" at Charlottesville, about 85 km northeast of Lynchburg. Two miners were killed in a panic caused by the tremor at a mine near Richmond.
1852	29-Apr	4.8	Town of Wytheville Wythe County	A severe earthquake that was observed over a large area threw down a chimney near Wytheville, in southwest Virginia, and shook down tops of chimneys at Buckingham Courthouse, about 55 km south of Charlottesville. Houses were shaken violently at Staunton, about 65 km west of Charlottesville. A brick was shaken from a chimney as far south as Davie County, N.C. Also felt in the District of Columbia, Maryland, New York, Ohio, and Pennsylvania.
1852	2-Nov	4.3	Central Virginia Buckingham County	Chimney damage occurred at Buckingham, about 55 km south of Charlottesville. This earthquake was reported to be "quite strong" at Fredericksburg, Richmond, and Scottsville. At Scottsville, where every house in the village was shaken, water in the canal was "troubled," and boats were tossed to and fro.
1875	23-Dec	4.8	Central Virginia Goochland County	The highest intensities from this earthquake occurred mainly at towns near the James River waterfront in Goochland and Powhatan Counties, and in Louisa County. In Richmond (Henrico County), the most severe damage was sustained in the downtown business and residential areas adjacent to the James River or on islands in the river. Damage included bricks knocked from chimneys, fallen plaster, an overturned stove, and several broken windows. Waves "suddenly rose several feet" at the James River dock at Richmond, causing boats to "part their cables" and drift below the wharf. At Manakin, about 20 km west of Richmond, shingles were shaken from a roof and many lamps and chimneys were broken. Several small aftershocks were reported through Jan. 2, 1876.
1897	3-May	4.3	Southwest Virginia Pulaski County	This earthquake was most severe at Radford (about 65 km west of Roanoke), where a few chimneys were wrecked, and plaster fell from walls. Chimneys were damaged at nearby Pulaski and at Roanoke. Felt in most of southwest Virginia and as far south as Winston-Salem, NC
1897	31-May	5.8	Town of Pearisburg Giles County	This earthquake was the largest in intensity and areal extent in Virginia in historical times and is the 3rd largest in the eastern US and was felt in 12 states. The earthquake had a maximum Modified Mercalli Intensity of VIII, and the area of maximum ground motion extended over an elliptical area-from near Lynchburg, Va., west to Bluefield, W.Va., and from Giles County south to Bristol, Tenn. The MM intensity VIII assigned to this earthquake is based on "many downed chimneys" and "changes in the flow of springs." The shock was strong at Pearisburg, where walls of old brick houses were cracked, and many chimneys were thrown down or badly damaged. Many chimneys also were shaken down at Bedford, Pulaski, Radford, and Roanoke, Va., and Bristol, Tenn.; many chimneys were damaged at Christiansburg, Dublin, Floyd, Houston, Lexington, Lynchburg, Rocky Mount, Salem, Tazewell, and Wytheville, Va.; Charlotte, Oxford, Raleigh, and Winston, N.C.; Knoxville, Tenn.; and Bluefield, W.Va. Aftershocks continued through June 6, 1897.

Year	Month	Magnitude (Richter Scale)	Epicenter Location	Description
1898	5-Feb	4.4	Pulaski County	Bricks were thrown from chimneys, furniture was shifted in a few houses, and residents rushed into the streets at Pulaski, about 70 km southwest of Roanoke. Felt throughout southwest Virginia and south to Raleigh, NC
1907	11-Feb	4	Town of Arvonia Buckingham County	Chimneys were cracked at Ashby, about 20 km southeast of Arvonia, and a window was broken at a store at Buckingham, 25 km southwest of Arvonia. A "terrific" shock sent people rushing outdoors at Arvonia and displaced furniture. Felt strongly from Powhatan to Albemarle County.
1918	10-Apr	4.6	Town of Luray Page County	In the Shenandoah Valley, at Luray, windows were broken, and plaster was cracked severely. Ceilings of houses were cracked badly a few kilometers north of Luray, at Edinburg; windows were broken at Harrisonburg and Staunton, Va., and Washington, D.C. (at Georgetown University). In addition, a new spring formed in Page County, near Hamburg, almost in the middle of a road. A minor aftershock was reported in the area, about 5 hours later. Also felt in Maryland, Pennsylvania, and West Virginia.
1919	6-Sep	Unknown	Town of Front Royal Warren County	This earthquake affected towns mainly in Warren and Rappahannock Counties. At Arco, in the Blue Ridge Mountains south of Front Royal, chimneys were damaged, plaster fell from walls, and springs and streams were muddied. Reports from the adjacent northern part of Rappahannock County state that similar shocks were felt and that streams were "rendered turbid." Also felt in parts of Maryland and West Virginia. Several aftershocks occurred.
1929	26-Dec	3.7	Charlottesville City Albemarle County	A moderate tremor at Charlottesville shook bricks from chimneys in some places; also felt in other parts of Albemarle County.
1959	23-Apr	3.9	Giles County	The earthquake was strongest in Giles County, at Eggleston and Pembroke. Residents there reported several damaged chimneys and articles shaken from shelves and walls. One chimney toppled at the Norfolk and Western Station in Eggleston. Also felt in WV.
1975	11-Nov	3.2	Southwest Virginia Giles County	Windows were broken in the Blacksburg area of Montgomery County, and plaster was cracked at Poplar Hill (south of Pearisburg, in Giles County). Also felt in Pulaski County.
1976	13-Sep	3.3	Southwest Virginia Carroll County	Bricks fell from chimneys and pictures fell from walls in Surry County at Mount Airy, N.C. At the nearby town of Toast, N.C., cracks formed in masonry and plaster. The earthquake was observed in many towns in North Carolina and Virginia and in a few towns in South Carolina and West Virginia.
2003	9-Dec	4.5	Central Virginia Powhatan County	This was a complex event consisting of two sub-events occurring 12 seconds apart. Felt (V) at Columbia, Fork Union, Goochland, Oilville, Rockville and Sandy Hook; (IV) at Appomattox, Amelia Court House, Amherst, Blackstone, Bumpass, Charlottesville, Chester, Chesterfield, Colonial Heights, Cumberland, Dillwyn, Farmville, Glen Allen, Lawrenceville, Louisa, Manakin Sabot, Mechanicsville, Midlothian, Mineral, Palmyra, Petersburg, Powhatan, Richmond, Scottsville and Spotsylvania; (III) at Alexandria, Fairfax, Falls Church, Fredericksburg, Lexington, Lynchburg, McLean, Roanoke, Staunton and Vienna. Felt in much of Maryland and Virginia. Also felt in north-central North Carolina and a few areas of Delaware, New Jersey, New York, Pennsylvania, and West Virginia.
2008	6-May	2.0	Annandale	A minor earthquake occurred near Annandale, Virginia. Felt reports were primarily received from people in Fairfax County, Virginia; the District of Columbia; and Montgomery County, Maryland.
2011	23-Aug	5.8	Mineral, Virginia	Virginia and much of the East Coast experiences a widely- felt earthquake. According to the USGS, the epicenter of the event was located near Cuckoo, in Louisa County. With a magnitude of 5.8, this was the largest earthquake recorded by seismometers in Virginia. Between August 25, 2011, and January 1, 2012, 876 aftershocks were recorded. The event resulted in a Federal Disaster Declaration for Virginia.

Table 3-33 - USGS Recorded Earthquakes in Virginia (2000 to 2022)

Date and Time	Magnitude	Location
2000-04-29T03:34:53.100Z	2.5	3 km N of Glen Allen, Virginia
2000-08-18T10:09:55.100Z	2.7	2 km SSE of Narrows, Virginia
2001-03-28T11:19:24.600Z	2.6	2 km S of Narrows, Virginia
2001-06-25T23:04:48.200Z	2.5	8 km S of Remington, Virginia
2001-09-03T02:05:57.900Z	2.5	Virginia
2001-09-22T16:01:20.600Z	3.2	5 km E of Pantops, Virginia
2001-10-01T09:55:59.500Z	1.8	3 km ESE of Glenvar, Virginia
2001-11-08T02:15:12.200Z	1.8	7 km NW of Pulaski, Virginia
2001-11-18T17:15:45.300Z	1.6	6 km E of Blacksburg, Virginia
2003-05-05T16:32:34.390Z	3.6	Virginia
2003-10-17T01:49:40.820Z	2.5	5 km E of Gratton, Virginia
2003-11-06T12:22:49.200Z	2.6	9 km NNW of Wyndham, Virginia
2003-12-09T20:59:18.700Z	4.5	5 km ENE of Columbia, Virginia
2004-04-30T13:26:10.580Z	2.1	0 km WNW of Clinchport, Virginia
2004-12-03T01:27:14.000Z	2.5	15 km SSW of Mineral, Virginia
2005-02-08T11:42:53.090Z	2.7	15 km E of Vansant, Virginia
2005-02-15T02:36:54.980Z	2.8	12 km NNW of Raven, Virginia
2005-02-15T04:17:43.980Z	2	9 km NNW of Richlands, Virginia
2005-12-30T23:24:38.600Z	2.2	16 km NNE of Blacksburg, Virginia
2006-07-02T15:38:38.300Z	1.7	16 km NE of Bland, Virginia
2006-11-02T17:53:02.110Z	4.3	13 km NNW of Raven, Virginia
2006-11-23T10:42:57.420Z	4.3	13 km NW of Raven, Virginia
2007-08-05T07:20:46.000Z	2.1	6 km WNW of Wyndham, Virginia
2008-05-06T17:30:23.990Z	2.02	0 km NNE of Ravensworth, Virginia
2009-01-12T23:07:39.400Z	2.3	13 km SSW of Pearisburg, Virginia
2009-05-16T08:08:17.650Z	3	2 km NNE of Cave Spring, Virginia
2009-07-04T12:24:43.760Z	2.8	3 km E of Narrows, Virginia
2009-07-07T03:59:52.580Z	2.3	0 km SE of Wyndham, Virginia
2009-07-31T10:14:10.310Z	2.1	4 km WNW of Ashland, Virginia
2009-08-02T21:57:07.840Z	2.3	21 km NNW of Ashland, Virginia
2009-08-14T13:48:18.960Z	2.9	4 km ENE of Nickelsville, Virginia
2009-10-06T07:07:52.700Z	1.7	11 km WNW of Goochland, Virginia
2009-11-25T22:24:46.130Z	2.7	14 km S of Arrington, Virginia
2009-12-16T13:20:50.910Z	2.2	5 km WSW of Dillwyn, Virginia
2009-12-18T16:27:57.340Z	2	2 km W of Wyndham, Virginia
2010-04-29T04:12:52.410Z	2.3	18 km NNW of Wyndham, Virginia
2010-10-02T20:17:00.050Z	3	10 km NNW of Ashland, Virginia
2010-10-30T06:10:13.600Z	2.4	3 km SSE of Ashland, Virginia
2011-03-28T07:26:21.910Z	2.5	2 km S of Pulaski, Virginia
2011-08-23T17:51:04.250Z	5.8	11 km SSW of Mineral, Virginia
2011-08-23T18:46:50.240Z	2.8	9 km SSW of Mineral, Virginia
2011-08-23T19:20:26.010Z	2.2	12 km S of Louisa, Virginia
2011-08-24T00:04:36.870Z	4.2	11 km SSW of Mineral, Virginia
2011-08-24T04:45:25.960Z	3.4	16 km NNW of Goochland, Virginia

Date and Time	Magnitude	Location
2011-08-25T04:06:47.480Z	2.5	14 km SSW of Mineral, Virginia
2011-08-25T05:07:52.290Z	4.5	8 km SW of Mineral, Virginia
2011-08-25T06:37:31.790Z	2.3	8 km S of Louisa, Virginia
2011-08-25T15:27:47.430Z	2.4	7 km S of Mineral, Virginia
2011-08-25T23:40:56.440Z	2.6	7 km SE of Mineral, Virginia
2011-08-26T22:52:21.880Z	2.1	12 km S of Louisa, Virginia
2011-08-27T09:02:28.970Z	2	9 km S of Louisa, Virginia
2011-08-27T18:43:44.850Z	1.8	8 km S of Louisa, Virginia
2011-08-28T20:18:05.370Z	2.2	9 km SSW of Mineral, Virginia
2011-08-29T01:06:36.080Z	2.3	10 km S of Louisa, Virginia
2011-08-29T03:15:21.620Z	2	9 km S of Louisa, Virginia
2011-08-29T03:16:51.570Z	2.7	10 km S of Louisa, Virginia
2011-08-29T04:19:26.350Z	2.2	9 km S of Louisa, Virginia
2011-08-29T23:39:50.330Z	2.1	5 km SSW of Mineral, Virginia
2011-08-30T03:48:28.740Z	2.6	13 km SSW of Mineral, Virginia
2011-08-30T13:26:50.800Z	2.1	11 km S of Louisa, Virginia
2011-08-31T13:44:10.480Z	2.1	9 km SSE of Mineral, Virginia
2011-08-31T15:01:54.880Z	1.8	8 km SSE of Louisa, Virginia
2011-09-01T09:09:37.960Z	3.4	7 km SSW of Mineral, Virginia
2011-09-03T21:10:53.320Z	2	8 km SW of Mineral, Virginia
2011-09-05T16:54:24.510Z	2.5	8 km SW of Mineral, Virginia
2011-09-06T09:03:16.810Z	2.1	10 km SSE of Mineral, Virginia
2011-09-06T21:17:53.630Z	2	9 km SSW of Mineral, Virginia
2011-09-07T05:56:43.650Z	2.1	6 km SSW of Mineral, Virginia
2011-09-16T16:17:39.500Z	2.1	9 km S of Louisa, Virginia
2011-09-17T08:33:08.260Z	2	10 km S of Louisa, Virginia
2011-09-17T12:42:34.730Z	1.9	9 km SSE of Louisa, Virginia
2011-09-17T15:33:13.330Z	2.6	11 km S of Louisa, Virginia
2011-09-17T18:37:37.740Z	2.1	8 km ESE of Mineral, Virginia
2011-09-18T08:43:03.000Z	2.1	7 km SSW of Mineral, Virginia
2011-09-19T04:58:43.560Z	2	7 km ESE of Mineral, Virginia
2011-09-19T15:29:41.000Z	1.8	12 km S of Louisa, Virginia
2011-09-19T20:33:12.600Z	2.2	7 km ESE of Mineral, Virginia
2011-10-05T06:18:49.200Z	2.5	10 km S of Louisa, Virginia
2011-10-06T22:42:39.300Z	2.1	8 km SE of Mineral, Virginia
2011-10-09T15:53:24.120Z	2.4	8 km SSE of Louisa, Virginia
2011-10-10T01:04:53.300Z	2.2	11 km SSW of Mineral, Virginia
2011-10-12T16:40:00.370Z	3	9 km S of Louisa, Virginia
2011-10-19T00:02:44.910Z	2.3	9 km S of Louisa, Virginia
2011-10-25T05:38:28.060Z	2	6 km SSW of Mineral, Virginia
2011-11-03T12:50:31.880Z	2.3	8 km SW of Mineral, Virginia
2011-11-19T20:12:24.350Z	2.4	9 km S of Louisa, Virginia
2011-11-20T01:06:37.510Z	2.3	9 km S of Louisa, Virginia
2011-11-21T01:06:23.000Z	1.8	8 km SW of Mineral, Virginia
2011-11-21T01:17:02.570Z	1.9	8 km SW of Mineral, Virginia
2011-11-21T05:25:25.000Z	2.1	14 km SW of Louisa, Virginia

Date and Time	Magnitude	Location
2011-11-23T07:09:33.830Z	2	9 km S of Louisa, Virginia
2011-11-30T02:29:24.340Z	2	10 km S of Louisa, Virginia
2011-12-02T17:56:42.130Z	1.6	9 km SSE of Louisa, Virginia
2011-12-05T05:41:28.600Z	1.9	7 km S of Louisa, Virginia
2011-12-09T22:10:55.070Z	2.2	8 km NNW of Wyndham, Virginia
2011-12-12T06:47:48.060Z	2.1	5 km SSE of Mineral, Virginia
2011-12-12T21:57:00.430Z	2	7 km S of Louisa, Virginia
2011-12-14T14:17:31.980Z	2	4 km SSE of Mineral, Virginia
2011-12-17T03:42:55.790Z	1.8	8 km SW of Mineral, Virginia
2011-12-24T07:30:05.000Z	2	12 km S of Louisa, Virginia
2012-01-08T14:25:55.840Z	1.9	11 km S of Louisa, Virginia
2012-01-13T23:18:05.350Z	2.3	15 km SSW of Mineral, Virginia
2012-01-18T13:08:29.110Z	2.5	7 km SSW of Mineral, Virginia
2012-01-18T14:19:55.180Z	2	12 km S of Louisa, Virginia
2012-01-18T21:03:21.650Z	2.5	10 km SSE of Louisa, Virginia
2012-01-28T01:57:53.760Z	1.7	9 km S of Louisa, Virginia
2012-01-30T23:39:47.250Z	3.1	9 km SSE of Louisa, Virginia
2012-02-19T07:12:30.260Z	2.7	12 km S of Louisa, Virginia
2012-02-24T11:37:26.710Z	1.7	17 km S of Louisa, Virginia
2012-02-27T01:59:04.120Z	1.9	7 km WNW of Ashland, Virginia
2012-02-28T05:15:00.280Z	1.8	11 km S of Louisa, Virginia
2012-03-07T08:00:57.630Z	1.6	7 km SSE of Louisa, Virginia
2012-03-07T08:52:33.370Z	1.7	8 km SW of Mineral, Virginia
2012-03-16T18:30:48.110Z	2.2	6 km E of Cumberland, Virginia
2012-03-26T03:21:50.950Z	3	13 km S of Louisa, Virginia
2012-03-29T18:38:22.580Z	1.7	11 km S of Louisa, Virginia
2012-04-03T19:00:54.120Z	2.4	12 km S of Louisa, Virginia
2012-04-26T05:04:37.340Z	1.7	12 km S of Louisa, Virginia
2012-05-01T14:58:15.070Z	2.1	18 km WSW of Bowling Green, Virginia
2012-05-02T08:36:35.940Z	1.7	11 km S of Louisa, Virginia
2012-06-04T12:05:01.690Z	2	11 km W of Goochland, Virginia
2012-06-08T21:59:37.750Z	1.8	8 km S of Louisa, Virginia
2012-06-16T15:50:24.760Z	1.8	9 km S of Louisa, Virginia
2012-07-01T09:04:11.390Z	2	8 km ESE of Mineral, Virginia
2012-07-17T06:28:05.900Z	1.9	13 km WNW of Wyndham, Virginia
2012-10-07T13:39:13.760Z	2.2	12 km ENE of Goochland, Virginia
2013-01-09T23:35:06.600Z	1.9	2 km N of Louisa, Virginia
2013-05-15T11:01:48.220Z	2.3	7 km S of Louisa, Virginia
2013-05-30T13:52:05.120Z	2	14 km NNW of Ashland, Virginia
2013-06-13T15:14:24.820Z	2.04	7 km WNW of Calverton, Virginia
2013-08-11T23:54:49.000Z	1.9	10 km SSE of Mineral, Virginia
2013-08-30T04:27:04.680Z	2.3	13 km S of Louisa, Virginia
2013-11-09T10:59:44.090Z	1.9	10 km SW of Mineral, Virginia
2013-12-05T22:52:26.670Z	1.6	3 km SSW of Mineral, Virginia
2014-05-22T01:47:15.960Z	3.1	15 km ENE of Cumberland, Virginia
2014-06-03T00:34:39.480Z	1.3	4 km SE of Mineral, Virginia

Date and Time	Magnitude	Location
2014-06-05T01:25:31.650Z	1.7	9 km SW of Mineral, Virginia
2014-06-06T17:10:00.710Z	1.5	8 km SSE of Louisa, Virginia
2014-07-19T04:15:02.800Z	1.73	11 km SSW of Bowling Green, Virginia
2014-07-25T16:54:22.370Z	2.2	7 km SSW of Mineral, Virginia
2014-07-27T04:05:53.330Z	1.9	6 km SSW of Mineral, Virginia
2014-11-23T00:53:28.940Z	2.4	13 km N of Bristol, Virginia
2015-02-17T10:24:38.700Z	2.27	11 km E of Bland, Virginia
2015-02-26T08:48:28.100Z	2.54	4 km NNE of Goochland, Virginia
2015-03-15T07:02:35.790Z	2.8	6 km SW of Mineral, Virginia
2015-06-27T05:08:29.020Z	2.2	8 km S of Louisa, Virginia
2015-08-24T08:42:09.940Z	1.84	11 km SSW of Mineral, Virginia
2015-09-13T01:39:00.240Z	2.25	7 km S of Louisa, Virginia
2015-09-14T01:08:23.050Z	1.53	7 km ESE of Mineral, Virginia
2015-09-14T02:58:22.610Z	1.43	9 km ESE of Mineral, Virginia
2015-09-14T03:39:56.880Z	1.52	7 km ENE of Mineral, Virginia
2015-09-18T19:24:56.630Z	1.34	5 km SSE of Mineral, Virginia
2015-09-27T18:04:36.040Z	1.88	Virginia
2015-11-04T11:00:52.070Z	2.67	3 km NE of Dillwyn, Virginia
2016-03-27T08:00:52.180Z	2.27	14 km S of Louisa, Virginia
2016-04-21T02:09:11.860Z	2.01	7 km ESE of Mineral, Virginia
2016-08-07T01:34:30.790Z	1.94	10 km SE of Jonesville, Virginia
2016-09-25T03:34:27.790Z	1.89	14 km SSE of Mineral, Virginia
2016-09-25T04:31:52.410Z	1.63	14 km SSE of Mineral, Virginia
2016-12-01T01:27:04.780Z	2.51	12 km WSW of Spencer, West Virginia
2016-12-22T11:22:35.730Z	2.19	18 km NW of Ashland, Virginia
2017-03-13T02:11:35.270Z	2.6	6 km ENE of Goochland, Virginia
2017-03-22T11:03:13.190Z	2.36	4 km NNE of Dillwyn, Virginia
2017-05-12T04:31:10.020Z	2.75	6 km SSW of Narrows, Virginia
2017-06-23T07:30:37.590Z	2.33	6 km ESE of Bland, Virginia
2017-08-03T06:37:25.750Z	2.27	5 km SSE of Dillwyn, Virginia
2017-08-25T03:31:31.710Z	2.4	3 km S of Bowling Green, Virginia
2018-02-28T02:10:36.410Z	2.26	0 km SSE of Columbia, Virginia
2018-06-03T06:11:59.600Z	2.24	1 km SSE of Adwolf, Virginia
2018-07-05T07:42:39.710Z	1.74	7 km SW of Mineral, Virginia
2018-08-17T03:24:00.500Z	1.32	2 km ENE of Belmont, Virginia
2018-11-09T16:25:52.510Z	2.36	6 km ENE of Goochland, Virginia
2018-11-09T16:45:27.520Z	2.46	5 km ENE of Goochland, Virginia
2019-03-11T02:27:32.990Z	2.25	1 km SW of Nickelsville, Virginia
2019-03-21T00:53:40.500Z	2.02	4 km SE of Coeburn, Virginia
2019-03-31T00:08:31.930Z	1.79	0 km S of Independence, Virginia
2019-06-13T14:49:24.840Z	2.1	10 km S of Mineral, Virginia
2019-09-23T03:55:03.020Z	2.51	3 km WNW of Wyndham, Virginia
2019-11-05T05:51:49.200Z	1.84	10 km SSW of Mineral, Virginia
2019-11-26T20:38:36.830Z	1.79	11 km E of Goochland, Virginia
2019-12-10T04:10:09.120Z	2.13	20 km W of New Castle, Virginia
2019-12-10T06:43:10.900Z	2.49	21 km W of New Castle, Virginia

Date and Time	Magnitude	Location
2019-12-11T09:41:34.540Z	2.54	21 km W of New Castle, Virginia
2020-01-20T23:02:53.210Z	2.31	10 km NW of Pulaski, Virginia
2020-02-03T10:04:11.360Z	2.66	10 km S of Louisa, Virginia
2020-05-14T08:33:28.510Z	2.1	9 km N of Richlands, Virginia
2020-09-20T19:36:04.850Z	2	13 km SW of Goochland, Virginia
2020-09-26T11:23:33.140Z	2.19	6 km S of Allisonia, Virginia
2021-01-16T05:49:14.370Z	2.32	14 km NNE of Deerfield, Virginia
2021-06-13T09:23:23.840Z	2.44	3 km NE of Dante, Virginia
2021-06-16T09:19:36.960Z	2	9 km N of Independence, Virginia
2021-06-17T02:43:10.050Z	2.26	9 km N of Independence, Virginia
2021-06-22T03:46:04.880Z	2.24	6 km WNW of Ashland, Virginia
2021-06-25T19:40:45.277Z	2.6	2 km SE of Woodlawn, Maryland
2021-07-15T00:55:47.410Z	2.76	10 km S of Narrows, Virginia
2021-08-28T06:43:53.810Z	2.34	4 km SSE of Verona, Virginia
2021-09-27T13:37:24.600Z	2.56	4 km N of Lafayette, Virginia
2021-11-10T01:34:53.680Z	2.18	8 km ENE of Cumberland, Virginia
2021-11-21T11:04:12.110Z	2.56	9 km SSW of Abingdon, Virginia
2022-02-04T10:33:56.430Z	1.89	2 km N of Dillwyn, Virginia
2022-02-10T03:20:57.340Z	2.32	9 km WSW of Forest, Virginia
2022-04-12T19:19:35.870Z	2.44	13 km NW of Ashland, Virginia
2022-05-20T04:00:09.310Z	1.79	9 km S of Louisa, Virginia
2022-05-23T08:18:46.320Z	2.26	2 km WSW of Columbia, Virginia
2022-05-29T19:12:10.280Z	2.29	16 km S of Louisa, Virginia
2022-05-30T02:03:55.940Z	2.3	15 km S of Louisa, Virginia
2022-05-30T16:11:26.570Z	1.55	16 km S of Louisa, Virginia
2022-10-11T04:03:28.600Z	2.17	Virginia
2022-10-25T09:25:27.730Z	2.59	Virginia-North Carolina border region

3.8.2.4 Probability of Future Occurrence

Although experts can estimate the likelihood of an earthquake occurring in a particular region, extensive research and sophisticated equipment have not yet provided scientists with the ability to predict an earthquake with certainty. Earthquake risk is related to the following factors unique to each earthquake:

- Ground motion;
- Fault rupture under or near a building, often occurring in buildings located close to faults;
- Reduction of the soil bearing capacity under or near a building;
- Earthquake-induced landslide near a building; and,
- Earthquake-induced waves in bodies of water near a building.

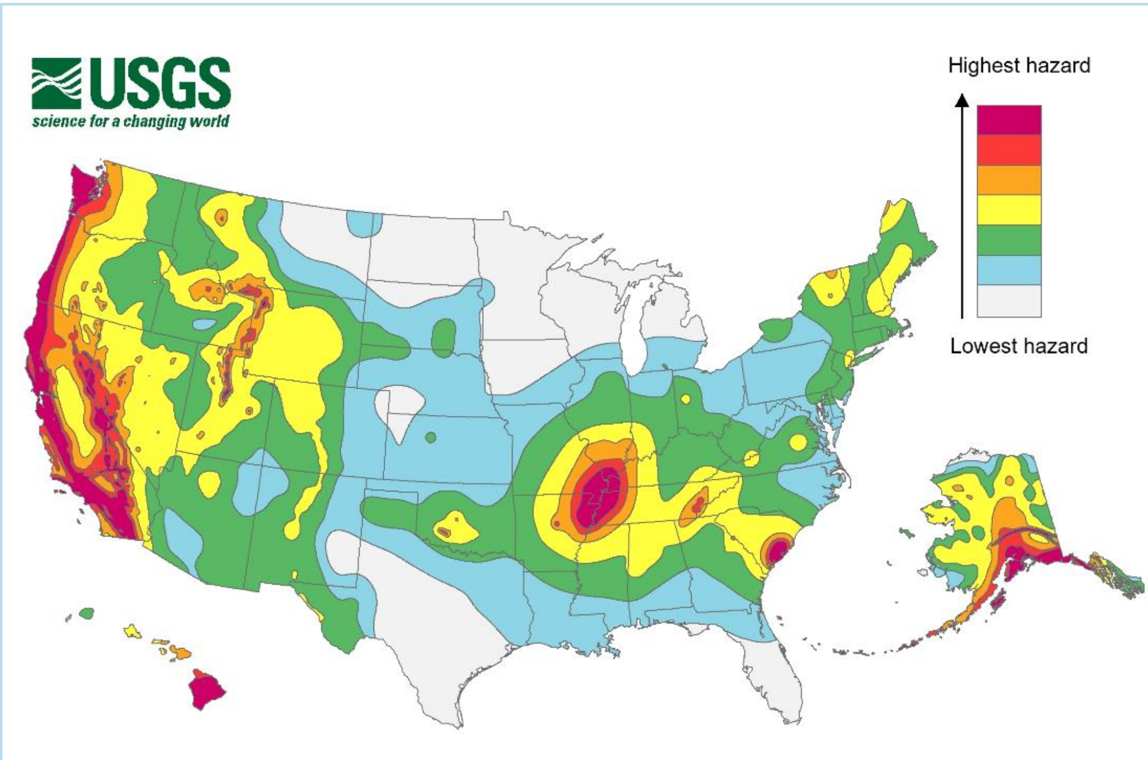
Earthquakes are low probability, high-consequence events. Although earthquakes may occur only once in the lifetime of an asset, they can have devastating impacts. A moderate earthquake can cause serious damage to unreinforced buildings, building contents, and non-structural systems, and can cause serious disruption in building operations. Moderate and even very large earthquakes are inevitable, although very infrequent, in areas of normally low seismic activity.

Consequently, in these regions, buildings are seldom designed to deal with an earthquake threat; therefore, they are extremely vulnerable.

Probabilistic ground motion maps are typically used to assess the magnitude and frequency of seismic events. These maps measure the probability of exceeding a certain ground motion, expressed as percent peak ground acceleration (%PGA), over a specified period of years.

Figure 3-42 is an earthquake hazard map showing peak ground accelerations having a 2-percent probability of being exceeded in 50 years, for a firm rock site. The map is based on the most recent USGS models for the conterminous US (2018), Hawaii (1998), and Alaska (2007). The models are based on seismicity and fault-slip rates and consider the frequency of earthquakes of various magnitudes. Locally, the hazard may be greater than shown because site geology (proximity to the earthquake epicenter and soil type) may amplify ground motions.

Figure 3-42 - Virginia Seismic Hazard: 2 Percent in 50 Years PGA Hazard[9]



Impact and Vulnerability

Jurisdictional vulnerability and impact in the Commonwealth have been calculated in terms of total direct economic loss, as defined by Hazus. This includes damage to building inventories, critical facilities, and transportation and utility infrastructure, as well as the social and economic impacts. Results are provided by community in the Jurisdictional Risk subsection below.

Risk

In April 2008, FEMA released a report that updated a nationwide evaluation of earthquake losses in the US. The evaluation considered two measures of losses: 1) Annualized Earthquake Losses (AEL) in any single year; and 2) Annualized Earthquake Loss Ratio (AELR), which is a measure of seismic risk in relation to the value of the building inventory. The ratio is considered a more accurate picture of seismic risk and makes it easier to compare between regions. FEMA's evaluation ranked Virginia 37th in the nation for AELR in the April 2008 revision and 28th in the national for AEL[10].

The Virginia Tech Seismological Observatory (VTSO) produced a report titled *Seismic Hazard Assessment for Virginia* in 1994 that was supported through funding by VDEM, FEMA, the US Nuclear Regulatory Commission, Virginia Power, and the USGS. This study provided a county-by-county assessment of the seismic hazards in Virginia. Geological conditions throughout much of the eastern part of the US are such that identification of seismogenic structures is difficult: no examples of surface faulting due to neotectonic earthquakes are known in the study region. However, it is possible to define areas with common geologic and seismic characteristics. These source zones are taken to represent areas within which available geological information suggests, or at least does not rule out, a common neotectonic environment. These zones include:

- Giles County, VA
- Central VA
- Eastern TN
- Southern Appalachians
- Northern VA and MD
- Central Appalachians
- Piedmont-Coastal Plains
- Charleston, SC
- Appalachian foreland
- New Madrid

Over much of the eastern US, crustal structure potentially associated with seismicity is not resolved, and the geologic causes of earthquakes are poorly understood. The report summarizes, in depth, the source zones characteristics and hazard calculations used to arrive at the county-by-county analysis covering 160 sites within Virginia and in adjacent parts of bordering states. Results show a higher probability of occurrence in the Giles County zone and Central Virginia.

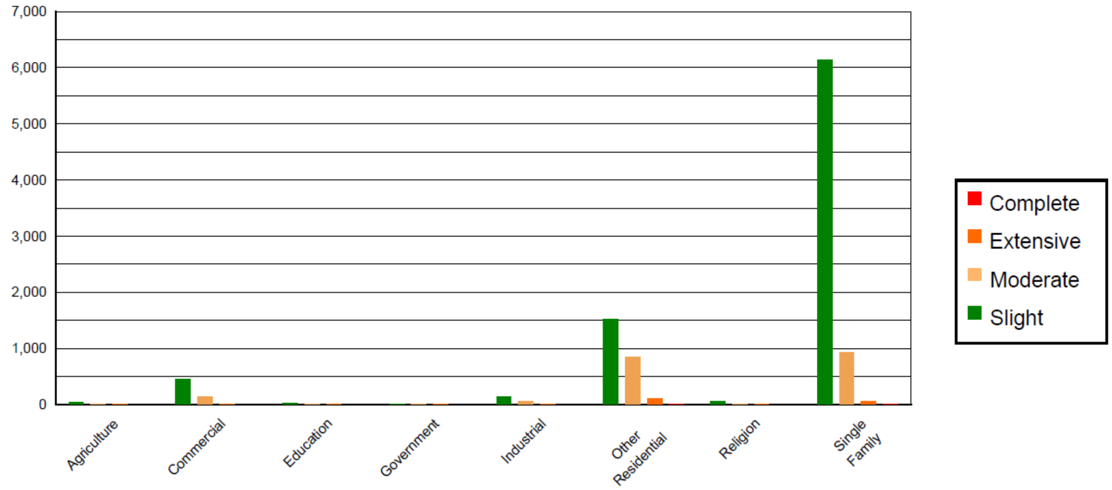
3.8.2.5 2011 Earthquake Hazus Model

The Mineral earthquake of 2011 was modeled in Hazus for the purposes of the 2018 HIRA update. The epicenter of the earthquake was located close to Cuckoo, in Louisa County[11]. Based on the actual event, the scenario region was slightly more than 40,000 mi², encompassing the entire Commonwealth of Virginia. The scenario placed the epicenter in Louisa County, at a depth of 6 km. Highlights of the model results are included below.

Building Damage

Hazus estimated that approximately 54,861 buildings would be at least moderately damaged by the event; this is more than 2% of the buildings in Virginia. An estimated 3,602 buildings would be damaged beyond repair. Figure 3-43 shows the graphical distribution of damage by type of occupancy. As the figure shows, most building damage was found to be in residential structures.

Figure 3-43 - 2011 Earthquake Scenario– Building Damage by Occupancy



Critical Facility Damages

Hazus estimated that Virginia has 24,163 hospital beds for use. On the day of the event, the model estimated that only 21,447 beds would be available for use; the event would cause an 11 percent reduction in hospital bed availability. After 7 days, 96 percent of the beds would be back in service. Within 30 days, 99 percent would be available.

Transportation and Utility Damages

Hazus estimated damages to highways, railways, light rail, bus facilities, ferry facilities, port facilities, and airports. Of these, the scenario produces damages to only bridges; of the estimated 9,470 bridges in the scenario, 41 were estimated to be moderately damages and five were completed damaged.

Hazus modeled damages to utility system facilities, pipelines, potable water, and electric power systems. Relatively minor utility system facility damages were estimated, with no systems predicted to be completely damaged.

Finally, Hazus considered the expected performance of potable water and electrical systems that serve residential structures. Potable water performed well, with all household service restored by day 30 after the event. For electrical, 31 households were estimated to still be without power at day 90 after the event.

Debris Generated

Hazus was also used to estimate the amount of debris that would be generated by the event. The types of debris considered were brick/wood and reinforced concrete/steel. Hazus estimated that a total of 2.32 million tons of debris would be generated by the event. Of that amount, 63 percent would be brick/wood, and 37 percent would be reinforced concrete/steel. Assuming a load of 25 tons per truck, this would equate to 92,600 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced because of the scenario event. The model estimated that 4,049 households would be displaced. Of these, 2,471 people would be expected to seek temporary shelter in public shelters, far less than 1-percent of the state's population.

Casualties

Hazus estimated the number of people that would be injured or killed because of the scenario event. Casualty estimates are provided for three separate times of day – 0200, 1400, and 1700. The 0200 estimate considered the residential occupancy load as maximum. The 1400 estimate considered that the educational, commercial, and industrial sector loads as maximum; the 1700 estimate represents peak commute time. Casualties are broken down into four severity levels that describe the level of injuries:

- Severity Level 1: injuries will require medical attention, but not hospitalization.
- Severity Level 2: injuries will require hospitalization but are not considered life threatening.
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Fatalities occur because of the earthquake.

Economic Losses

Finally, Hazus estimated economic losses for the scenario event at $6.8 billion, including buildings, transportation and utility lines. Twenty-one percent of the losses were related to business interruption in Virginia. An estimated 67- percent of the losses were associated with residential displacement.

For transportation and utility lines, Hazus only considers the direct repair cost for components; no losses are computed for business interruption due to utility outages.

As a result of the 2011 Mineral Earthquake, Virginia incurred $200-300 million in damages[12]. The Louisa County School Board received $41,826,395 in funding from FEMA's Public Assistance Program[13]. The earthquake also caused significant regional damage including structural damage to the Washington Monument and the National Cathedral[14]. Virginia has not yet experienced a catastrophic earthquake.

A magnitude six earthquake is possible for Virginia and would likely result in large-scale structural failure. A probabilistic magnitude six earthquake was also modeled for the 2500-year return period, using Hazus. The modeled event shows that most damage would be limited to buildings, and that most of that damage would be to residential structures. Hazus estimated that more than 5% of the buildings in Virginia – an estimated 146,102 structures – would be at least moderately damaged by the event. Almost 3,000 structures would be damaged beyond repair. Hazus estimated that building-related damages would total $15.2 billion for the event, but that damages to transportation, utilities, and people would be negligible, as would the amount of debris generated by the events.

State Facility Risk

Like other infrastructure statewide, Commonwealth-owned assets have relatively low or very low risk to earthquake damage. As shown with the Louisa County earthquake, damage patterns are hard to decern beyond the immediate high impact zone.

Although the risk is considered low, an examination of state-owned assets in Louisa County and Giles County, where the state's most severe earthquakes were historically centered and where the state's only seismic zones are centered, provides an indication of state assets at risk. Risk is associated with minor damage to the foundations of state-owned buildings and other statuary, breaks to pipelines, road damage and bridge damage. Earthquakes can also trigger landslides and other mass movements that can damage state-owned structures and infrastructure such as roads. Table 3-34 provides a summary of state structural assets in Louisa and Giles County and the estimated value of those assets. While earthquakes are not expected to damage these assets in a significant way due to the overall low risk rating, the table presents the value of assets deemed to be at highest risk.

Table 3-34 - Summary of state assets in Louisa County and Giles County at risk of earthquake damage

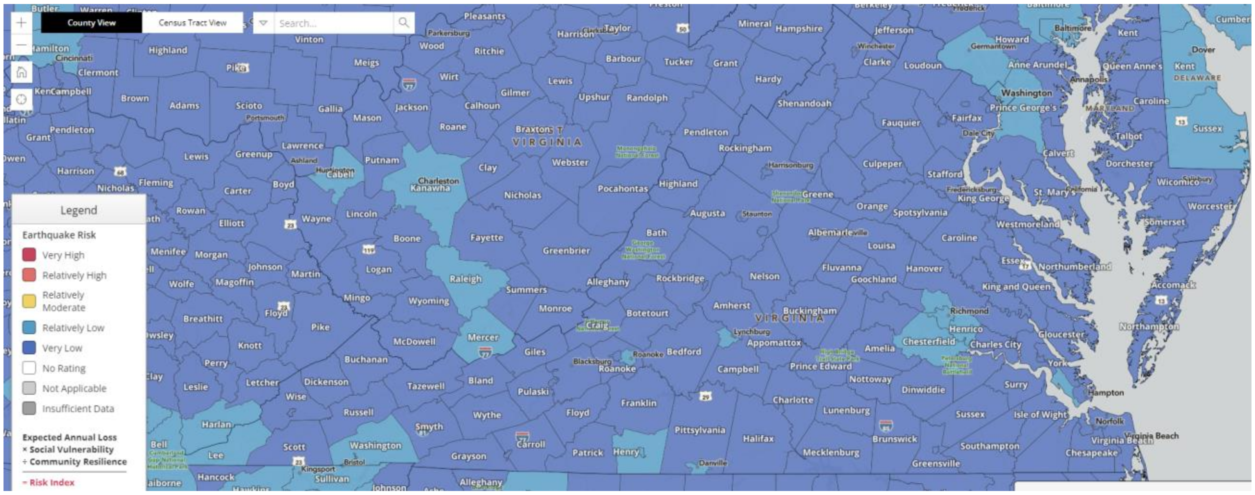
State Asset by Agency	Location	Combined Value of Structures
Department of Forestry (fire tower, oil/gas house, office)	Louisa	$294,000
Virginia Tech (cooperative extension office)	Louisa	Not provided
VDOT (29 structures)	Louisa and Louisa County	$1,889,000
VDOT (10 structures)	Mineral	$496,000
VSP (repeater building, Area 4 HQ office)	Mineral	$586,000
VDOT (12 structures)	Pearisburg	$47,3000
VSP (repeater)	Pearisburg	$25,000
Virginia Tech (Giles Office)	Pearisburg	Not provided
University of Virginia (33 structures)	Giles	$11,900,000
VDOT (fuel canopy, Pearisburg office building)	Giles	$420,000
Virginia Tech Glen Lyn APCO Research Lab	Glen Lyn	Not provided

3.8.2.6 National Risk Index

The National Risk Index (NRI) includes three components: a natural hazards component (Expected Annual Loss), a consequence enhancing component (Social Vulnerability), and a consequence reduction component (Community Resilience). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for earthquake are reviewed for each community (county tract).

As shown in Figure 3-44, throughout Virginia earthquake has a relatively low or very low risk index.

Figure 3-44 - National Risk Index for Earthquake



Future Conditions

While scientists have observed some correlation between climate change on rising temperatures, melting glaciers and isostatic rebound, a causal connection to subsequent earthquakes is less documented, especially for the eastern US. Earthquakes and weather have a few possible correlations that are still under investigation and should be considered more theoretical than scientific: 1.) Glacier melt and isostatic rebound causing earthquakes; 2.) Changing surface stress loads from increased surface water causing microseismicity or tiny earthquakes with magnitudes less than zero, and changes in water quantity stored in large dams inducing seismicity; 3.) Longer duration droughts and/or groundwater withdrawals that change stress loads on the Earth's crust causing earthquakes; and 4.) Injection wells that lubricate faults and induce seismicity.

Jurisdictional Risk

Probabilistic earthquake events can be modeled in Hazus. Hazus was used to generate damage and loss estimates for the probabilistic ground motions associated with a return period of 2500 years (Table 3-35). The building damage estimates were then used as the basis for computing direct economic losses. These include direct building losses and business interruption costs. The percentage of the total building stock in the jurisdiction was calculated as a percentage of the state's building stock, estimated by Hazus. From there, a proportional amount of the total estimated building damages was assigned to each jurisdiction based on their percentage of building stock. Finally, the losses were annualized over the return period of the scenario event. Fairfax County had the highest loss due to earthquake in this scenario. The Commonwealth of Virginia can expect $7,262,799 in annualized losses due to earthquake.

Table 3-35 - 2500-year Scenario – Expected Annualized Loss by Jurisdiction

Earthquake Annualized Loss			
> $750,000			
Fairfax County	$1,131,429		
$250,000 - $749,999			
Loudoun County	$319,382	Prince William County	$363,204
Virginia Beach	$395,612		
$150,000 - $249,999			
Arlington County	$192,663	Chesterfield County	$288,699
Henrico County	$293,909	Chesapeake	$191,833
Norfolk	$209,673	Richmond	$194,370
$100,000 - $149,999			
Stafford County	$120,145	Alexandria	$166,390
Newport News	$148,866		
$50,000 - $99,999			
Albemarle County	$96,764	Fauquier County	$72,170
Frederick County	$65,075	Hanover County	$105,145
James City County	$72,118	Montgomery County	$71,364
Roanoke County	$84,446	Spotsylvania County	$110,371
York County	$66,247	Hampton	$110,126
Lynchburg	$65,852	Portsmouth	$73,786
Roanoke	$85,142		
$25,000 - $49,999			
Accomack County	$30,230	Augusta County	$56,005
Bedford County	$54,926	Botetourt County	$30,496
Campbell County	$39,725	Culpeper County	$39,747
Franklin County	$49,033	Gloucester	$31,826
Henry County	$39,804	Isle of Wight County	$31,481
Louisa County	$30,007	Pittsylvania County	$41,033
Rockingham County	$58,736	Shenandoah County	$44,656
Warren County	$34,536	Washington County	$41,695
Charlottesville	$37,928	Danville	$37,584
Harrisonburg	$37,015	Manassas	$34,673
Petersburg	$31,302	Suffolk	$69,445
Fairfax	$31,279		

< $24,999			
Alleghany County	$13,218	Amelia County	$8,538
Amherst County	$23,208	Appomattox County	$10,796
Bath County	$6,167	Bland County	$4,485
Brunswick County	$11,162	Buchanan County	$12,952
Buckingham County	$8,590	Caroline County	$23,338
Carroll County	$20,485	Charles City	$5,290
Charlotte County	$8,230	Clarke County	$15,856
Craig County	$4,083	Cumberland County	$7,044
Dickenson County	$4,431	Dinwiddie county	$20,046
Essex County	$9,717	Floyd County	$10,293
Fluvanna County	$21,390	Giles County	$12,599
Goochland County	$22,741	Grayson County	$10,939
Greene County	$13,534	Greensville County	$6,275
Halifax County	$25,537	Highland County	$2,752
King and Queen County	$4,671	King George County	$21,526
King William County	$13,548	Lancaster County	$13,857
Lee County	$491,081	Lunenburg County	$7,188
Madison County	$11,643	Mathews County	$8,352
Mecklenburg County	$25,077	Middlesex County	$12,096
Nelson County	$16,308	New Kent County	$16,955
Northampton County	$11,349	Northumberland County	$15,719
Nottoway County	$10,767	Orange County	$29,153
Page County	$18,198	Patrick County	$12,865
Powhatan County	$23,561	Prince Edward County	$14,476
Prince George County	$25,250	Pulaski County	$26,702
Rappahannock County	$8,460	Richmond County	$6,533
Rockbridge County	$18,716	Russell County	$15,309
Scott County	$14,907	Smyth County	$21,189
Southampton County	$12,901	Surry County	$5,433
Sussex County	$7,015	Tazewell County	$28,477
Westmoreland County	$18,788	Wise County	$23,445
Wythe County	$21,102	Bedford	$6,102
Bristol	$14,977	Buena Vista	$5,283
Colonial Heights	$17,609	Covington	$5,031
Emporia	$5,204	Falls Church	$15,942
Franklin	$6,548	Fredericksburg	$26,026
Galax	$6,656	Hopewell	$17,688
Lexington	$6,986	Manassas Park	$11,012
Martinsville	$14,353	Norton	$3,910
Poquoson	$12,096	Radford	$11,593
Salem	$25,357	Staunton	$22,058
Waynesboro	$18,788	Williamsburg	$13,857
Winchester	$27,657		

The hazard ranking for earthquake is based on events reported in the NCEI Storm Events Database and a generalized geographic extent. The geographic extent ranking category was assigned a Low ranking for all jurisdictions; this was based on the 2500-year return period used in the Hazus scenario, which represents a 0.04 percent annual chance of occurrence in any given year. Most of the Commonwealth is in the medium and medium low risk categories. The ranking results and Hazus annualized losses highlight similar areas that are at a somewhat higher risk due to earthquake. These areas include Northern Virginia, City of Richmond, and Southwest Virginia.

3.8.2.7 Local Plan Risk Assessment

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

Of the 20 local plans, eight local plans included annualized loss estimates for earthquake: all but three of these ranked earthquakes as low risk, Lenowisco PDC, West Piedmont PDC, and Northern Virginia RC all ranked earthquake as medium risk. These annualized loss estimates were based on Hazus modeling. Table 3-36 summarizes the hazard ranking parameters and annual loss estimates for earthquake among the local/regional planning districts. The overall hazard ranking among the local planning districts for earthquakes is low.

Table 3-36 - Ranking Parameters for each Planning Jurisdiction

Local	Past Events	Density	Vulnerability Analysis	Annual Loss
Richmond-Crater	Yes	Yes	Yes	$4,167,000
Southside	Yes	Yes	*	*
Commonwealth	**	**	**	**
Northern Shenandoah Valley	Yes	*	*	*
Rappahannock-Rapidan	Yes	Yes	*	$360,000
Thomas Jefferson	Yes	Yes	*	*
George Washington	Yes	Yes	*	*
Cumberland Plateau	Yes	Yes	Yes	*
Lenowisco	Yes	Yes	Yes	$47,436
Mount Rogers	Yes	Yes	Yes	*
Accomack-Northampton	**	**	**	**
Hampton Roads	Yes	Yes	Yes	$1,100,000
Northern Neck	Yes	Yes	*	*
Middle Peninsula	Yes	Yes	*	*
West Piedmont	Yes	Yes	Yes	$29,468,177
Central Virginia	Yes	Yes	Yes	$307,000
New River Valley	Yes	Yes	Yes	$781,183
Roanoke Valley-Allegheny	Yes	Yes	*	*
Central Shenandoah	Yes	Yes	*	*
Northern Virginia	Yes	Yes	Yes	$1,490,000

* Not reported in HMP
** Not identified as hazard in HMP

3.8.2.8 Comparison with Local Ranking

In total, 18 of the 20 local hazard mitigation plans ranked earthquake hazard. None of the plans ranked earthquake as a high hazard. 5 plans ranked earthquake as medium hazard and 13 ranked as low hazard. The overall ranking among the 18 local plans for earthquake was low. The 2023 statewide analysis has ranked earthquake as medium-low.

3.8.2.9 Changes in Development

Most local hazard mitigation 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 terms. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Table 3-37 includes the complete ranking parameters for all the jurisdictions for earthquake within the Commonwealth of Virginia.

Table 3-37 - Earthquake Hazard Ranking Parameters and Risk Summary by County/Community

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Albemarle	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Alexandria, City of	Medium-High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Alleghany	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Amelia	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Amherst	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Appomattox	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Arlington	High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Augusta	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Bath	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Bedford	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Bland	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Brunswick	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Buchanan	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Buckingham	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Campbell	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Caroline	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Carroll	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Charles City	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Charlotte	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Charlottesville, Cityof	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Chesapeake, City of	High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Chesterfield	High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Clarke	Low	Medium	Low	Low	Low	Medium-Low	Low	Low
Colonial Heights, City of	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Covington, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Craig	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Culpeper	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Cumberland	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Danville, City of	Medium	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Dickinson	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Dinwiddie	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Emporia	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Essex	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Fairfax	High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Fairfax, City of	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Falls Church, Cityof	Low	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Fauquier	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Floyd	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Fluvanna	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Franklin	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Frederick	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Fredericksburg, Cityof	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Galax, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Giles	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Gloucester	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Goochland	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Grayson	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Greene	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Greensville	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Halifax	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Hampton, City of	Medium-High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Hanover	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Harrisonburg, Cityof	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Henrico	High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Henry	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Highland	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Hopewell, City of	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Isle of Wight	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
James City	Medium-High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
King and Queen	Low	Low	Low	Low	Low	Medium-Low	Low	Low
King George	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
King William	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Lancaster	Low	Medium	Low	Low	Low	Medium-Low	Low	Low
Lee	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Lexington, City of	Low	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Loudoun	High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Louisa	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Lunenburg	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Madison	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Manassas, City of	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Manassas Park, Cityof	Low	High	Low	Low	Low	Medium-Low	Low	Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Mathews	Low	Medium	Low	Low	Low	Medium-Low	Low	Low
Mecklenburg	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Middlesex	Low	Medium	Low	Low	Low	Medium-Low	Low	Low
Montgomery	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Nelson	Low	Low	Low	Low	Low	Medium-Low	Low	Low
New Kent	Low	Medium	Low	Low	Low	Medium-Low	Low	Low
Newport News, Cityof	High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Norfolk, City of	High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Northampton	Low	Medium	Low	Low	Low	Medium-Low	Low	Low
Northumberland	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Norton	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Nottoway	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Orange	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Page	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Patrick	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Petersburg, City of	Medium	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Pittsylvania	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Poquoson	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Powhatan	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Prince Edward	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Prince George	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Prince William	High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Pulaski	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Radford, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Rappahannock	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Richmond	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Richmond, City of	High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Roanoke	Medium-High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Roanoke, City of	Medium-High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Rockbridge	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Rockingham	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Russell	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Salem, City of	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Scott	Medium	Low	Low	Low	Low	Medium-Low	Low	Low
Shenandoah	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Smyth	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Southampton	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Spotsylvania	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Stafford	Medium-High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Staunton, City of	Medium	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Suffolk	Medium-High	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Surry	Low	Low	Low	Low	Low	Medium-Low	Low	Low
Sussex	Low	Low	Low	Low	Low	Medium-Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Tazewell	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Virginia Beach, City of	High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Warren	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Washington	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Waynesboro, Cityof	Medium	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Westmoreland	Low	Medium	Low	Low	Low	Medium-Low	Low	Low
Williamsburg, Cityof	Low	Medium-High	Low	Low	Low	Medium-Low	Low	Low
Winchester, City of	Medium	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Wise	Medium	Medium	Low	Low	Low	Medium-Low	Low	Low
Wythe	Medium	Medium	Low	Low	Low	Medium-Low	Low	Low
York	Medium-High	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low

Table 3-38 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Local impacts expected to be serious for those who are inside poorly build structures close to the event, and light to moderate in areas with better construction and that are further away from the event.
Health and Safety of Response Personnel	Local impacts expected to be serious for those who are inside poorly built structures close to the event, and light to moderate in areas with better construction and that are further away from the event.
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 may be extensive.
Delivery of Services	Disruption of lines of communication and damage to facilities and/or roads may have considerable impacts on the delivery of services.
The Environment	The environment may be subject to extensive damage due to secondary effects such as HAZMAT debris, broken utility lines, and movement of soil.
Economic and Financial Condition	Local economy and finances moderately impacted, duration depends on magnitude of event.
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.

Community Lifelines Impacted by Earthquake

Based on the hazard analysis and description of vulnerability and impacts of earthquakes in Virginia, the main community lifelines impacted are:

- Food, Water, Shelter
- Health and Medical
- Communications
- Safety and Security
- Transportation
- Hazardous Materials

3.8.3 Erosion

3.8.3.1 Background

Shoreline or coastal erosion is a process whereby large storms, flooding, strong wave action, sea level rise, and human activities, such as inappropriate land use, alterations, and shore protection structures, wear away beaches, banks and bluffs. Erosion undermines banks and can destroys homes, businesses, and public infrastructure. Erosion is marked by the gradual breakdown and movement of land due to both physical and chemical processes of water, wind, and general meteorological conditions. Natural, or geologic, erosion has occurred since the Earth’s formation and continues at a very slow and uniform rate each year. Major storms such as hurricanes and tropical storms may cause more sudden, rapid erosion by combining heavy rainfall, high winds, heavy surf and storm surge to significantly impact riverbanks and the shoreline.

The extent or severity of erosion may vary from year to year and is related to a number of factors: composition of the shoreline (rock, sand, clay, marsh, or human-made structures), fetch, orientation to prevailing wind direction, and relative sea level rise. The degree of recession at a particular site may also be dependent upon intensity of the wave action and exposure to tidal currents, character of the sediments and degree of vegetative cover, supply of sand moving along the shoreline, gradient or slope from fastland to shoreline to nearshore bottom.

While coastal erosion can destroy infrastructure like roads, septic tanks, and even structures such as homes and businesses, the most common damage in Virginia's Piedmont region is loss of trees, denuded shores, wetland loss and sediment introduced into the Chesapeake Bay system. While tidal surge events can cause nominal increases in the rate of erosion, large-scale storm events generating an extensive surge will cause a rapid acceleration in coastal erosion rates. Accelerated erosion in areas with no natural or man-made protective features is more likely to increase severe impacts to infrastructure. Through loss of land and undercutting, infrastructure such as pipelines, piers, roadways, and other structures can be significantly damaged or destroyed.

Two types of erosion relate to natural hazards that threaten property damage: riverine and coastal erosion. The primary concern of both riverine and coastal erosion is the gradual removal of rock, vegetation and other sediment materials from riverbanks, stream beds and/or shorelines that result in soil instability and possible damages to property and infrastructure.

The USDA and the National Resources Inventory (NRI) summarized erosion into two different categories:

- Water (sheet and rill) erosion - the removal of layers of soil from the land surface by the action of rainfall and runoff; and,
- Wind erosion - the process of detachment, transport, and deposition of soil by wind.

The average annual erosion rate on the Atlantic coast is roughly 2 to 3 feet per year; however, erosion rates vary greatly from location to location and year to year. A study by The Heinz Center (2000), Evaluation of Erosion Hazards, states that over the next 60 years, erosion may claim one out of four houses within 500 feet of the US shoreline. It also states that nationwide, erosion may be responsible for approximately $500 million in property loss to coastal property owners per year, including both damage to structures and loss of land. This HIRA update focuses primarily on the coastal erosion hazard, with minor narrative description of other erosion hazards.

Erosion can often occur in conjunction with or as a result of other hazard types. High intensity wildfire events have significant impacts on vegetation and groundcover that stabilize the soil. Decreased soil stability greatly increases risk of localized landslides and flooding. These risks are greater in areas with steep topography. The effects can carry on for years in the forms of increased runoff and erosion. Virginia's biggest winter weather threat comes from a storm pattern known as a Northeaster or Nor'easter. Strong winds also characterize Nor'easters, often resulting in coastal flooding and erosion. These large storms usually originate to the south, and travel northward along the Atlantic coast. Warm, moist air from the ocean combined with cold air from the north can produce significant snowstorms throughout the mid-Atlantic and northeast coastal states. Depending on the specifics of each storm, the event may result primarily in rain, snow, or some combination thereof. Erosion is often associated with heavy rainfall events, as well. Debris flows develop on steep slopes because of heavy rainfall that saturates the soil, which under the extra weight and lubrication, breaks loose and becomes a slurry that takes everything with it, including large trees and houses. Channeled debris flows can reach speeds approaching a hundred miles an hour and strike without warning. Further discussion on landslide hazard is under the landslide section within this HIRA. Flooding following a dam failure may also result in internal erosion caused by embankment or foundation leakage or piping.

During severe storms, damage is not just limited to flooding, but also involves shoreline erosion from increased wave activity, undermining and destroying buildings, roadways, and utility lines. Scouring floodwaters can excavate bridge supports and foundations, thus compromising highways and railroads. The extent of erosion is related to several factors: composition of the shoreline (rock, sand, clay, marsh, or man-made structures), fetch, orientation to prevailing wind direction, and relative sea level rise. Additionally, there is the localized effect of land subsidence, and flood heights can vary by several feet over Virginia's Tidewater region, given basin shape, wind direction, and state of the tide.[xliv]

Shoreline erosion can negatively impact water quality and habitat. Fine soil particles (silt and clay) can cloud the water column and reduce the amount of sunlight that reaches the bottom. Less sunlight greatly reduces the amount of submerged aquatic vegetation, which provides critical habitat for juvenile fish and crabs.

3.8.3.2 Location and Spatial Extent

Virginia's coastal zone includes 5,000 miles of tidal shoreline, much of it containing desirable sites for homes. According to NOAA's Office for Coastal Management, 59% of Virginia's population lives in coastal areas[xlv]. The Chesapeake Bay shorelines and the mouths of the major rivers in Virginia are especially vulnerable to erosion due to fetch. Fetch is the distance of open water over which the wind can blow. The greater the fetch distance, the greater the potential wave will be during storms. If left unmanaged, shoreline erosion can cause a drop in property values, loss of productive land, and in the worst cases, injury, or loss of life.[xlvi] See Figure 3-45 for location of areas along the Chesapeake Bay shoreline that are experiencing greater than 10 feet per year of erosion.

The Comprehensive Coastal Inventory Program (CCI) at VIMS has created a new GIS shoreline database to develop revised Shoreline Situation Reports (SSR) for cities and counties in the region. SSRs were developed by VIMS in the 1970s and are available online at: http://ccrm.vims.edu/gis_data_maps/index.html. These reports have been the foundation for shoreline management planning in Virginia for more than 30 years. CCI has developed new protocols for collecting, disseminating, and reporting data relevant to shoreline management issues today. Contemporary digital inventory updates generated from 1998 to the present using GIS, GPS and remote sensing are currently available online at: http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/.

The data inventory developed for the SSRs is based on a three-tiered shoreline assessment approach. The three-tiered shoreline assessment approach divides the shore zone into three regions: 1.) the immediate riparian zone, evaluated for land use; 2.) the bank, evaluated for height, stability, cover, and natural protection; and 3.) the shoreline, describing the presence of shoreline structures for shore protection and recreational purposes. In most cases this assessment characterizes conditions that can be observed from high resolution imagery. A small boat navigating along the shoreline was used to verify the remotely sensed data and collect features that could not be ascertained from the imagery. The final prepared maps are available online at the site noted above. Although the maps alone do not indicate potential loss from erosion, they provide areas for future study and indicate where shoreline structure protection is currently in place to protect against coastal erosion. Figure 3-46 is an example using VIMS shoreline change data showing areas where shorelines have eroded or migrated locally along the Chesapeake Bay and outer coast of Virginia.

Figure 3-45 - Summary of locations with high erosion and accretion rates along the Chesapeake Bay Region in Virginia.

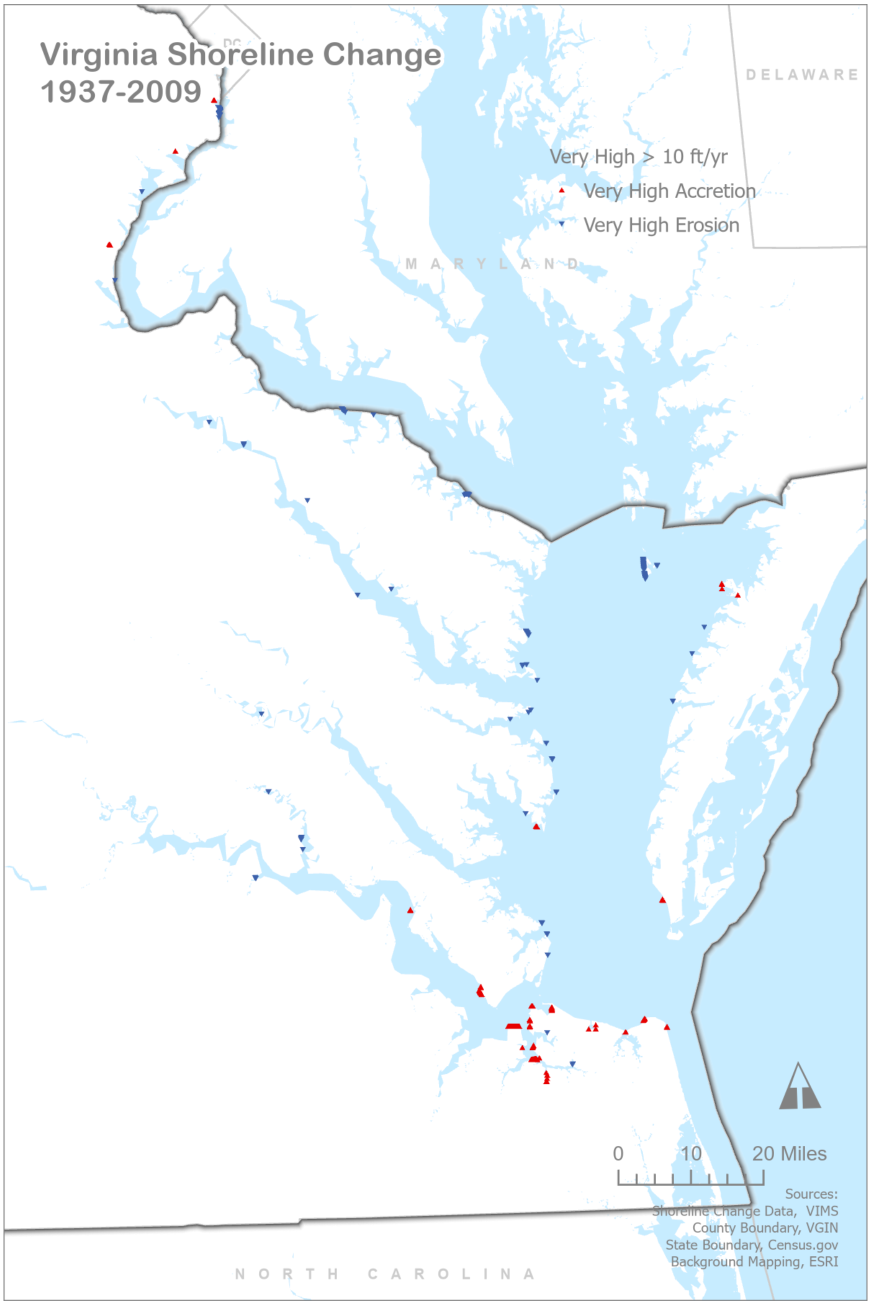


Figure 3-46 - Example of Virginia Shoreline Change, NOAA, 2016

Virginia Institute of Marine Science (VIMS) estimates that approximately 20 of the 27 miles of open ocean coastline from the North Carolina/Virginia line to Cape Henry, are eroding, versus accreting. Naturally accreting beaches include Croatan, Cape Henry and False Cape. Studies show that approximately one-third of Virginia Beach's 22.9-mile coast is experiencing moderate to severe erosion. The average erosion rates for this area are 7.3 feet/year. Some areas experience erosion as high as 10 feet per year.

3.8.3.3 Significant Historical Events

Shoreline erosion events typically occur in conjunction with hurricanes, tropical storms and nor'easters, so the list of "Ocean and Lake Surf" events provided from the NCEI database is not considered a comprehensive list of all erosive events. There are many events that result in erosion in a particular area. For example, during large-scale coastal storm events, sandy shorelines may experience significant erosion to dune features that may increase the risk to inland flooding. Table 3-39 summarizes notable storms that have contributed to significant erosion along the coastal regions in Virginia from 1993-2021.

Table 3-39 - Notable Storm Events Causing Erosion (1993 - 2021)

Location	Date	Type of Event	Deaths/ Injuries	Property Damage	Details
Virginia Beach	8/31/1993	Heavy Surf	1/0	$0	A 15-year-old boy drowned, presumably caught in a strong undertow, as Hurricane Emily was approaching the North Carolina coast.
Isle of Wight, Norfolk, Suffolk, Virginia Beach, Portsmouth	11/17/1994	Coastal Flooding	0/0	$655,000	Strong easterly flow between Hurricane Gordon, a category 1 storm meandering 150 miles south of Cape Hatteras, and a strong anticyclone over New England, caused significant coastal flooding and damage in Sandbridge. The worst flooding occurred on the 18th, when tides were running 4 feet above normal. The heaviest damage occurred along 14th Street, where 100 feet of the fishing pier washed away. Several homes suffered minor damage, with two requiring extra work to remain in place. A 1000-foot stretch of road and several protective steel bulkheads were damaged. Seas, which were as high as 18 feet 60 miles east of the Virginia Capes, and 7 feet near the mouth of the Chesapeake Bay, forced the Naval Carrier George Washington to remain 2 miles offshore Thursday night through Friday morning. The above-normal tides caused other minor flooding in Tidewater. The Nansemond River overflowed its banks in Suffolk, causing minor flooding. High tides on the James and Pagan Rivers, caused several roads to be under water in eastern Isle of Wight County on the 17th.
Isle of Wight, Norfolk, Suffolk, Virginia Beach	12/23/1994	Coastal Flooding	0/0	$65,000	A double-structured storm system produced minor coastal flooding in the Tidewater region on the 23rd. The effects were much less than expected as the main storm moved well east of the mid-Atlantic before curling northwest into Long Island. The secondary low-pressure area was significantly weaker, but still produced northeast winds of 35 to 45 mph around Tidewater. High tides of 1 to 3 feet above normal caused most of the flooding. In the Sandbridge section of Virginia Beach, a beachfront home collapsed into the sea. The combination of pounding surf and wind from flow around Hurricane Gordon in late November and this event finished off the home. In addition, a few more bulkheads were flattened. Several roads in the Tidewater area had minor flooding, including Rescue Road in Smithfield (Isle of Wight Co).
Virginia Beach	8/13/1995	Rip Current	1/0	$0	Vacationer from New York drowned after venturing too far into severe rip current conditions.
Norfolk, Virginia Beach, Newport News, York County, Poquoson	4/24/1997	Coastal Flooding	0/0	$0	Moderate coastal flooding occurred across portions of the Hampton Roads area during the time of high tide April 23rd and continued into April 24th. The areas that were the most seriously affected included the Willoughby Spit, Ghent, and downtown sections of Norfolk, the Old-Town section of Portsmouth, and Sandbridge at Virginia Beach. Tides peaked at 5.8 feet above Mean Lower Low Water (MLLW) at Sewells Point in Norfolk. Based on reports received from downtown Norfolk and the Grandview section of Hampton, tides were somewhat higher in the estuaries (Lafayette River, the Hague, the Harris and Back Rivers) draining into the Elizabeth River and Hampton Roads.
Norfolk, Virginia Beach, Portsmouth	6/3/1997	Coastal Flooding	0/0	$0	Minor to moderate flooding occurred across portions of Hampton Roads during high tide the evening of June 3rd. In Virginia Beach, officials reported part of a new boardwalk washed away and several lifeguard stands lost. Crawford Parkway in downtown Portsmouth was reported flooded and in downtown Norfolk, several streets were reported under water.

Location	Date	Type of Event	Deaths/ Injuries	Property Damage	Details
Norfolk, Virginia Beach, Portsmouth, Newport News, Poquoson	10/19/1997	Coastal Flooding	0/0	$0	Minor to moderate flooding occurred across portions of Hampton Roads during high tide Sunday, October 19th. Some minor flooding was reported in low-lying areas of Norfolk, with water in a few homes and a few streets closed. Minor flooding was also reported in downtown Portsmouth and in the Sandbridge and Sandfiddler areas of Virginia Beach. Tides peaked between 5.2 and 5.8 feet above MLLW at Sewells Point in Norfolk. Minor coastal flooding was reported in portions of Newport News and York county.
Norfolk, Virginia Beach, York County, Poquoson, Newport News	1/27/1998	Coastal Flooding	0/0	$1,500,000	A Nor'easter battered eastern Virginia on January 27th and 28th. Slow movement of the storm combined with the highest astronomical tides of the month resulted in an extended period of gale to storm force onshore winds which drove tides to 6.44 feet above MLLW at Sewells Point. Tide levels resulted in moderate coastal flooding throughout Hampton Roads. One house collapsed into the Atlantic Ocean at Sandbridge. Another home sustained severe damage. The rainfall combined with the gale and storm force winds resulted in scattered tree limbs downed across much of eastern Virginia. In addition, there were widely scattered power outages.
Norfolk, Virginia Beach, York County, Poquoson, Newport News	2/4/1998	Coastal Flooding	0/0	$75,000,000	A Nor'easter battered eastern Virginia from February 3rd through the 5th. The slow movement of the storm resulted in an extended period of gale to storm force onshore winds which drove tides to 7.0 feet above MLLW at Sewells Point. Tide levels resulted in moderate to severe coastal flooding throughout Hampton Roads. Norfolk, Virginia Beach and Hampton reported some structural damage to buildings along the bay and coast, as well as significant beach erosion. Norfolk reported main roads and intersections under 3 feet of water or greater with many roads impassable. North facing areas in Willoughby and Ocean View suffered the greatest damage. In the Chick's Beach area of Virginia Beach, 4 condominiums were undermined by the tidal flooding, and residents of those buildings had to be evacuated. Twenty-nine house fires were also reported in Norfolk as a result of flood water shorting out furnaces. The rainfall combined with the gale and storm force winds resulted in some trees downed across much of eastern Virginia. In addition, there were widely scattered power outages.
Hampton	9/18/2003	Coastal Flooding, Heavy Surf			Hurricane Isabel caused historic flooding and severe erosion in the region. In Hampton, the coastal flooding, heavy surf and wave action breached the barrier beach at Factory Point.
Virginia Beach	1/29/2005	Heavy Surf	1/1	$0	A small boat with 2 men on board was heading out of Rudee Inlet. They made it through the first set of breakers then stopped the boat. A wave overtook them and flipped the boat. One man climbed onto and stayed with the overturned boat and was rescued. He was treated for mild hypothermia and later released. The other man died of hypothermia.
York County, Poquoson	9/1/2006	Coastal Flood	0/0	$1,900,000	Tides of 4 to 5 feet above normal combined with 6-to-8-foot waves caused significant damage to homes, piers, bulkheads, boats, and marinas across portions of the Virginia Peninsula and Middle Peninsula near the Chesapeake Bay and adjacent tributaries.

Location	Date	Type of Event	Deaths/ Injuries	Property Damage	Details
Norfolk, York County, Hampton	10/6/2006	Coastal Flood	0/0	$200,000	Strong onshore winds resulted in major coastal flooding during times of high tide. Tidal departures were 2.5 to 3.5 above normal during the event. A strong low-pressure system off the North Carolina coast coupled with an upper-level cutoff low to dump intense rainfall across portions of southeast Virginia. Rainfall amounts in excess of 10 inches resulted in numerous road closures and moderate to major river flooding from late Friday, October 6th through Saturday, October 7th. Up to 28,000 Dominion Virginia Power customers lost power during the event.
Norfolk, Chesapeake York County, Hampton	11/22 and 11/23/2006	Coastal Flood	0/0	$145,000	Strong onshore winds caused moderate coastal flooding during times of high tide. Tidal departures were about 3 feet above normal during the event. An intense low-pressure system off the North Carolina coast combined with an upper-level cutoff low to provide very strong winds, heavy rains, and moderate coastal flooding across portions of eastern and southeast Virginia from late November 21st into afternoon November 23rd.
Virginia Beach	5/23/2009	Rip Current	1/0	$0	A man body boarding was caught up in a rip current and pulled offshore.
Isle of Wight, Chesapeake, Newport News, York County, Hampton	11/12/2009	Coastal Flood	0/0	$16,200,000	An intense Nor'easter produced moderate to severe coastal flooding across much of eastern and southeast Virginia and the Virginia Eastern Shore. The peak tide height at Money Point was 8.59 feet above MLLW, which was 6.17 feet above the astronomical tide. That tide height was 0.3 feet higher than the previous record storm tide measured at this location during Hurricane Isabel in September 2003.
Norfolk, Virginia Beach, York County, Chesapeake	12/19/2009	Coastal Flood	0/0	$30,000	A strong coastal low-pressure area produced moderate to severe coastal flooding across much of eastern and southeast Virginia. The peak tide height at Money Point was 6.77 feet above MLLW. Several streets, homes and businesses were flooded in low lying areas close or directly exposed to the Chesapeake Bay. The peak tide height at Yorktown was 5.32 feet above MLLW. Several streets, homes and businesses were flooded in low lying areas of the county close or directly exposed to the Chesapeake Bay.
Virginia Beach	8/25/2011	Rip Current	1/0	-	A surfer who got caught in a rip current drowned in Virginia Beach.
Virginia Beach	6/16/2012	Rip Current	1/0	-	A man was caught up in a rip current and drowned in Virginia Beach.
Chesapeake, James City County, Newport News, York County, Norfolk, Isle of Wight, Virginia Beach, Suffolk, Hampton	10/28/2012	Coastal Flood	0/0	$2,060,000	Tropical Cyclone Sandy moving northward well off the Mid Atlantic Coast then northwest into extreme southern New Jersey produced very strong northeast winds followed by very strong west or northwest winds. The very strong winds caused moderate to severe coastal flooding across portions of eastern and southeast Virginia. Water levels reached 3.5 feet to around 4.5 feet above normal adjacent to the Chesapeake Bay resulting in moderate to severe coastal flooding. Flooding of streets due to the combination of rain and storm surge was widespread during the height of the storm. However, water levels were lower than Irene in 2011.

Location	Date	Type of Event	Deaths/ Injuries	Property Damage	Details
Chesapeake, James City County, Newport News, York County, Norfolk, Isle of Wight, Virginia Beach, Suffolk, Hampton, Poquoson	10/2-3/2015	Coastal Flood	0/0	$1,000,000 (Norfolk)	Anomalously strong/nearly stationary high pressure over New England produced strong onshore winds over the Mid-Atlantic. The strength and duration of the onshore winds produced moderate coastal flooding along the Atlantic Coast and Chesapeake Bay. A tidal departure of 3 to 4 feet resulted in moderate flooding along the Chesapeake Bay.
Virginia Beach	7/9/2019	Rip Current	1/0	-	A 35-year-old male drown after being caught in a rip current while trying to save a child at False Cape State Park.
Norfolk, Virginia Beach, York County, Surry County	9/6/2019	Coastal Flood	0/0	-	Very strong northeast to north winds associated with Hurricane Dorian produced tidal anomalies between 2.5 and 3.5 feet over the southern Chesapeake Bay. This caused moderate coastal flooding over portions of Hampton Roads.
York County, James City County, Surry County	10/11/2019	Coastal Flood	0/0	-	The combination of low pressure sitting off the New Jersey coast and strong high pressure over southeast Canada resulted in persistent north or northeast winds over the region. Persistent winds and high waves produced tidal anomalies between 2 and 3 feet above normal high-water levels.
Virginia Beach, Norfolk	11/17/2019	Coastal Flood	0/0	-	The combination of high pressure over northern New England and low pressure just off the Middle Atlantic Coast resulted in very strong northeast to north winds over the southern Chesapeake Bay, which caused minor to moderate coastal flooding.
Grandview area of Hampton	1/23/2000-1/26/2000	Nor'easter /Coastal Flood	0/0	-	This Nor'easter brought snowfalls between 5 and 20 inches to the eastern half of Virginia, which does not frequently receive such snow depths. Heavy winds created blizzard conditions and created snowdrifts between 4 and 5 feet in some areas. Significant flooding and erosion affected coastal areas including the Grandview area of Hampton.
James City County	5/19/2020	Coastal Flood	0/0	-	Combination of strong high pressure over New England and low pressure over southeast US produced a persistent northeast or east wind into James River, which caused minor to moderate coastal flooding at Jamestown tidal gauge and some locations in the county. Minor to moderate tidal flooding occurred along James River. Jamestown reached 4.72 feet MLLW.
Virginia Beach	8/4/2020	Coastal Flood	0/0	-	The center of Tropical Storm Isaias tracked north just inland of the Middle Atlantic Coast from August 3-4. Winds caused moderate (perhaps some locally major) tidal/coastal flooding across portions of SE Virginia, including portions of Virginia Beach adjacent to Back Bay.
Totals			**7/1**	**$98,755,000**	

Northern Neck did not list specific events that caused coastal erosion. However, due to the more than 1,000 miles of shoreline that includes valuable infrastructure, there has been a significant risk to coastal erosion from severe storms such as hurricanes and nor'easters.

Similarly, the Eastern Shore does not describe specific historical events where coastal erosion occurred. However, there is discussion of the impact of sea level rise and its impact on increased erosion. It is noted that seal level rise is exacerbating erosion by increased inundation on both the seaside and bayside marshes, which act to protect the mainland from both floods and erosion.

The Middle Peninsula also does not list specific historical events that have caused coastal or inland erosion to the region. The discussion is more general and summarizes how hurricanes and nor'easters produce severe winds and storm surges that create significant soil erosion along rivers and streams in the Middle Peninsula. The location and the angle at which these hurricanes/nor'easters come ashore region can significantly affect the amount of soil erosion during a particular storm. For example, with Hurricane Isabel in 2003, its enormous wind field tracked in a north-northwest direction to the west of the Chesapeake Bay with the right front quadrant blowing from the south-southeast. This pushed the storm surge up the Bay and piling it into the western shore – causing serious soil erosion to the eastern land masses in Mathews, Gloucester, and Middlesex Counties.

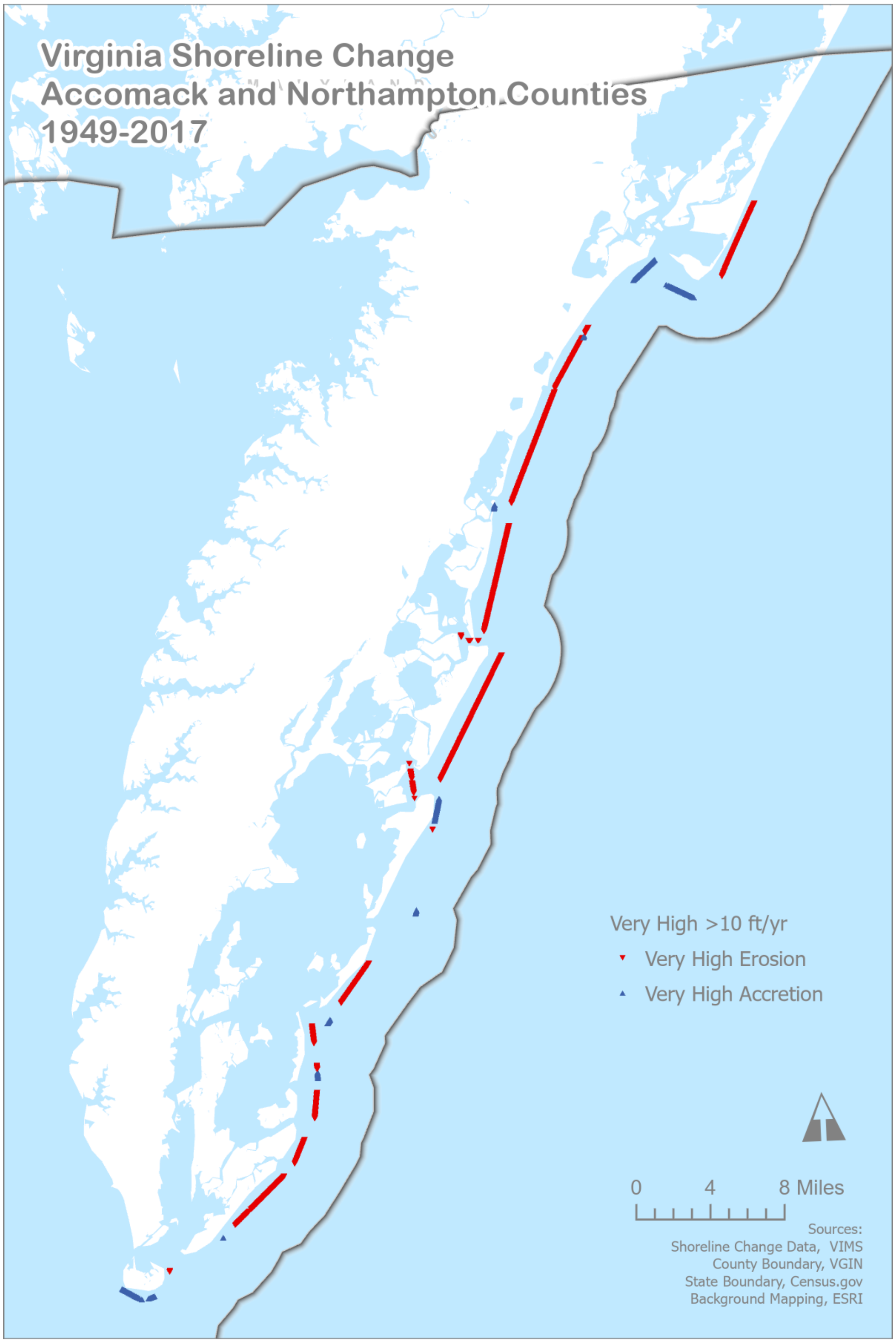
In terms of coastal erosion, the Middle Peninsula experiences wind driven waves during severe storms that destroy houses, wash away protective dunes, and erode the soil so that the ground level can be lowered by several feet. Because of the coastal nature of the Middle Peninsula, the region is very susceptible to this type of flooding and resulting damage.

3.8.3.4 Probability of Future Occurrence

Impact and Vulnerability

The geography of Virginia provides ample evidence for the rise and fall of sea level over the course of thousands of years. Today, the ocean is once again slowly encroaching upon the land. Changes in sea level are important in Virginia because it can threaten the extensive development that has occurred in the coastal region and along the larger rivers throughout the Commonwealth. These changes may also result in the potential loss of extensive tidal wetlands and shallow water habitats in the Chesapeake Bay, tributaries, and the vast barrier island lagoon system on the seaside of the Eastern Shore. Figure 3-47 provides a geographical representation of high erosion areas (where erosion is greater than 10 feet per year) along Accomack and Northampton Counties in Virginia. [3]

Figure 3-47 - Location of High Erosion and Accretion along the Eastern Shore between 1949 and 2017.



The City of Virginia Beach recognizes the economic importance of the existing beaches in the city and regularly surveys their coastline. The City of Virginia Beach identified Chesapeake Beach as having "chronic erosion", Bay Lake Beach is "slightly accretional", the majority of Ocean Park Beach is erosional, Cape Henry Beach is relatively stable, areas of North End Beach vary from "naturally accretional" to "moderately erosional", Resort Beach is erosional (with a

50-year history of beach fill), Croatan Beach is historically stable with current localized erosion, and Sandbridge Beach has extremely high erosion rates (nourished for the first time in 1998). As much as 8 feet per year of beach disappears at Sandbridge because the shape of the ocean floor focuses wave energy on the shore.[xlvii] The probability of future coastal erosion in the city is high, and the city works diligently to mitigate the impacts.

Risk

The risk associated with erosion in Virginia has not been formally quantified due to the difficulty in assessing the rate of incidence and separating erosion risk from other hazards. Erosion can occur along streams and rivers in every part of the state, but the risk is highest on the coast due to the increased frequency of events. Risk should be considered on a localized scale across the Commonwealth. Details on erosion, in particular coastal erosion, is discussed within many of the local/regional hazard mitigation plans along Virginia's Chesapeake and Atlantic Coastlines.

3.8.3.5 State Facility Risk

An examination of state assets in communities with documented and problematic shoreline erosion, including Virginia Beach, Northampton County and Accomack County, reveals several facilities that are located on or near shorelines that may be impacted by erosion. Damage can be expected to immediate shoreline structures that may be undermined by erosion, as well as soil loss along trails, roads or bridge foundations that are part of the affected facilities. Table 3-40 details the value of structural assets owned by the state that are at risk of damage from shoreline erosion.

Table 3-40 - State assets at highest risk of shoreline erosion

Locality	Agency and Facility	Number of State Assets at Risk	Total Value of at Risk Assets
City of Virginia Beach	Game and Inland Fisheries Princess Ann Wildlife Management Area	6	$631,300
	DCR False Cape State Park	26	$3,284,300
	Virginia Air Guard	133	$169,180,500
	DCR First Landing State Park	50	$13,011,700
Accomack County	VIMS	18	$14,275,400
	Marine Resources Commission	1	None provided
Northampton County	University of Virginia Oyster Lab	2	$3,192,600
	DCR Kiptopeke State Park	28	$6,812,800

3.8.3.6 National Risk Index

Erosion is not one of the NRI's hazards that is analyzed therefore there is no risk rating provided for erosion.

Future Conditions

Shoreline, or coastal, erosion over the long-term and short-term will likely continue to occur along the Virginia coastline. It is a long-term hazard that undermines waterfront homes, businesses, public facilities, and infrastructure along shorelines, even rendering structures uninhabitable or unusable. However, shoreline erosion will be more immediate and severe during hurricanes, tropical storms and nor'easters. Shoreline erosion is driven by several natural influences such as sea level rise and land subsidence, large storms such as tropical storms, nor'easters and hurricanes, storm surge, flooding and powerful ocean waves. Shoreline erosion may be exacerbated under future conditions. Man-made influences such as coastal development and some shoreline stabilization projects can exacerbate shoreline erosion as well, even when initially intended to minimize immediate erosive effects. While not as sudden as other hazard events discussed in this plan, shoreline erosion influences the stability and condition of coastal property and beaches when other short-term hazard events occur. For example, erosive forces may undermine tree roots and revetments along a shoreline, exacerbating the effects of flooding and sea level rise.

A valuable factor in accurately determining specific shoreline erosion hazard areas is the continuous implementation of shoreline reinforcement or nourishment projects completed by federal, state, and local government agencies. Typically, areas of high concern for long term erosion are addressed through shoreline hardening or stabilization projects, such as seawalls, breakwaters, and beach sand replenishment. Additionally, wind erosion is likely to continue to occur over the long-term and short-term across the state. As climate change increases the annual average temperature and thus, seasonal drought conditions, high intensity wildfire events have significant impacts on vegetation and groundcover that normally serves to stabilize the soil. Decreased soil stability may increase the risk of localized wind and wave erosion.[xlviii]

Jurisdictional Risk

3.8.3.7 Local Plan Risk Assessment

Local plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

Seven of the 20 local hazard mitigation plans considered erosion or coastal erosion/shoreline hazard. Many times, erosion was combined with other hazards such as flooding, hurricane, or landslide and is not easily segregated. Of the plans that provided a general description of erosion/coastal erosion, some of them used NOAA and/or VIMS shoreline change data to spatially analyze local areas of high erosion and structure density within or nearby the erosion hazard areas. The Middle Peninsula HMP considered coastal/shoreline erosion as its own specific hazard, identifying that hurricanes and nor'easters produce severe winds and storm surges that create significant soil erosion along rivers and streams. Using data from the Coastal Erosion Information System (CEIS), the plan notes that "much work is needed to accurately document regional and local erosion rates." Consistent with the Middle Peninsula HMP, the consensus in the local plans is that it is not feasible to estimate potential damages as erosion is not easily predicted or quantified. These plans generally discuss factors contributing to erosion, including land use and climate change impacts (see for example the Hampton Roads HMP), but do not provide estimates of potential losses. An exception is the Northern Neck plan that estimated the number of and dollar value of buildings exposed to coastal erosion. This analysis was feasible since the entire region's coastal areas were assessed at high risk and exposure was defined using a 500 foot buffer. Similar analysis could be done for other regions if erosion hazard areas could be similarly identified and building, and infrastructure data are available.

Ranking the jurisdictions in Virginia based on relative risk for erosion would require additional erosion rate data not available at this time. A tiered system may be useful for summarizing the risk:

Tier one: Virginia Beach, Accomack County and Northampton County have experienced severe coastal erosion in the past and that is expected to continue as sea level rises.

Tier two: the other communities in Hampton Roads (Chesapeake, James City County, Newport News, York County, Norfolk, Isle of Wight, Suffolk, Hampton) are also highly vulnerable to coastal erosion based on past experience.

Tier three: communities of the Middle Peninsula (Essex, Gloucester, King & Queen, King William, Mathews and Middlesex Counties and the Towns of Urbanna, Tappahannock, and West Point) are all also experiencing notable erosion in specific areas.

Generally speaking, the erosion experienced by the Tier one communities is beginning to influence entire communities and neighborhoods beyond just waterfront property owners. On Tangier Island, the erosion is affecting both quality of life and the livelihoods of the entire island population of 378 people. Critical infrastructure and shorelines in many areas are subject to short-term change or damages resulting from storms and high tides. Economic impacts accrue over the long-term as businesses may relocate or have to rebuild shoreline protection systems, and the communities invest in either constant repairs or costly upgrades to shoreline infrastructure.

Tier two communities have erosion in some areas that can occasionally impact infrastructure (bridges, piers/docks, waterfront structures) and utilities, as well as waterfront property owners. Economic impacts are possible in the long-term, and the real property tax base can be impacted by reduced property values in light of the combined impacts of erosion and flooding.

Tier three communities may occasionally experience erosion that impacts infrastructure, but the primary impact is to private waterfront property owners. The economic impacts of this type of erosion are more limited, affecting a small subset of the entire community, or occasionally affecting infrastructure.

3.8.3.8 Comparison with Local Ranking

Three jurisdictions ranked erosion as high risk: George Washington Regional Commission, Accomack-Northampton PDC, and West Piedmont Planning District Commission (erosion as a primary impact of flooding). Northern Neck PDC and Middle Peninsula PDC all ranked coastal erosion as a standalone hazard of medium risk. Two other regional plans ranked erosion as a low-risk hazard. Most of the local plans combined erosion with other hazards (i.e., flooding, hurricane, landslide). The overall risk for erosion is medium among the 7 regional plans that ranked the hazard. For comparison, the 2023 HMP ranked erosion as a low hazard.

3.8.3.9 Changes in Development

The West Piedmont Hazard Mitigation Plan discusses future land use plans and impacts to erosion vulnerability. Development plans for this region indicate that development will not occur in tracts of sensitive slope, floodplains, or wetlands, therefore the number of structures vulnerable to erosion should not increase.[xlix] Most 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes.

Community Lifelines Impacted by Erosion

Based on the hazard analysis and description of vulnerability and impacts of erosion in Virginia, the main community lifelines impacted are:

- Energy (pipelines)
- Transportation

3.8.4 Extreme Cold

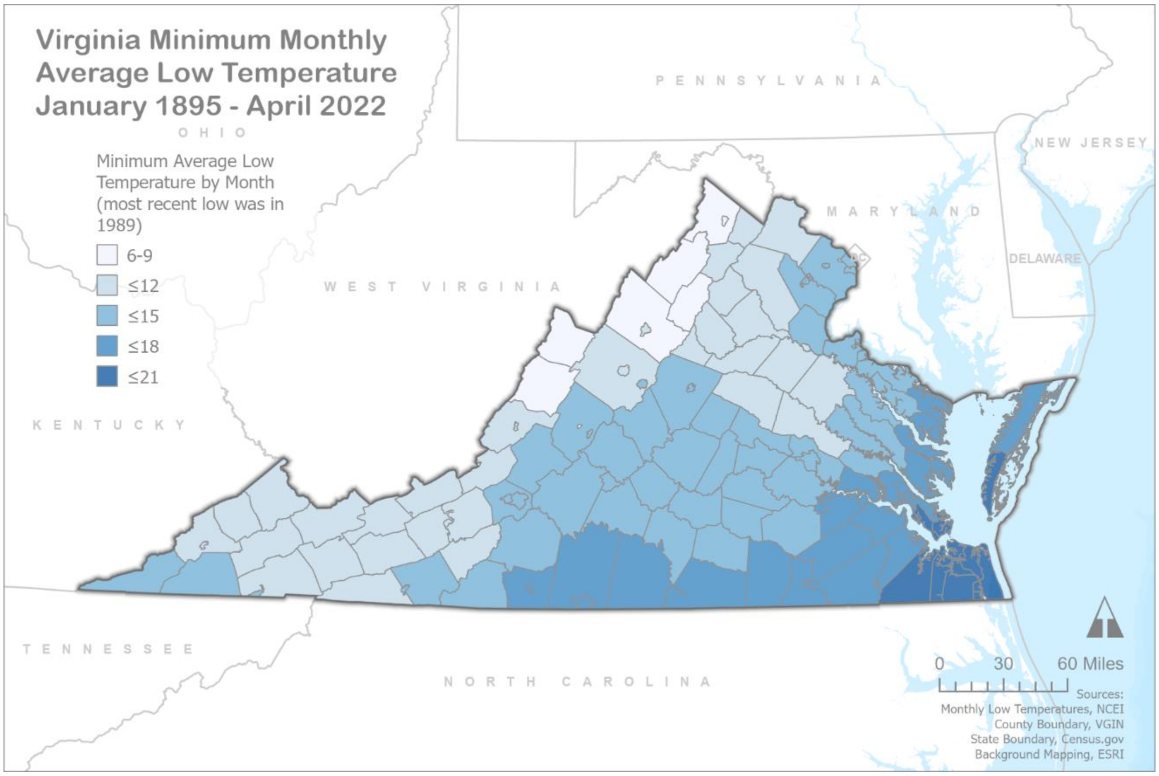
3.8.4.1 Background

Regardless of precipitation, excessively cold temperatures pose occasional threats to the Commonwealth. While wind chill advisories are issued nearly every year, life-threatening excessive cold is a rare occurrence, and the impact of such events depends on the preparedness of individual households and heating fuel/energy providers.

3.8.4.2 Location and Spatial Extent

Definitions of extreme cold can vary dramatically across the state and country. Jurisdictions in the southeastern part of the state that do not receive frequent winter weather might consider a day below 32ºF as extreme, while jurisdictions in the Blue Ridge or Piedmont area may have a different threshold for defining extreme cold. In Virginia, the average low temperatures are generally widespread across the state during the winter months. These values are the lowest value of average low temperatures taken by month since 1895. There has not been an occurrence of a lowest-low temperature since 1989 (over 30 years). The area with the greatest occurrence of the Commonwealth’s lowest temperatures can be seen in the southeastern portion of the state as highlighted in Figure 3-48, below.

Figure 3-48 - Location of Monthly Minimum Average Low Temperatures (Fahrenheit) in Virginia, 1895-2022



3.8.4.3 Significant Historical Events

Several significant low temperatures, extreme cold events have impacted the state since detailed temperature and weather records began being compiled for the entire state. Two major extreme low temperature events were reported in 1940 and 1977, respectively. A blizzard in January 1940 sent temperatures plunging below -10°F in the central part of the Commonwealth and impacting 57 municipalities. A bitter winter in 1977 saw lows of about 10°F even along the coast, where parts of the Chesapeake Bay froze over. Approximately 64 communities were impacted by what many call the Deep Freeze of 1977. Other noteworthy extreme cold events in Virginia's recorded history include:

- Winter of 1609-1610 – Known as "The Starving Time" at Jamestown, winter weather, food shortages, fractured leadership and a siege by Native Americans led to two of every three colonists perishing. Starvation weakened the colonists and led to rampant illness.
- 1985 - The lowest temperature reported in Virginia was -30°F, recorded on January 21, 1985, at the Mountain Lake Biological Station in Giles County.
- 1989 - The most recent reported average low temperature for Staunton was in 1989 at 10.8°F; and,
- 2000 - On January 27, 2000, the lowest temperature recorded was -7°F in Fairfax County, and there was one fatality due to hypothermia.

Table 3-41 provides a summary of reported events in the NCEI database for Cold/Wind Chill and Extreme Cold/Wind Chill in the period from January 2000 through August 2022.

Table 3-41 - NCEI recorded events for Extreme Cold, 2000 to 2022

Jurisdiction(s)	Date	Death or Injuries	Property or Crop Damage	Event Description
Stafford, Arlington / Alexandria / Falls Church, Fairfax, Clarke, Loudoun, Fauquier, Warren, Page, Shenandoah, Prince William, Highland, Frederick / Winchester, Rockingham / Harrisonburg, King George, Madison, Culpeper, Rappahannock, Nelson, Albemarle / Charlotttesville, Augusta / Staunton / Waynesborro, Spotsylvania / Fredericksburg, Orange, Greene, Shenandoah, Spotsylvania / Fredericksburg, Orange, Madison, Fairfax, Loudoun, Clarke, Frederick / Winchester, Nelson, Greene, Rockingham / Harrisonburg, Albemarle / Charlotttesville, Augusta / Staunton / Waynesborro, King George, Stafford, Culpeper, Fauquier, Warren, Rappahannock, Page, Highland, Prince William, Arlington / Alexandria / Falls Church, Rappahannock, Albemarle / Charlotttesville, King George, Rockingham / Harrisonburg, Stafford, Nelson, Orange, Arlington / Alexandria / Falls Church, Page, Shenandoah, Greene, Loudoun, Fairfax, Madison, Augusta / Staunton / Waynesborro, Spotsylvania / Fredericksburg, Prince William, Fauquier, Clarke, Frederick / Winchester, Warren, Highland, Culpeper, Buchanan, Dickenson	1/21/2000	One fatality due to hypo-thermia	$0	High pressure was located directly over the Mid-Atlantic region between the 27th and 29th. The combination of clear skies, calm winds, and a snowpack led to extremely cold temperatures . On the 27th, a 59-year-old woman was found dead in the parking lot of a shopping center in Fairfax, and apparent victim of hypothermia. Temperatures were in the teens at dawn on the 27th and only reached the low 20s by early afternoon. On the morning of the 28th and 29th, the mercury dropped into the single digits above and below zero in many locations. Low temperatures from the 28th included 13 degrees at Dulles International Airport, 0 degrees in Fredericksburg and Waynesboro, 5 degrees in Culpeper, 7 degrees in Harrisonburg, 14 degrees in Winchester and Washington Reagan National Airport, 10 degrees in Staunton, -7 degrees in Elkton, and -3 degrees in Mustoe. Low temperatures from the 29th included 8 degrees at Dulles International Airport, 1 degree in Fredericksburg and Luray, 9 degrees in Front Royal, -1 degree in Waynesboro, 6 degrees in Culpeper, 11 degrees in Winchester, 12 degrees at National Airport, 8 degrees in Staunton, -4 degrees in Tye River, and -2 degrees in Mustoe.
Buchanan, Dickenson	10/8/2000	None	$0	Dawn temperatures were mostly in the mid 20s to lower 30s. Clintwood observed 26 degrees, while both Hurley and the Breaks Interstate Park saw 30 degrees."
Buchanan, Dickenson	11/21/2000	None	$0	Daytime high temperatures were in the 30s, with overnight low readings of 10 to 15 degrees. Patchy ice formed on the small streams, which is rare for Thanksgiving."
Buchanan, Dickenson	12/1/2000	None	$0	Winds aloft favored the northwest this month, resulting in the monthly average temperature to be 7 to 9 degrees colder than normal.
Shenandoah, Warren, Rappahannock, Culpeper, Orange, King George, Stafford, Fauquier, Prince William, Arlington, Spotsylvania, Albemarle, Augusta, Clarke, Frederick, Fairfax, Nelson, Highland, Loudoun, Rockingham, Greene, Madison, Page	12/22/2000	None	$0	After a cold front moved across the region during the afternoon of the 22nd, northwest winds picked up to 20 to 30 MPH. Temperatures dropped into the teens which created wind chills between -10 and -20 degrees. As the winds subsided during the early morning hours of the 23rd, temperatures ranged from the single digits above zero to the low teens.
Highland, Warren, Fauquier, Prince William / Manassas, Fairfax, Loudoun, Clarke,	4/19/2001	None	$0	High pressure over the Mid-Atlantic region created calm winds and clear skies during the early morning hours of the 19th. These

Jurisdiction(s)	Date	Death or Injuries	Property or Crop Damage	Event Description
Frederick / Winchester, Page, Shenandoah, Stafford, Culpeper, Rappahannock, Rockingham / Harrisonburg, Greene, Madison, Orange, Spotsylvania / Fredericksburg, Nelson, Albemarle / Charlotttesville, King George, Augusta / Staunton / Waynesborro				conditions in combination with a chilly airmass in place allowed temperatures to plummet into the mid 20s to lower 30s between 3 and 7 AM EDT. The resulted in a hard freeze which unfortunately was preceded by unseasonably warm weather which had caused many plants to bloom early. Farmers with budding peach and apple crops and homeowners and nurseries with outdoor vegetation in bloom reported losses.
Buchanan, Dickenson, Frederick / Winchester, Culpeper, Rappahannock, Madison, Loudoun, Page, Rockingham / Harrisonburg, Greene, Albemarle / Charlotttesville, Nelson, Highland, Shenandoah, Warren, Augusta / Staunton / Waynesborro, Fauquier, Clarke	5/20/2002	None	Monetary losses were estimated to be in thousands of dollars.	A cold area of high pressure from Canada pushed into the mid-Atlantic region on the 19th and remained overhead through the 22nd. This caused skies to clear, winds to drop to zero, and temperatures to plummet into the mid 20s to lower 30s during the early morning hours of the 20th, 21st, and 22nd. A record low temperature of 31 degrees was set at Dulles International Airport on the morning of the 22nd. Several backyard gardeners and local farmers lost tender vegetation to the late season frost. Damaged vegetation included grapes, soybeans, tomatoes, sweet potatoes, squash, cucumbers, beans, and young Christmas trees. Corn plants were expected to have stunted growth due to the damaging frost.
Albemarle / Charlotttesville, Shenandoah, Highland, Page, Rappahannock, Fauquier, Frederick / Winchester, Nelson, Augusta / Staunton / Waynesborro, Stafford, King George, Spotsylvania / Fredericksburg, Greene, Orange, Madison, Warren, Fairfax, Loudoun, Rockingham / Harrisonburg, Clarke, Prince William / Manassas, Culpeper	12/7/2002	None	$0	Long standing low temperature records were set on the morning of the 7th as a fresh snow pack, calm winds, and clear skies allowed temperatures to plummet around 20 to 30 degrees below normal overnight. At Dulles International Airport at 7:25 AM the temperature fell to 1 degree above zero. This smashed the previous record of 18 degrees set in 1977. Other low temperatures recorded across Northern Virginia include 12 degrees in Fredericksburg and Manassas, 8 in Charlottesville and Great Falls (Fairfax Co.), zero in Edinburg (Shenandoah Co.) and at Shenandoah Valley Airport (Augusta Co.), 1 below at Lincoln (Loudoun Co.) and Winchester (Frederick Co.), and 4 below at the National Weather Service Office in Sterling (Loudoun Co.). At Washington Reagan National Airport, the low temperature only fell to 18 degrees due to the urban heat island effect. The record low for December 7th is 10 degrees set in 1882.
King George, Arlington, Stafford, Loudoun, Fairfax, Fairfax, Loudoun, Arlington / Alexandria / Falls Church, Loudoun	1/15/2004	None	$0	Very cold Arctic air settled over the portions of Northern Virginia. The minimum temperatures ranged from the lower teens to the digits, and north winds averaged 10 to 15 mph. This produced wind chills on the average of 10 degrees below zero. There were dozens of cases of broken water mains and water pipes due to the extremely cold temperatures.
Pulaski	4/7/2007	None	$15,000	Icy road conditions contributed to a one vehicle accident.

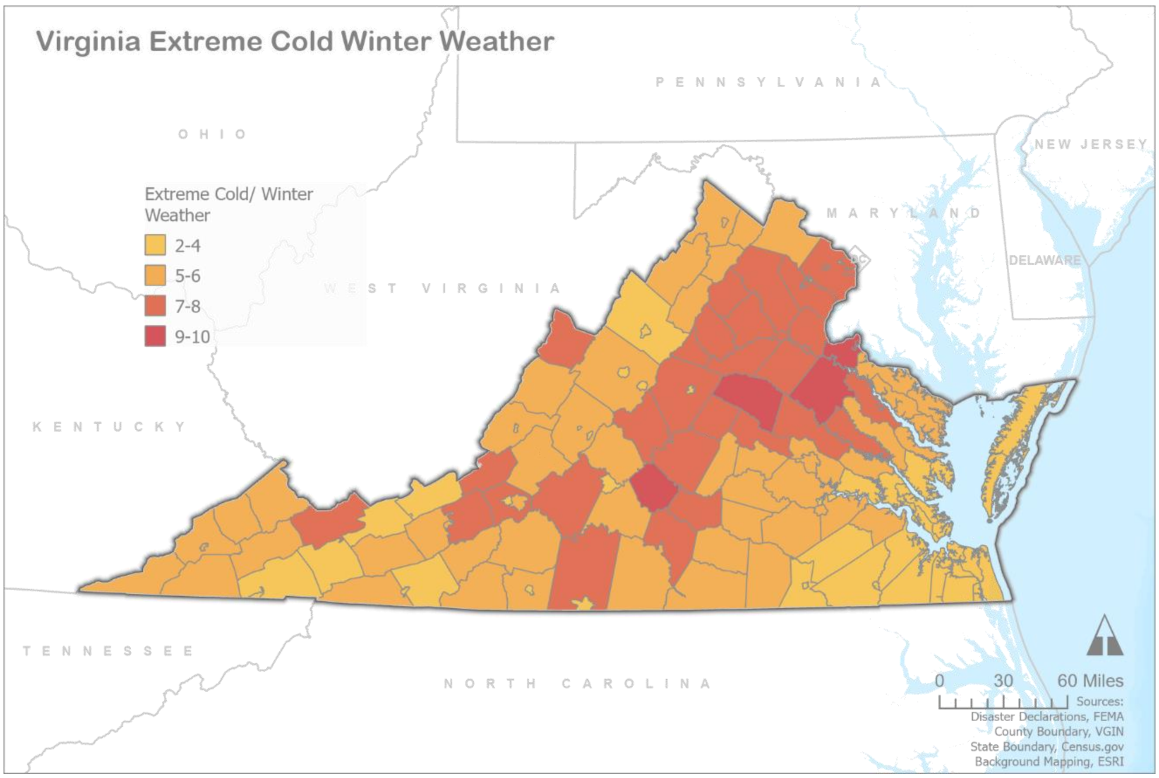
3.8.4.4 Probability of Future Occurrence

The state has experienced extended periods of extreme cold in the past, especially during blizzards or winter storms, and will likely continue to experience seasonal low temperatures and fluctuations with storms and severe weather.

Impact and Vulnerability

Extreme cold vulnerability is a factor of individual, property, and societal elements. At the individual level, the potential for exposure to extreme cold, falling on ice-covered walkways, and automobile accidents is heightened during winter weather events. Extreme cold temperatures during the winter months impact the entire Commonwealth of Virginia; however, there are some spatial variations in the number of occurrences of extreme cold events as shown in Figure 3-49. Please see the section on winter weather for additional information on impacts.

Figure 3-49 - Number of occurrences of extreme cold temperatures in Virginia, 1962-2022.



Risk

A Wind Chill Warning is issued when a combination of extreme cold and winds occur. This combination can result in frostbite, hypothermia, or even death when people are exposed in this type of condition for an extended period of time, especially without proper clothing protection. These warnings are issued when wind chill values are expected to be less than -15°F. Wind Chill Watch is issued when dangerously cold wind chills are possible, typically within 12 to 48 hours. Wind Chill Advisory is issued when wind chill temperatures create inconvenience to life with prolonged exposure. If caution is not exercised, hypothermia and frostbite may occur. An advisory will be issued for wind chill values less than 0°F but not colder than -14°F. Any of these events are likely to occur within a given year across Virginia, usually occurring with winter weather including snow, sleet, or ice (see Winter Weather section for more information). The risk for wind chills and extreme cold is relatively higher in central and northern Virginia, however extreme cold occurrences can be seen statewide annually. (See Figure 3-48). The risk associated with extreme cold in Virginia has not been formally quantified and should be considered on a localized scale across the Commonwealth.

3.8.4.5 State Facility Risk

Extreme cold poses a much higher risk to people than to structures or other state-owned assets. While state-owned structures may experience an occasional pipe bursting or utility disruption due to extreme cold, the risk is minimal and would not normally be expected to notably affect the value of an asset. Damage to roads and bridges from repeated freeze-thaw is also possible, but can be repaired. Figure 3-50 shows that the historic risk of experiencing extreme cold is greatest in the counties of King George, Caroline, Louisa and Appomattox. State assets at risk in those counties are summarized in Table 3-42.

Table 3-42 - State-owned assets at risk from Extreme Cold

Locality	Agency and Facility	Number of State Assets at Risk	Total Value of at Risk Assets
Appomattox County	DCR Holliday Lake State Park	17	$2,002,400
	Game & Inland Fisheries Holliday Lake 4-H Center	6	$39,600
	VDOT Complex	11	$1,499,000
	Virginia Tech Holliday Lake 4-H Center	2	$135,900
Caroline County	DOC Caroline Correctional Unit	32	$15,935,144
	DEQ Magnetic Center	1	$5,700
	VDOF	1	$169,200
	VDOT Dawn Area HQ, Ladysmith Area HQ, Bowling Green Residency Complex	34	$2,057,800
	Northern Region Correctional Field Units	1	$5,288,700
King George County	DCR Caledon Natural Area	11	$3,062,600
	Lands End Wildlife Management Area	8	$103,700
	VDOT Edgehill Area	12	$1,012,300
	University of Mary Washington Dahlgren Center	1	$23,782,600
Louisa County	UVA Medical facilities	1	$15,699,889
	VDOT Cuckoo Area HQ, Zion Crossroads Area HQ, Louisa Residency Complex	33	$1,879,900
	State Police Area 4 office	1	$500,300
	Game & Inland Fisheries	1 storage building	$3,700
	VDOF Louisa office and facilities	3 (fire tower is inactive)	$294,000

3.8.4.6 National Risk Index

The National Risk Index (NRI) includes three components: a *natural hazards component* (**Expected Annual Loss**), a *consequence enhancing component* (**Social Vulnerability**), and a *consequence reduction component* (**Community Resilience**). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for drought are reviewed for each community (county tract).

Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for extreme cold is reviewed for each community (county tract).

As shown in Figure 3-50, extreme cold or cold wave NRI Risk Index Rating is not provided for much of the central and eastern sections of the state of Virginia. For the areas along the northern and western boundaries of the state the greatest risk index ratings are for the City of Roanoke, Washington County, Russell County and Highland County. As shown in Table 3-43, these are the most vulnerable jurisdictions in the Commonwealth, and have a risk index rating of Relatively Moderate. All other rated jurisdictions are classified as Relatively Low or Very Low.

Figure 3-50 - Extreme Cold/Cold Wave National Risk Rating.

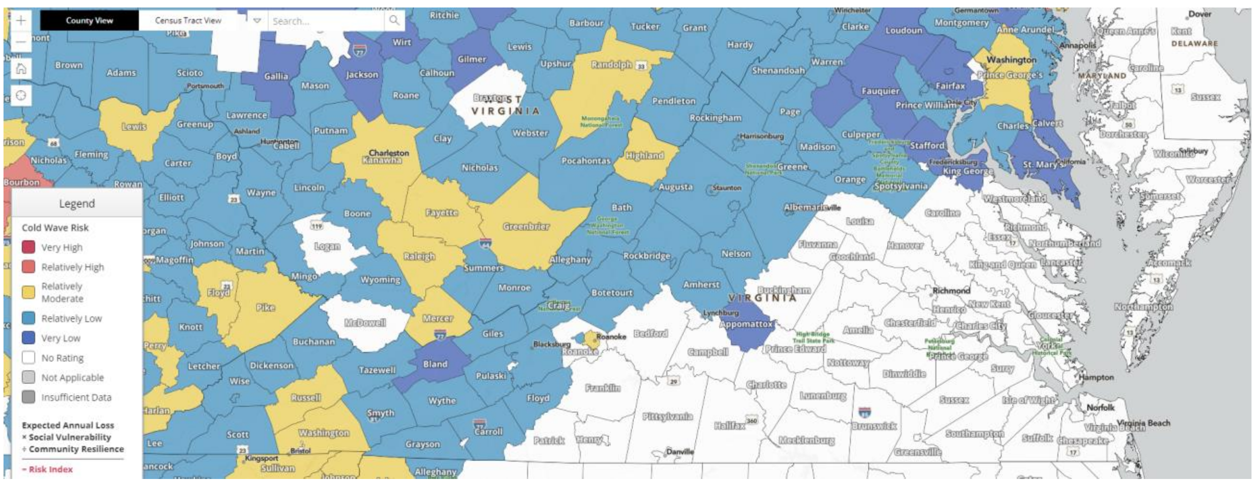


Table 3-43 - Communities With Highest Risk Index Ratings for Cold Wave

Locality	Number of Schools in Locality	Medical Care Facilities in Locality	NRI Risk Index Rating
Roanoke County	34	Catawba Hospital	Relatively Moderate
Washington County	25	Johnston Memorial, Konnarock Family Health Center, Holston Family Health Center	
Russell County	17	William Davis Clinic, Russell County Medical Center	
Highland County	2	none	

Source: NRI

Impacts in these communities are highest because of their mountainous location, high elevation and geography relative to the warmer Atlantic Ocean currents. Risk is high because the impacts to residents without transportation and to the elderly are accentuated during a cold wave; poverty is also a factor in population resilience during a cold wave because of the cost of heat. Critical facilities, including schools and medical care facilities, in these counties may be impacted by transportation/access limitations, pipes freezing, and communication and power line outages.

Future Conditions

Since the beginning of the 20th century, global annual average temperatures have risen approximately 1.5°F. Although temperatures have seen fluctuations since then, there has been a steady trend of gradual warming occurring since the early 1990s. This trend indicates that the future occurrences of extreme cold temperatures, although possible, is less likely.[l] In fact, a Climate Central analysis released in February 2013 found that the states with the coldest winters have been warming the fastest.[li] Climate data shows that extreme cold events across the continental US are occurring far less frequently than an in the past. This is largely related to winter warming trends due to manmade global warming and natural climate variability.[lii]

Jurisdictional Risk

Local Plan Risk Assessment

Local plans, with few exceptions, have not identified extreme cold as a standalone hazard. The Middle Peninsula PDC and the Southside PDC plans consider extreme cold and extreme heat together under extreme temperatures. Others, such as the Hampton Roads PDC and the Northern Shenandoah Valley PDC, include extreme cold under winter storms. These plans generally discuss the broad risks of extreme cold, often in conjunction with winter storms, but do not provide estimates of impacts of extreme cold (separate from winter storm impacts such as power loss) such as infrastructure or assets damages or injury/loss of life from exposure to extreme cold. The plans that address extreme cold as one temperature extreme tend to provide more in-depth analysis than those that consider extreme cold as an impact of winter storms. Across all these local plans, the discussion of the hazard is descriptive and does not provide estimates of damages or losses.

Several plans discuss how socially vulnerable populations are impacted as a result of extreme cold temperatures, especially after severe storms where there are local or regional power outages that threaten the availability of heat. In addition, populations that rely on public transportation may have limited ability to wait for buses in extreme cold situations. More comprehensive analysis of extreme cold in the local plans could hone in on the specific impacts of extreme cold including factors such as impact on infrastructure and buildings, assessment of the populations that are socially vulnerable to extreme cold, and identification of geographic areas within the jurisdiction where socially vulnerable populations may be concentrated.

3.8.4.7 Local Plan Comparison

Overall, 6 out of the 20 the local hazard mitigation plans ranked extreme cold, and typically those plans described winter weather as part of extreme cold hazard or group extreme cold and extreme heat together as the extreme temperatures hazard. Out of the 6 plans that provided a ranking, 3 ranked extreme cold as a high hazard and 3 ranked extreme cold as a medium hazard. The overall hazard ranking for extreme cold for the 6 local plans that included it was medium-high. For comparison, the 2023 HMP ranked extreme cold as a medium hazard.

3.8.4.8 Changes in Development

Most local hazard mitigation 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Although extreme cold was considered high for local/regional plans, no information was given to reflect changes in development in the hazard prone areas.

Community Lifelines Impacted by Extreme Cold

Based on the hazard analysis and description of vulnerability and impacts of extreme cold in Virginia, the main community lifelines impacted are:

- Food, Water, Shelter
- Energy
- Health and Medical

3.8.5 Extreme Heat

3.8.5.1 Background

A heat wave is defined as prolonged periods of excessive heat, often combined with excessive humidity. Extreme heat is defined as temperatures that hover 10°F or more above the average high temperature for the region, and that last for several weeks. The main concern in periods of extreme heat is the potential public health impact, such as heat exhaustion or heat stroke. Individuals of concern include those living in residences without air conditioning, or in areas where electric service is unavailable due to system-wide blackouts.

Extreme heat combined with high relative humidity slows evaporation, limiting the body's ability to efficiently cool itself. Overexposure may result in heat exhaustion or stroke, which could lead to death. The CDC states that although heat related deaths and illnesses are preventable, more than 600 people in the US are killed by extreme heat each year. According to the NWS, heat is the leading weather-related killer in the US, although no deaths have been reported for the historical events described below for Virginia. The elderly and those with medical conditions such as diabetes are most at-risk, along with those who work outdoors in hot, humid weather, athletes, infants and children, and low-income households.

Asphalt and concrete store heat longer and gradually release heat at night, which can produce higher nighttime temperatures known as an "urban heat island effect." The impact of excessive heat is most prevalent in urban areas, where the heat island effects prevent inner-city buildings from releasing heat built up during the daylight hours. Thus, a secondary impact of excessive heat is severe strain on the electrical power system and potential brownouts or blackouts.

3.8.5.2 Location and Spatial Extent

Extreme heat typically impacts a large area that is normally not confined to any geographic boundaries, although urban heat island effects can exacerbate effects in urbanized areas. For excessive heat, the NWS uses heat index thresholds as criteria for the issuance of heat advisories and excessive heat warnings to affected communities. NWS heat advisory bulletins inform citizens of forecasted extreme heat conditions. The bulletins are based on projected or observed heat index values and include:

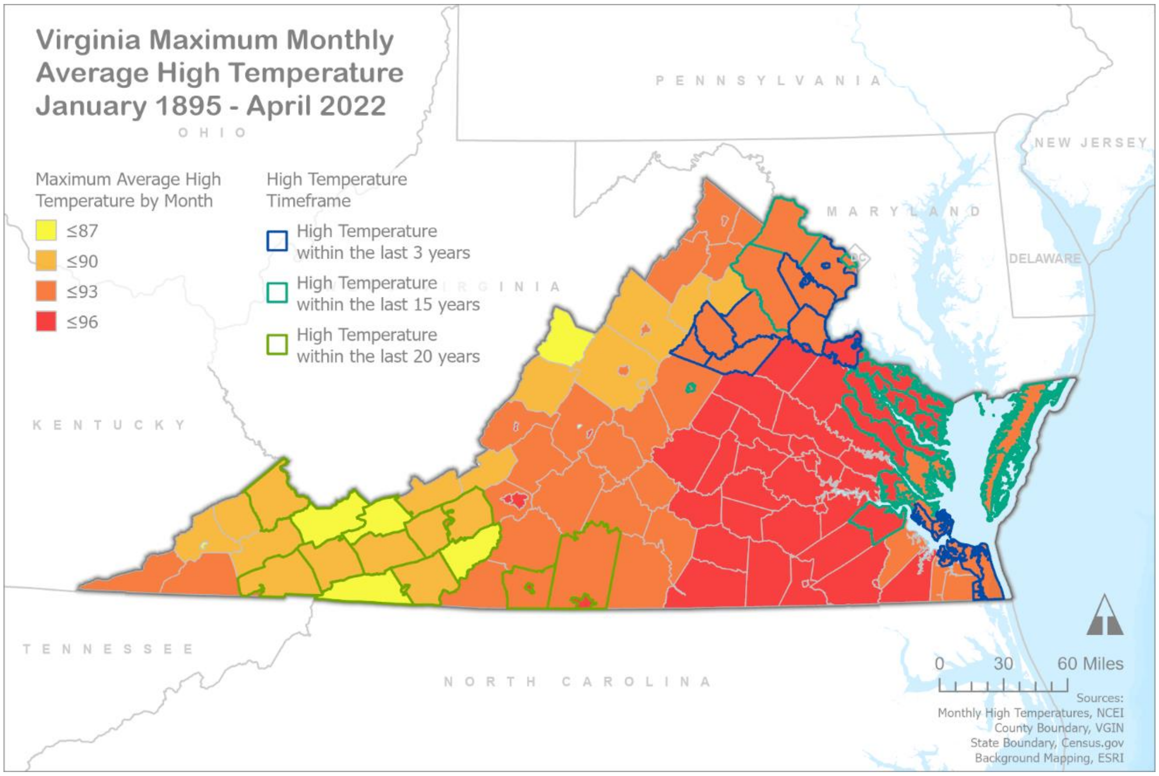
- Excessive Heat Outlook when there is a potential for an excessive heat event within three to seven days;
- Excessive Heat Watch when conditions are favorable for an excessive heat event within 12 to 48 hours, but some uncertainty exists regarding occurrence and timing; and,
- Excessive Heat Warning/Advisory when an excessive heat event is expected within 36 hours.

These bulletins are usually issued when confidence is high that the event will occur. A warning implies that conditions could pose a threat to life or property, while an advisory is issued for less serious conditions that may cause discomfort or inconvenience but could still lead to threat to life and property if caution is not taken.

For this planning effort new analysis was conducted to evaluate the maximum average high temperatures by month across the state. Figure 3-51 shows the maximum monthly average high temperature between January 1895 and April 2022. The data are further broken down to highlight those Virginia counties where, within the last 20-, 15-, and 3-years. It was noted that over the past 20 years the high temperatures mainly group along the southwest portion of the state whereas within the last 15 and 3 years the high temperatures were recorded along the eastern portions of the state.

The areas where high temperatures occur within the last 15-years and 3-years are located in the eastern region of Virginia, whereas counties with high temperatures within the last 20-years are clustered near the southwest corner of the state. The central eastern and central southern portions of the state have had the greatest maximum average high temperature by month over the time period of 1895-2022.

Figure 3-51 - Virginia Counties Maximum Monthly Average High Temperature for Chosen Timeframe.



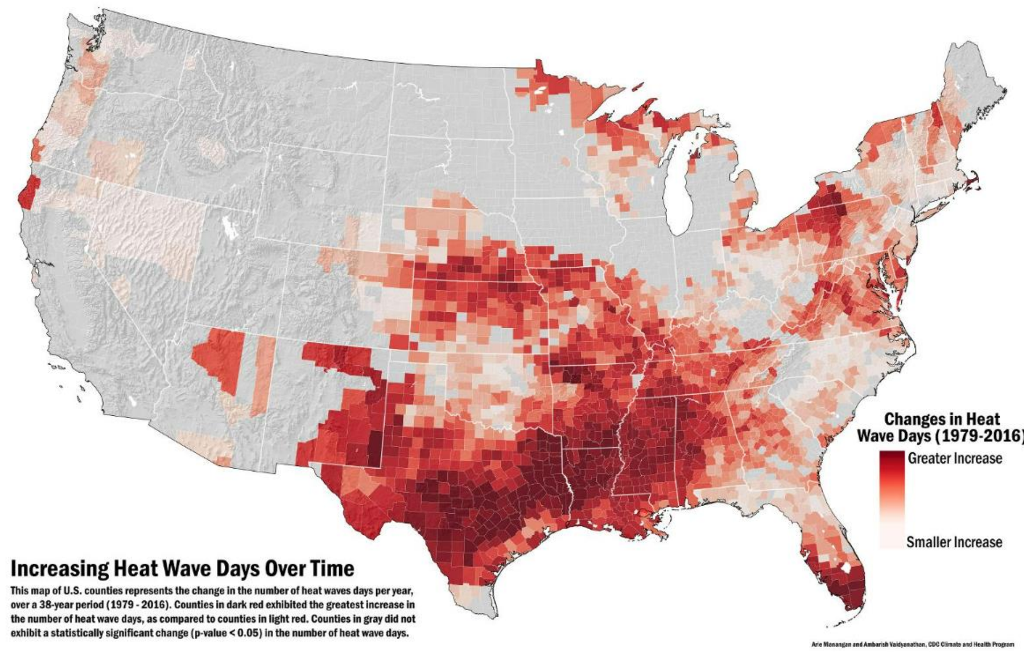
3.8.5.3 Significant Historical Events

The hottest temperature recorded in the Commonwealth of Virginia was 110°F in Balcony Falls on July 15, 1954. On June 8, 2008, high temperatures reached the mid to upper 90s across northern Virginia. Heat index values reached 105°F and one heat related fatality was reported in Alexandria. On July 19th-21st, 2019, high temperatures reached the upper 90’s to low 100’s with a dew point of near 70. Heat index values reached 105 -110°F.

Virginia experienced another extreme heat scenario between July 19 and 21, 2019, following severe storms. Thirteen municipalities were impacted with temperatures in the mid-90’s to lower 100’s exasperated by a dew point near 70°F which produced a heat index of over 105°F and 110°F for 2 to 3 days. More than one million people were left without electricity – and therefore cooling – for up to a week. This was the third largest power outage in the Commonwealth’s history. During this week, daytime temperatures were consistently above 90 degrees.

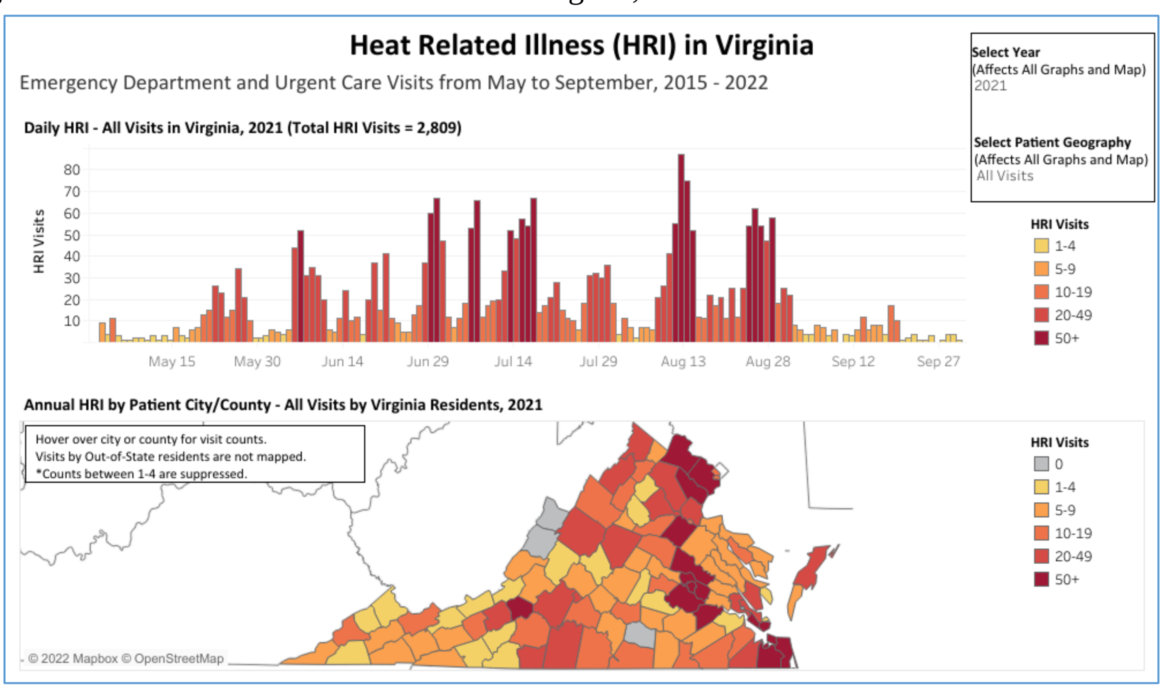
Based on historical data from 1979 to 2016, the CDC prepared the map shown in Figure 3-52. This map of US counties represents the change in the number of heat waves days per year, over the 38-year period. Counties in dark red exhibited the greatest increase in the number of heat wave days, as compared to counties in light red. Counties in gray did not exhibit a statistically significant change (p-value<0.05) in the number of heat wave days.

Figure 3-52 - Map of Increasing Heat Wave Days in the United States, 1979-2016 (CDC Climate and Health Program).



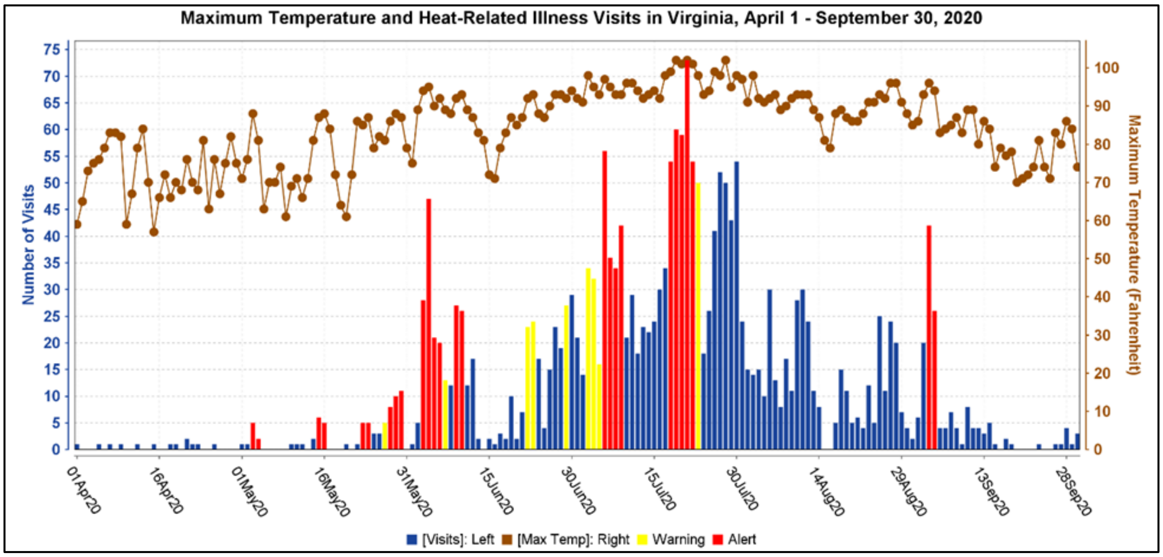
In 2017, the Virginia Department of Health began conducting syndromic surveillance regarding people seeking treatment in medical facilities for heat-related illnesses. The results of those surveillance records from 2017-2020 are shown in Figure 3-53 to Figure 3-57. Data from 2021 show an additional 2,809 visits for heat related illness statewide during that year. Over time, these data will be available to build a more robust history of historical heat-related events.

Figure 3-53 - Heat-Related Illness Visits in Virginia, 2021



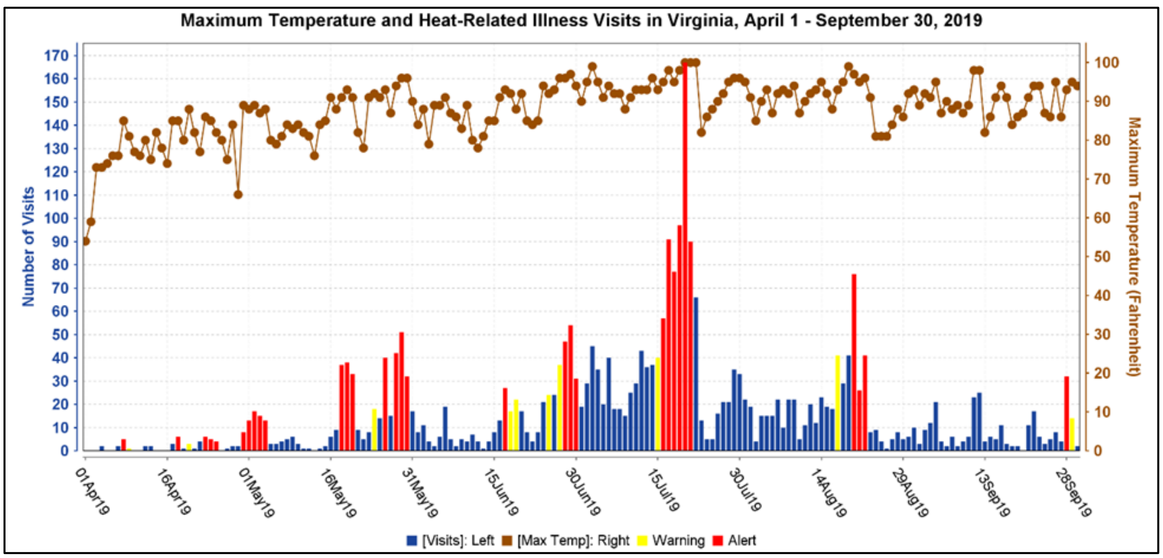
Source : https://www.vdh.virginia.gov/surveillance-and-investigation/syndromic-surveillance/hri-surveillance/

Figure 3-54 - Maximum Temperature and Heat-Related Illness Visits in Virginia, 2020



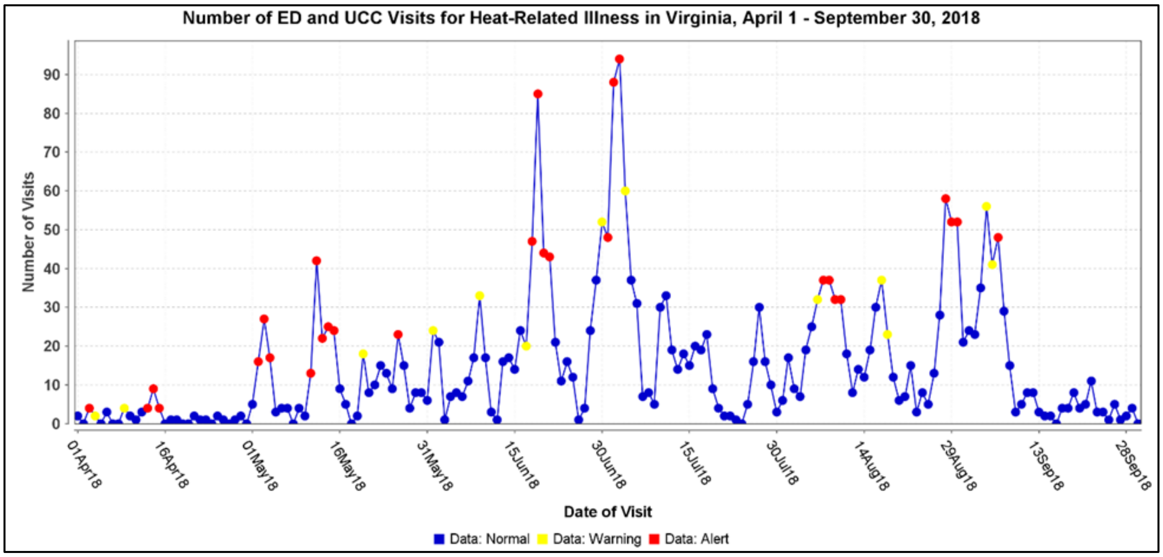
Source: VDH, accessed online 2021 https://www.vdh.virginia.gov/surveillance-and-investigation/syndromic-surveillance/weather-surveillance/.

Figure 3-55 - Maximum Temperature and Heat-Related Illness Visits in Virginia, 2019



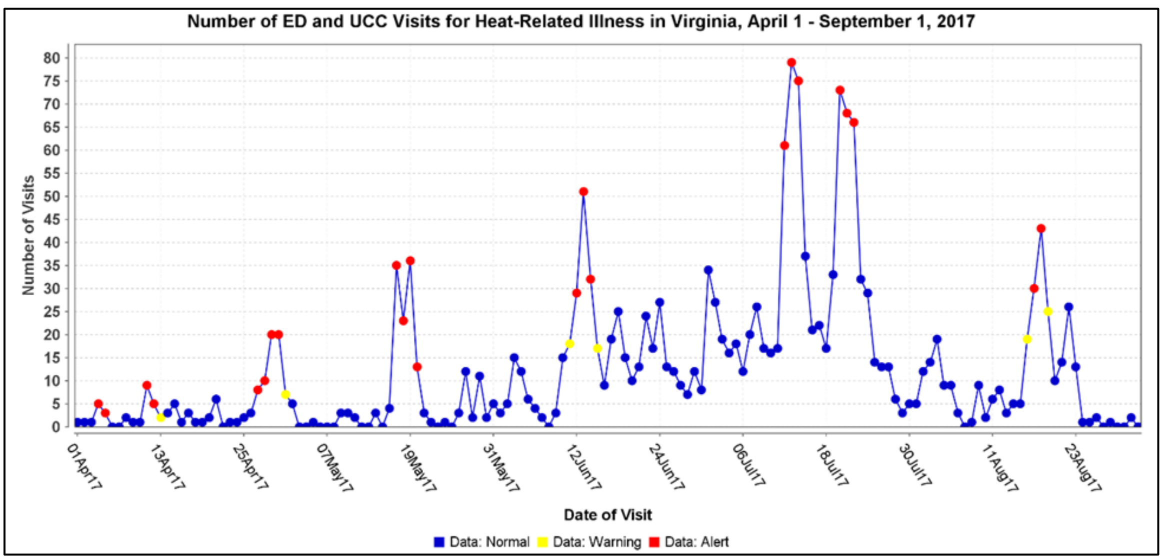
Source: VDH, accessed online 2021 https://www.vdh.virginia.gov/surveillance-and-investigation/syndromic-surveillance/weather-surveillance/.

Figure 3-56 - Maximum Temperature and Heat-Related Illness Visits in Virginia, 2018



Source: VDH, accessed online https://www.vdh.virginia.gov/surveillance-and-investigation/syndromic-surveillance/weather-surveillance/.

Figure 3-57 - Maximum Temperature and Heat-Related Illness Visits in Virginia, 2017



Source: VDH, accessed online https://www.vdh.virginia.gov/surveillance-and-investigation/syndromic-surveillance/weather-surveillance/.

3.8.5.4 Probability of Future Occurrence

Impact and Vulnerability

Medical conditions brought on by extreme heat can be mitigated by air conditioning, if available. Electrical grid strains are a concern during periods of extreme heat, as the need for increased air conditioning (and thus electricity) can place strain on the grid. In extreme situations, these strains can lead to brown or blackouts, where the grid fails, and no electricity (and therefore no air conditioning) is available to offset the effects of extreme heat. For those people who do not have ready access to air-conditioned spaces, public areas are often opened to the public to ensure there is a place people can go to cool off.

People are vulnerable to the effects of extreme heat. The human body is designed to operate within a defined temperature range and with sufficient hydration. In the absence of sufficient hydration, dehydration can occur and become debilitating within a matter of hours. Similarly, exposure to temperatures above the normal range for an extended time – a matter of minutes or hours, depending on the age and health of the person – can result in serious injury or death.

Risk

Extreme heat often results in the highest number of annual deaths among all weather-related hazards. Conditions that can exacerbate or induce heat-related illnesses include stagnant atmospheric conditions and poor air quality. Consequently, people living in urban areas may be at greater risk from the effects of a prolonged heat wave than those living in rural areas. Additionally, as previously mentioned, higher nighttime temperatures produced by the urban heat island effect increase risk for those living in urban areas.

3.8.5.5 State Facility Risk

Extreme heat poses a higher risk to people than to structures or other state-owned assets. While state-owned structures may experience an occasional utility disruption due to extreme heat, the risk is minimal and would not normally be expected to notably affect the value of an asset. Damage to roads and bridges from softening pavement is also possible but can be repaired. Many farming facilities, as noted as being vulnerable to drought would also be subject to extreme heat, especially those with livestock. According to NRI data, the annual frequency of experiencing extreme heat is greatest in the jurisdictions shown Table 3-44 State assets at risk in those communities are summarized in the table, as well.

Table 3-44 - State-owned assets at risk from Extreme Cold

Locality	Number of State Assets at Risk	Total Value of at Risk Assets
Chesapeake, City of	$125	$297,746,464
Emporia, City of	$1	$343,253
Fairfax County	$283	$2,412,457,961
Fairfax, City of	$4	$1,490,499
Greensville County	$49	$382,356,980
Isle of Wight County	$27	$1,740,899
King George County	$32	$27,961,071
Loudoun County	$74	$117,105,414
Manassas Park, City of	$0	$0
Manassas, City of	$1	Not provided
Prince William County	$125	$586,347,124
Southampton County	$167	$164,802,251
Spotsylvania County	$53	$83,144,349
Stafford County	$90	$70,591,707
Suffolk, City of	$88	$84,389,661

3.8.5.6 National Risk Index

The National Risk Index (NRI) includes three components: a *natural hazards component* (**Expected Annual Loss**), a *consequence enhancing component* (**Social Vulnerability**), and a *consequence reduction component* (**Community Resilience**). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for drought are reviewed for each community (county tract).

Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for Extreme Heat or Heat Wave (per NRI) are reviewed for each community (county tract). As shown in Table 3-45, there is no rating for extreme heat or heat wave in the middle part of the state, likely a result of some missing data component. Jurisdictions with the highest risk rating are shown in Figure 3-58.

Figure 3-58 - NRI Risk Rating for Heat Wave (Extreme Heat)

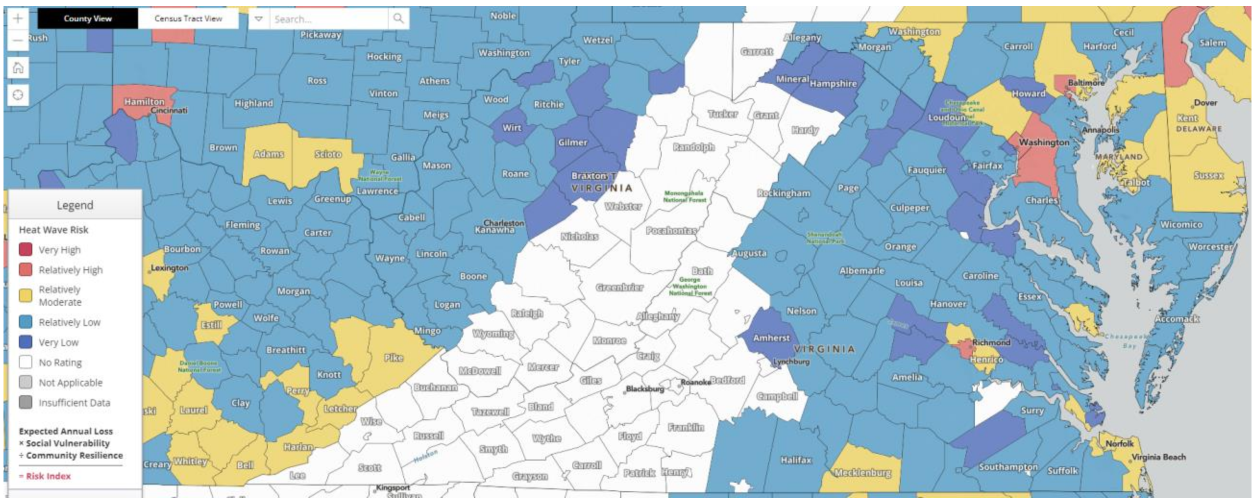


Table 3-45 - Communities With Highest Risk Index Ratings for Heat Wave

Locality	NRI Risk Index Rating
City of Richmond	Relatively High
City of Newport News	Relatively Moderate
Henrico County	
City of Norfolk	
City of Portsmouth	
Lancaster County	
Mecklenburg County	
City of Virginia Beach	

Source: NRI

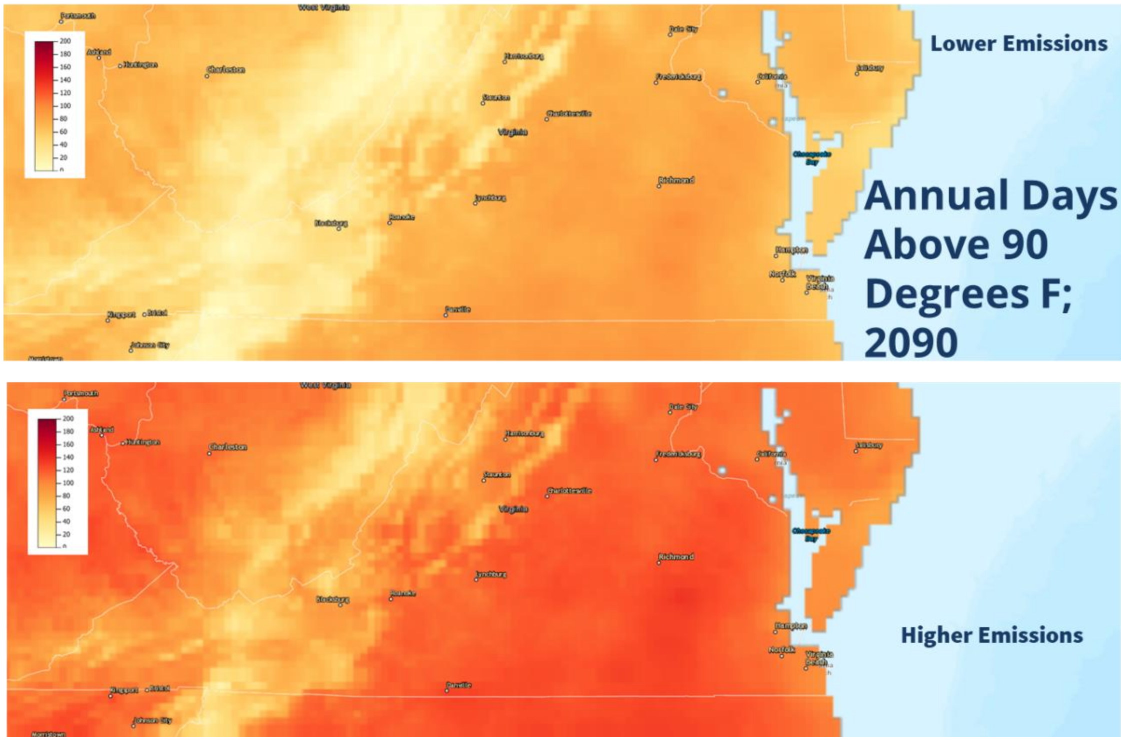
Both the historical losses and the demographic characteristics of the communities inform the list of localities at highest risk. The population most at risk is the elderly, and poverty level may impact access to air-conditioned spaces. The ability of the communities to provide air conditioned spaces to the public is also a factor. Extreme heat may impact critical facilities such as communication or power lines. Structures are generally not at risk from extreme heat unless utilities are interrupted.

Future Conditions

Some form of extreme temperature typically impacts the Commonwealth annually, and this is expected to continue and likely increase in severity and duration. The likelihood of more hot weather and more record hot weather increases as average temperatures increase due to climate change. The CDC Climate Change and Extreme Heat Events report states that ‘Scientists expect climate change to lead to longer, more severe, and more frequent extreme heat events. Even using different climate models and emissions scenarios, the results generally point to extreme heat events becoming worse in almost every regard.’ Additionally, increases in average temperatures because of climate change are projected to make extreme heat events last longer. Under an emissions scenario in which average temperatures have risen 6.3°F (IPCC A2 scenario), most Americans could expect to see extreme heat events lasting 10 to 20 days longer than in the past. However, the future incidence of extreme temperatures is highly unpredictable and may be localized (Northern Virginia Hazard Mitigation Plan, 2017), which makes the exact severity or manifestation of the hazard difficult to quantify.

One factor that has been projected is the influence of emission rates on extreme heat. It was found that emissions scenarios influence the model predictions for how extreme future heating may be. Figure 3-59 shows the expected annual days above 90 degrees in 2090 in the upper portion and the lower map reflects a higher emissions scenario with important consequences over much of the Commonwealth. The darker red areas in the central region reflect well over 100 days per year over 90 degrees.

Figure 3-59 - Projected days above 90 degrees through 2090, Lower Emissions and Higher Emissions Scenarios.



Source: The Climate Explorer: [Climate Explorer (nemac.org)]

Jurisdictional Risk

3.8.5.7 Local Plan Risk Assessment

Local plans, with few exceptions, have not identified extreme heat as a standalone hazard. The Hampton Roads plan is one example where extreme heat is included as a hazard. The Middle Peninsula PDC and the Southside PDC plans consider extreme cold and extreme heat together under extreme temperatures. Others, such as the Richmond-Crater HMP and the Commonwealth Regional Council plan, combine extreme heat with drought. These plans generally discuss the broad impacts of drought, which are exacerbated by extreme heat, but do not provide separate estimates of impacts of extreme heat, such as in terms of infrastructure (e.g., road buckling) or asset damages or injury/loss of life from heat exposure. However, across all these local plans the discussion of the hazard is descriptive and does not provide estimates of damages or losses.

The Hampton Roads plan relied on the average number of extreme summer heat days per year as part of the assessment of vulnerability, but these data are insufficient for much of the region. The Richmond-Crater HMP reports state-wide heat-related deaths and visits to emergency departments and urgent care centers but notes that such data are not readily available by jurisdiction. Disaggregation of this data (collected by VDH) could be helpful for local planning in the future. Land use and climate change will contribute to future extreme heat impacts and local plans should consider these. The Hampton Roads HMP provides an assessment of these anticipated impacts. Academic institutions in the Commonwealth have an increased focus on the study of extreme heat in recent years, and it is expected that this research may yield additional data for us in local plans in the future.

3.8.5.8 Comparison with Local Ranking

Twelve of the 20 local hazard mitigation plans in Virginia provided a ranking for extreme heat. Four of the 20 local plans ranked drought as a high hazard (Southside PDC, Commonwealth Regional Council, Central Shenandoah PDC, and Northern Virginia RC), 6 ranked as medium hazard, and 2 ranked the hazard as low. The local plan ranking average was medium for extreme heat. The 2023 statewide analysis has ranked drought as medium-high risk

3.8.5.9 Changes in Development

Most 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. In some cases, agricultural vulnerability was discussed as a part of the overall development trends section. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Most of the damages due to extreme heat are not related to infrastructure. Communities with large amounts of agricultural land have some heat related mitigation action items, which are typically tied to drought.

Community Lifelines Impacted by Extreme Heat

Based on the analysis and description of vulnerability and impacts of extreme heat in Virginia, the main community lifelines impacted are:

- Food, Water, Shelter
- Energy
- Health and Medical

3.8.6 Flooding

3.8.6.1 Background

Flooding 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 at any time of year, but is typically most prevalent in the spring, summer, and fall. (Failure of dams and levees is addressed in this HIRA under Impoundment Failure)

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, the one percent annual chance flood. As the name indicates, such a flood has a one percent probability of occurrence (or exceedance) in any given year. A one percent annual chance flood is interchangeably called the 100-year flood, although the “100-year” terminology is slightly misleading because readers may erroneously assume that the term refers to a flood that only occurs once in a 100-year period. For many regulatory, design and hazard identification purposes, the one percent annual chance flood is a common baseline flood.

Nationwide, the primary types of flooding include riverine, coastal, and urban flooding. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within a stream or river. Coastal flooding is typically a result of storm surge, tidal flooding, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, nor'easters, and other large coastal storms. Tidal floods are influenced by tidal variations and are directly related to land elevation and proximity to the coastline. This type of flooding is exacerbated by wind speed and direction, as well as occurrence in conjunction with other types of flooding. Urban flooding occurs when man-made development obstructs the natural flow of water or when impervious surfaces significantly decrease the ability of natural groundcover to absorb and retain surface water runoff.

Flooding is one of the most common hazards that occurs in both the US and Virginia. Between 1957 and 2022, 45 of the 72 federal disaster declarations in Virginia included flood impacts.[liii] Virginia is subject to a variety of flood types, with three major types being: 1) coastal flooding and storm surge associated with large amounts of tidally influenced water being pushed inland; 2) non-tidal, riverine flooding because of excess precipitation in the watershed; and 3) urban flooding where precipitation levels may exceed the design capacity of manmade stormwater conveyances in developed areas and runoff does not naturally absorb into permeable land surfaces.

Coastal Flooding and Storm Surge

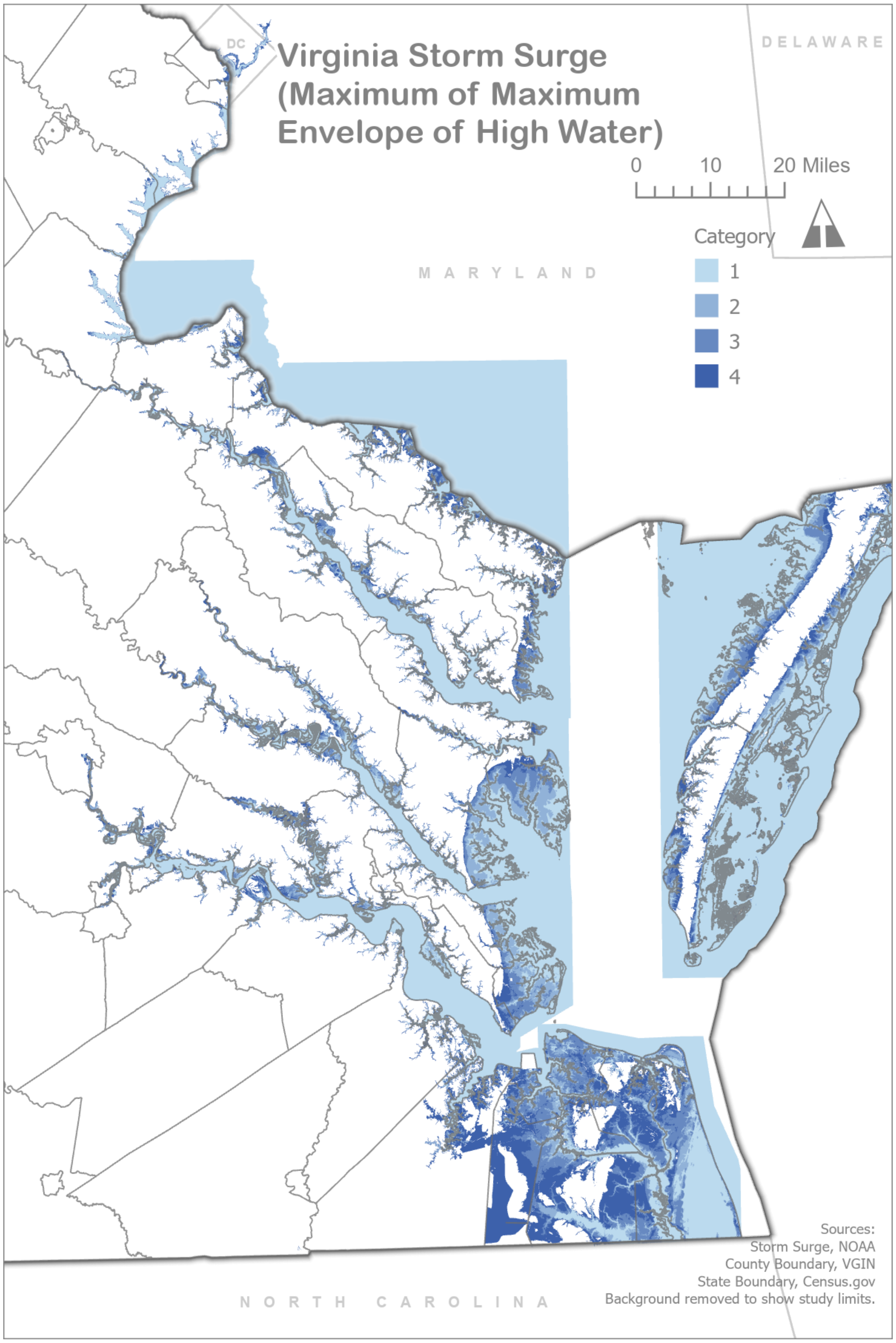
Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides. Storm surge should not be confused with storm tide, which is defined as the water level rise due to the combination of storm surge and the astronomical tide. Storm surge occurs when strong onshore winds push water from an ocean, bay or inlet onto the land. The height of a storm surge and its associated waves can be dependent upon many factors such as the shape of the offshore continental shelf and the depth of the ocean bottom offshore. For example, lower surges tend to result from a narrower continental shelf but can bring higher and more powerful storm waves. Storm surge arrives ahead of a storm or hurricane's actual landfall and will arrive sooner the more powerful the storm event is offshore. In addition, coastal areas experience flooding from overland flow, ponding, and inadequate storm water drainage.

Storm surge may arise from tropical cyclones (hurricanes, tropical storms and tropical depressions) or extratropical coastal storms (nor'easters). In Virginia, all coastal areas are susceptible to storm surge, especially the areas with flat topography and low land elevations. With highly populated and developed communities, the Hampton Roads region is particularly at risk to flood damage. Storm surge hazards also occur during nor'easters, as these coastal storms can be large, slow moving, and of long duration, with heavy rainfall and persistent wind. While the storm surge associated with hurricanes will typically last for a single tide cycle, the surge associated with nor'easters can last for multiple tide cycles.

Like hurricanes, nor’easters are ocean storms capable of causing substantial damage to coastal areas in the Eastern US due to strong winds and heavy surf. Nor'easters are named for the winds that blow in from the northeast and drive storms up the East Coast along the Gulf Stream, a band of warm water that lies off the Atlantic coast. They are caused by the interaction of the jet stream with horizontal temperature gradients and generally occur during the fall and winter months when moisture and cold air are plentiful. Nor’easters are known for dumping heavy amounts of rain and snow, producing hurricane-force winds, and creating high surf that causes severe beach erosion and coastal flooding. The coastal communities of Virginia are most vulnerable to the impacts of nor’easters. Since the storms typically make landfall with less warning than hurricanes (due to their rapid formation along the coast), residents and business owners may be caught unprepared for the impacts.

NOAA and the National Hurricane Center created the Maximum of the Maximum storm surge products, or MOM, provides a worst-case snapshot for a particular storm category. Each MOM considers combinations of forward speed, trajectory, and initial tide level. No single hurricane will produce the regional flooding depicted in the MOMs. Instead, the product is intended to capture the worst-case high-water value at each location for hurricane evacuation planning.[liv] The Chesapeake Bay MOM, Categories 1-4 maximum storm surge extent is depicted in Figure 3-60 below.

Figure 3-60 - Chesapeake Bay Maximum of the Maximum (MOM) Storm Surge for Category 1-4 Hurricane, NOAA



Sea Level Rise

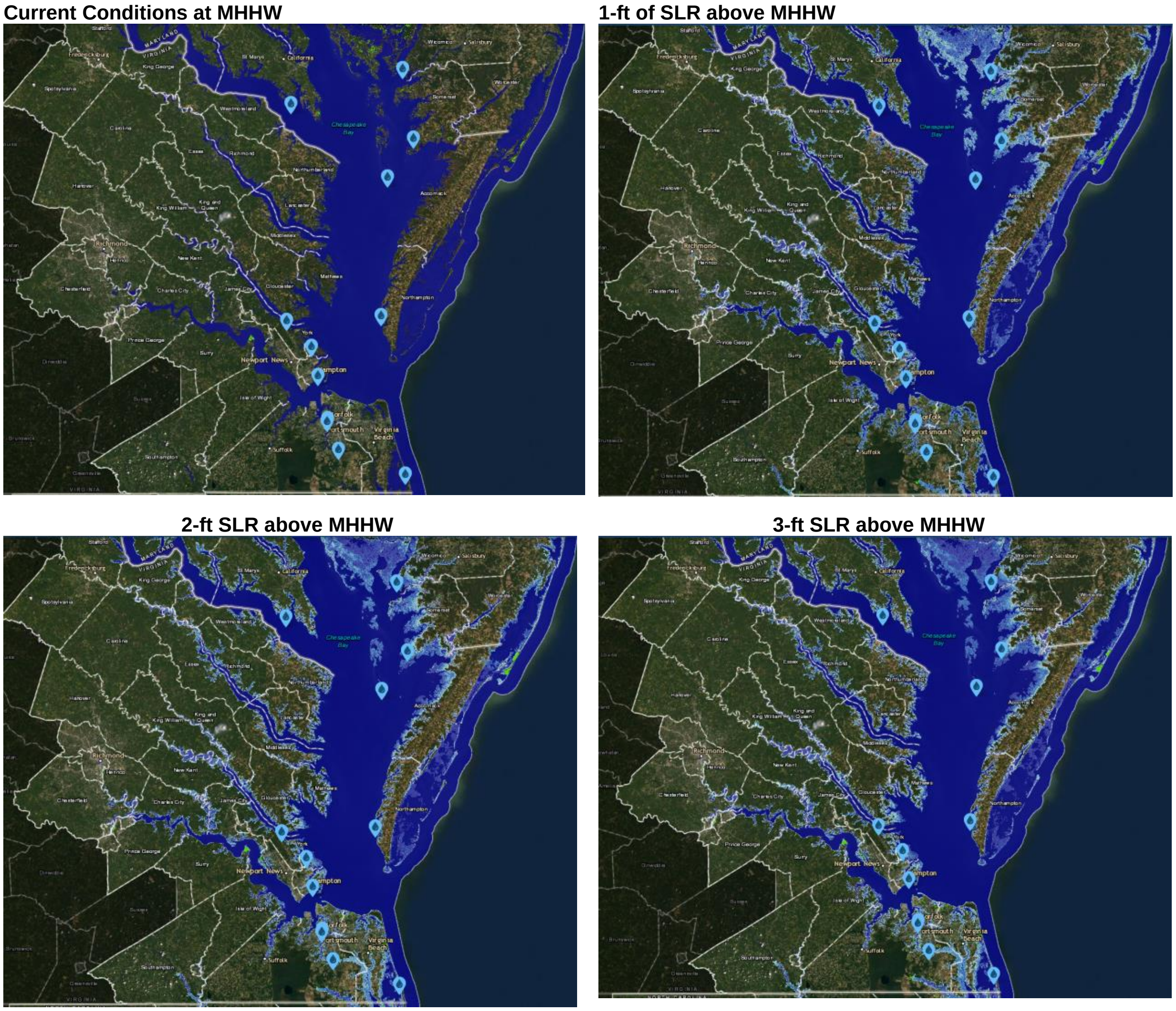
Sea level rise can have potentially major and catastrophic impacts for coastal communities by not only causing inundation of areas not previously inundated with water but by exacerbating other flood hazards. As sea level increases so do the impacts of coastal flooding and storm surge. In

Virginia, the rate of local sea level rise varies depending on effects of water movement in the Gulf Stream as well as land subsidence. '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.[lv] At Sewells Point, NOAA shows a local relative sea level rise (RSL) trend of 1.56 feet per century. However, at the Chesapeake Bay Bridge Tunnel, NOAA shows an RSL trend of 1.94 feet per century.[lvi] The Hampton Roads region generally has the highest rates of sea level rise on the Atlantic Coast, where data indicate that land subsidence has been responsible for more than half the relative sea level rise measured in the region.[lvii]

Several factors are influencing the rates of sea level rise relative to land in the Hampton Roads region, including an increased volume of water in the oceans from melting ice. Some scientists believe that thermal expansion of a gradually warming ocean increases ocean volume. The rate of sea level rise is relative to the land adjacent to the sea; land subsidence is the downward movement of the earth's crust. The Hampton Roads region is experiencing both regional subsidence (along the east coast of the United States) and local subsidence, exacerbating the effects of storms. Subsidence alone can damage wetland and coastal marsh ecosystems and damage infrastructure, but when combined with sea level rise, the effects can be even more devastating.

Sea level rise is a threat associated with climate change and is becoming a larger threat to communities along the coast each year. It is caused primarily by the thermal expansion of the oceans and the loss of land-based ice. Research included in NOAA's Sea Level Rise Report indicates that the rate of sea level rise globally has been accelerating steadily over the past century. However, the rate of acceleration is becoming more and more rapid and will have increasingly more devastating effects on coastal communities over time. NOAA's 2022 Sea Level Rise Technical Report concludes that RSL along the contiguous US coastline is expected to rise, on average, as much over the next 30 years (2020-2050) as it has over the last 100 years (1920-2020). [lviii] Note: the sea level rise projections under 1-, 2-, and 3-feet for the Virginia Coast (Figure 3-61).

Figure 3-61 - Sea Level Rise Projections for the Virginia Coastline under Current Conditions through 3-feet of SLR (NOAA Sea Level Rise Viewer: noaa.gov).



Riverine Flood Hazards

There are 52,232 miles of free-flowing streams and rivers within the Commonwealth. Riverine flooding occurs when rain events or rapid snowmelt add more water into a waterway than it can hold. This causes the water to rise, overtopping the riverbank, and flooding agricultural fields, roads, or populated areas.[lix]

Additional causes of riverine flooding may include features, such as roadways and pipelines, that act as choke points in rivers, blocking debris and restricting the flow of water during heavy flooding events; development of the landscape resulting in the loss of riparian zone and vegetation coverage within watersheds; land management, including forestry and farming practices; and deficiencies in manmade drainage systems.

The periodic inundation of floodplains adjacent to rivers, streams, and shorelines is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. FEMA has studied and mapped both the 1-percent-annual-chance floodplain (also called the Special Flood Hazard Area (SFHA)), and the 0.2-percent-annual-chance for the Commonwealth of Virginia. Figure 3-62 through Figure 3-68 show the SFHAs for all of Virginia by VDEM Region, including both coastal and riverine floodplain mapping.

Figure 3-62 - Overview of FEMA 1-percent Annual Chance Floodplains, Virginia, VDEM Region 1

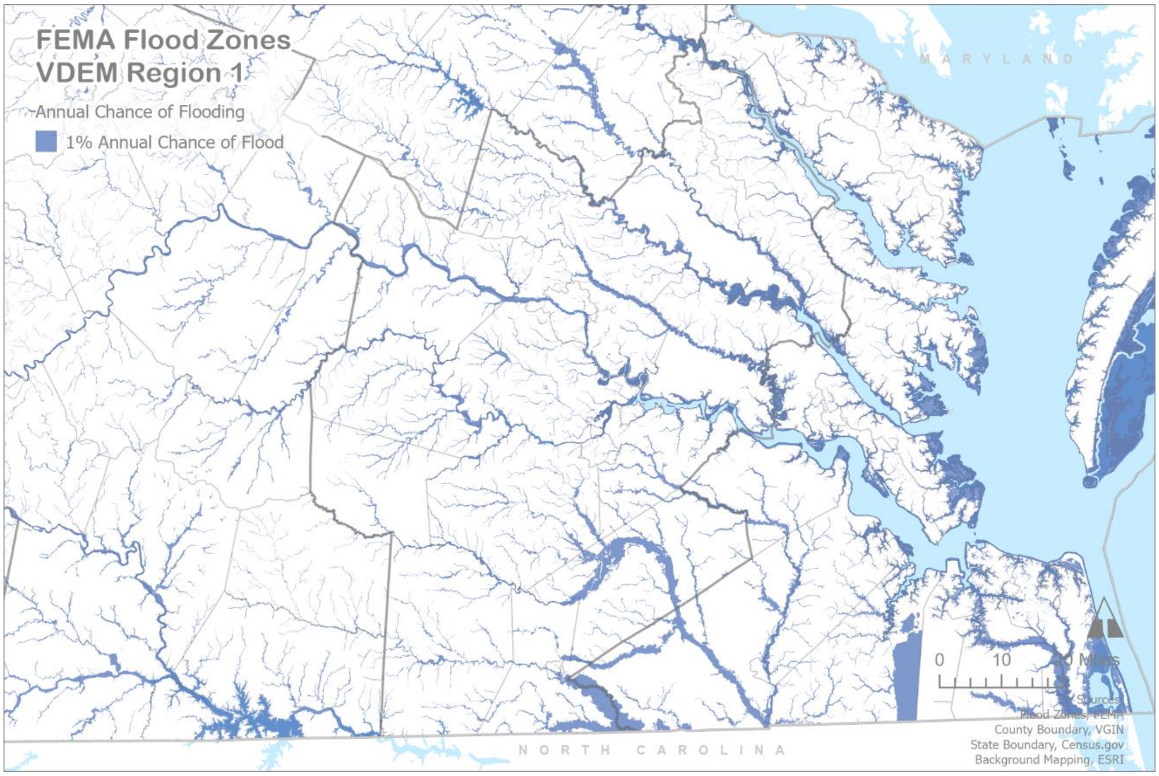


Figure 3-63 - Overview of FEMA 1-percent Annual Chance Floodplains, Virginia, VDEM Region 2

Figure 3-64 - Overview of FEMA 1-percent Annual Chance Floodplains, Virginia, VDEM Region 3

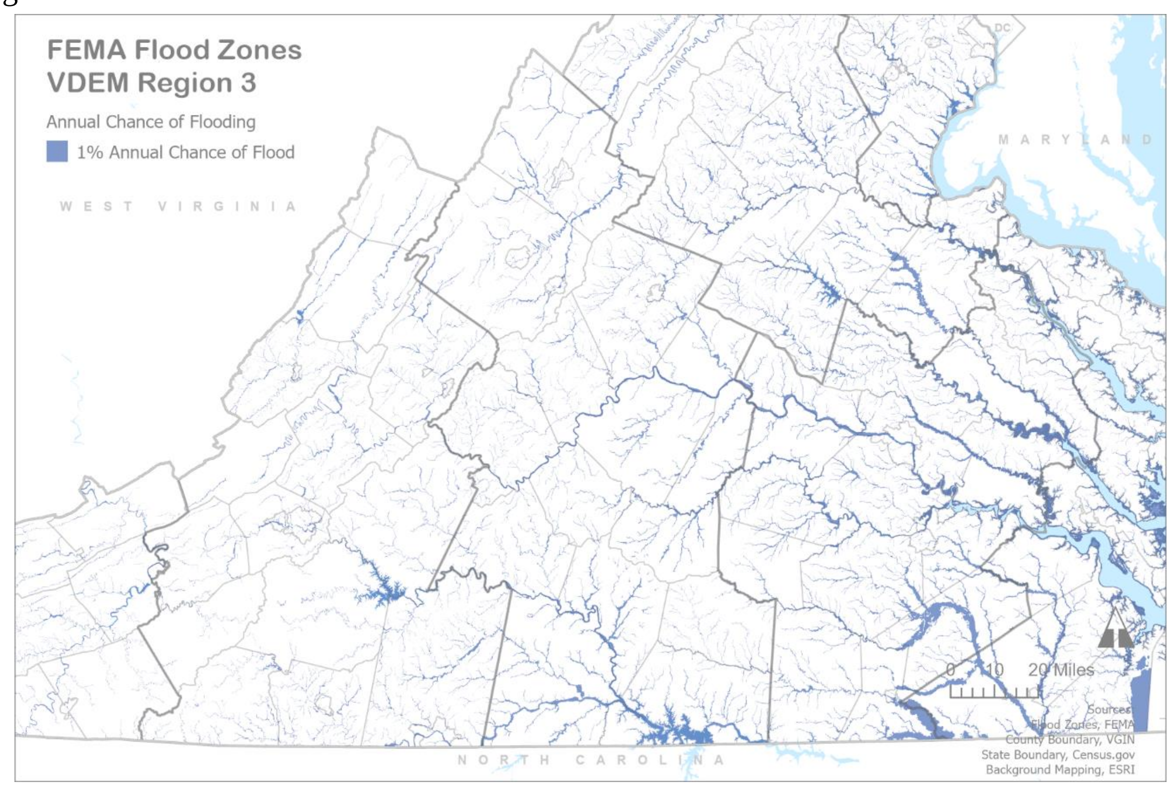


Figure 3-65 - Overview of FEMA 1-percent Annual Chance Floodplains, Virginia, VDEM Region 4

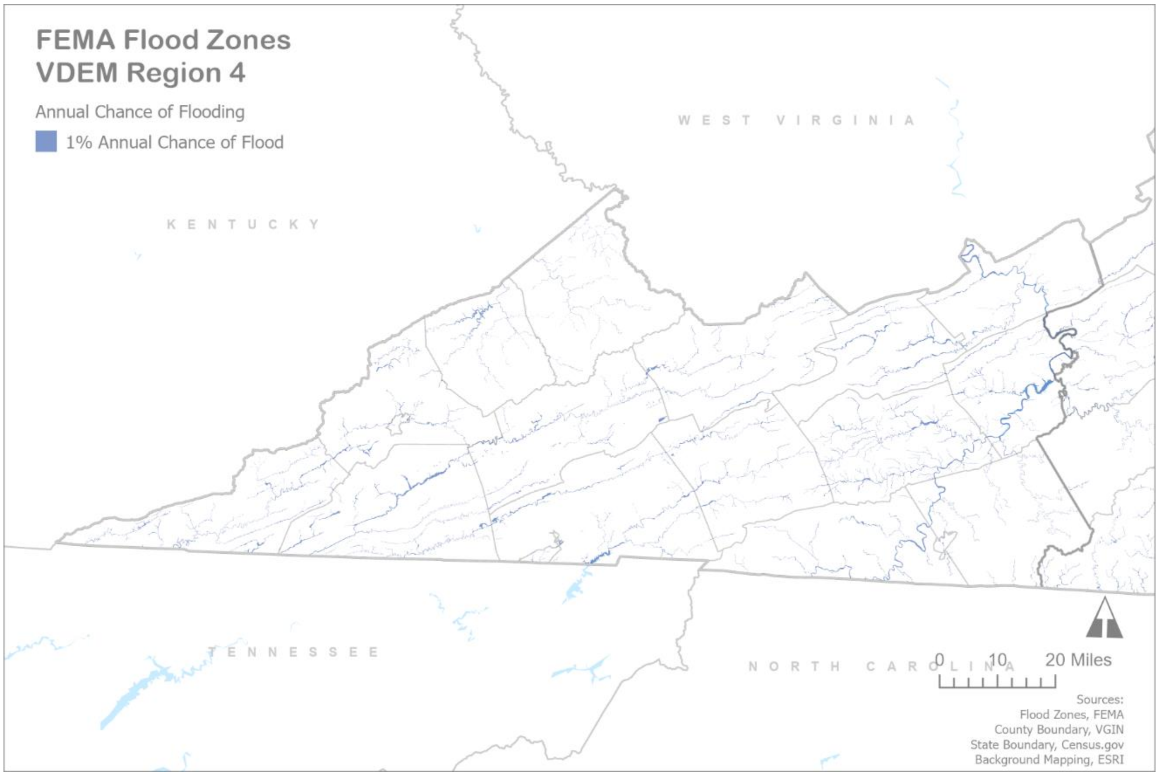


Figure 3-66 - Overview of FEMA 1-percent Annual Chance Floodplains, Virginia, VDEM Region 5

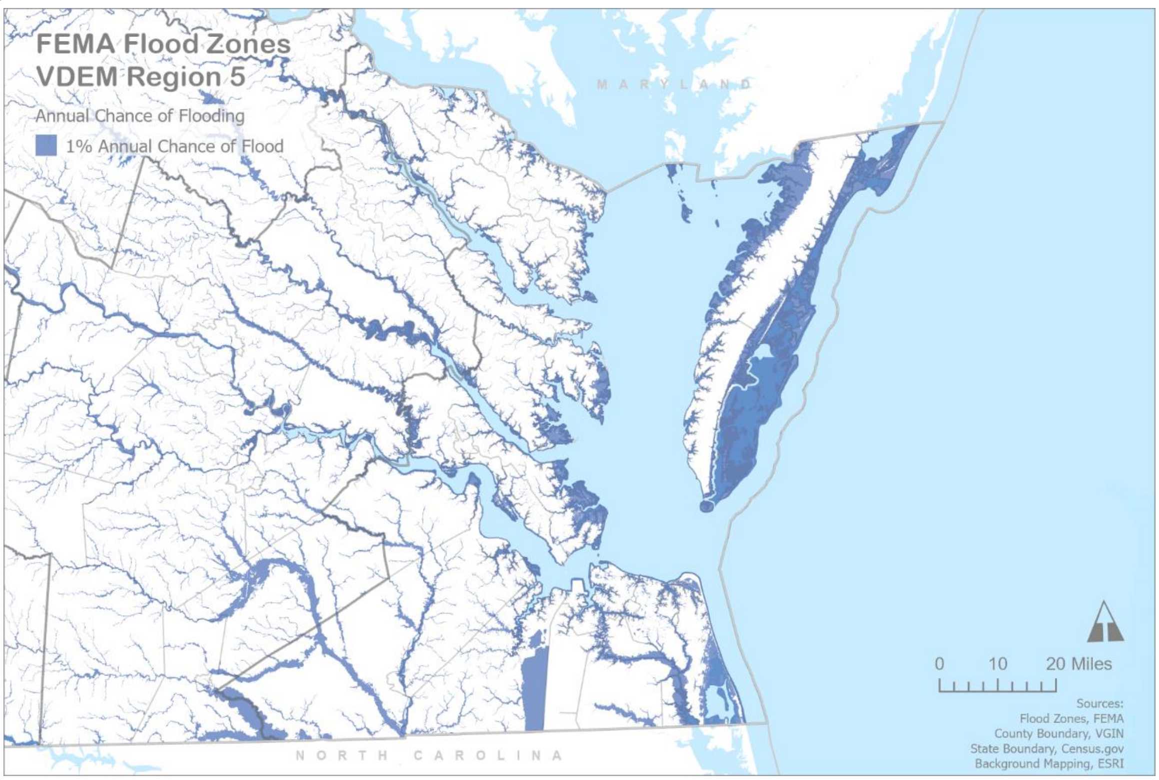


Figure 3-67 - Overview of FEMA 1-percent Annual Chance Floodplains, Virginia, VDEM Region 6

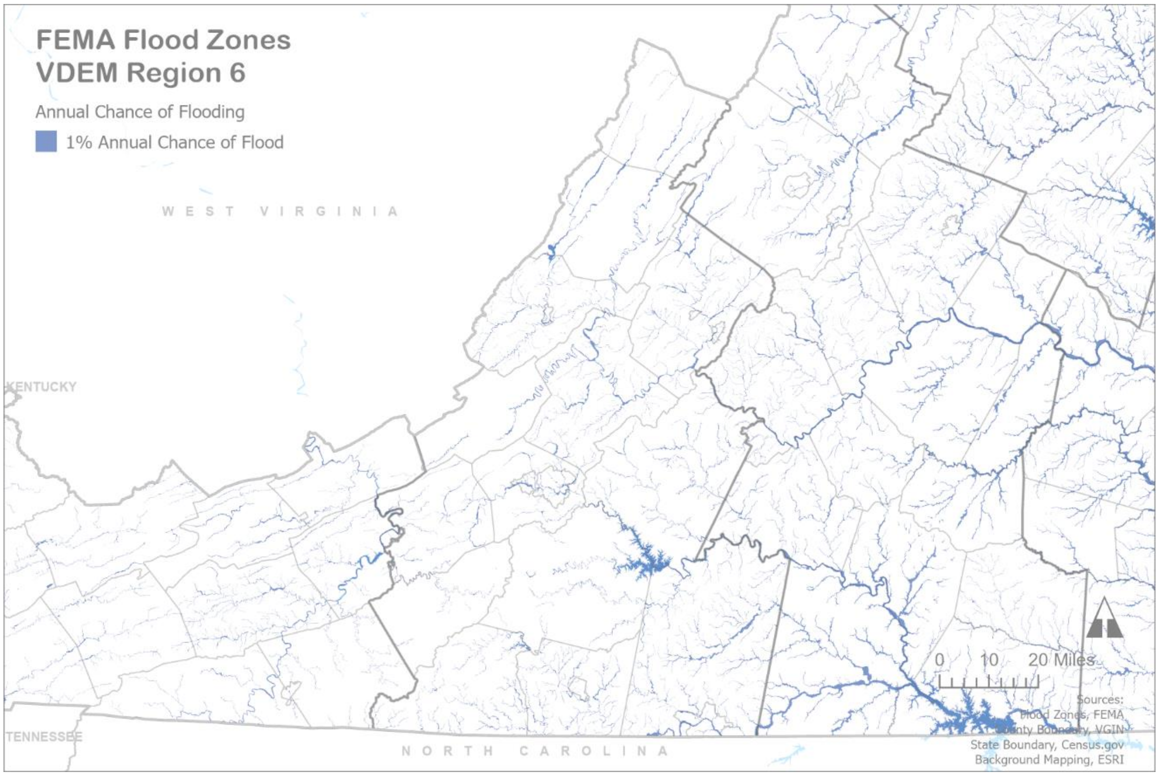


Figure 3-68 - Overview of FEMA 1-percent Annual Chance Floodplains, Virginia, VDEM Region 7

Flash Flood Hazards

Flash floods typically result from large amounts of rain occurring in short periods of time. Heavy rain events can quickly exceed the capacity of the ground to soak up the water, and the receiving streams are unable to contain the water within their banks. Urbanized and developed areas could experience an increase in flash flooding due to the increased number of impervious surfaces. Flash flooding is particularly dangerous in steep mountain valleys or other confined areas where there is little floodplain storage to attenuate the flood volume.

Urban or Storm Water Flooding Hazards

Storm water can be a cause of or a contributing factor to flash or urban flooding. Flooding increases as solid surfaces replace permeable surfaces or natural green spaces, because storm water is unable to filter into the landscape. Impervious cover decreases the amount of rainwater that can naturally infiltrate into the soil, thereby increasing the volume and rate of storm water runoff. Development of the landscape resulting in the loss of riparian zone and vegetation coverage within watersheds; land management, including forestry and farming practices; and deficiencies in man-made drainage systems all contribute to stormwater runoff. Storm water deposits sediment that decreases the depth and flow capacity of waterways (natural and man-made), further increasing flooding. Storm water runoff flooding is most evident in areas where urbanization has occurred. Changes in land use have a major impact on both the quantity and quality of storm water runoff. Urbanization, if not properly managed, can dramatically alter the natural hydrology of an area because it increases impervious cover.

Recurrent or "Nuisance" Flooding

Nuisance flooding is recurrent high-tide flooding with minor impacts. It has increased rapidly since the 1950's, especially along the US East Coast. Scientists further define nuisance flooding as occurring when the water level at a NOAA tidal gauge exceeds the local threshold for minor flooding impacts that has been established by the local Weather Forecasting Offices (WFO) of the NWS. The NWS sets those thresholds through years of flood monitoring. Each location's nuisance flood threshold is reported as height above the long-term average of the daily high tide. Some locations have more than one high tide each day; for those locations, the nuisance flood level is reported relative to the average of the higher of the location's high tides.

Annual occurrences of tidal flooding—exceeding local thresholds for minor impacts to infrastructure—have increased 5- to 10-fold since the 1960s in several US coastal cities. The changes in high tide flooding over time are greatest where elevation is lower, local RSL rise is higher, or extreme variability is less. Figure 3-69 describes a historical increase in frequency of daily flood/inundation events captured at Sewells Point, Virginia Tide Gauge. NOAA Tides and Currents reports that between May 2020 and April 2021, coastal communities saw twice as many high tide flooding days than they did 20 years ago with a trend of near record high tides is expected to continue through April 2022. Figure 3-69 below summarizes the high tide flooding outlooks for each tide station monitored by NOAA along the Virginia coast. By 2030, high tide flooding is likely to be in the range of 7 - 15 days and by 2050, between 25 - 75 days (NOAA, Tides and Currents 2022).

Precipitation flooding

Flooding also occurs when rain intensity exceeds capacity of storm drain systems due to blockages or naturally low-lying areas, especially as sea level rise impacts drainage outfalls to tidal water bodies. Tidal floods are influenced by tidal variations and are directly related to land elevation and proximity to the coastline. Precipitation flooding, combined with nuisance flooding, is occurring in the urbanized, coastal areas of Virginia with increasing regularity and is exacerbated by wind speed and direction, sea level rise and occurrence in conjunction with other types of flooding.

Figure 3-69 - Yearly Inundation Events Recorded at the Sewells Point, Virginia, 1920-Spring 2022

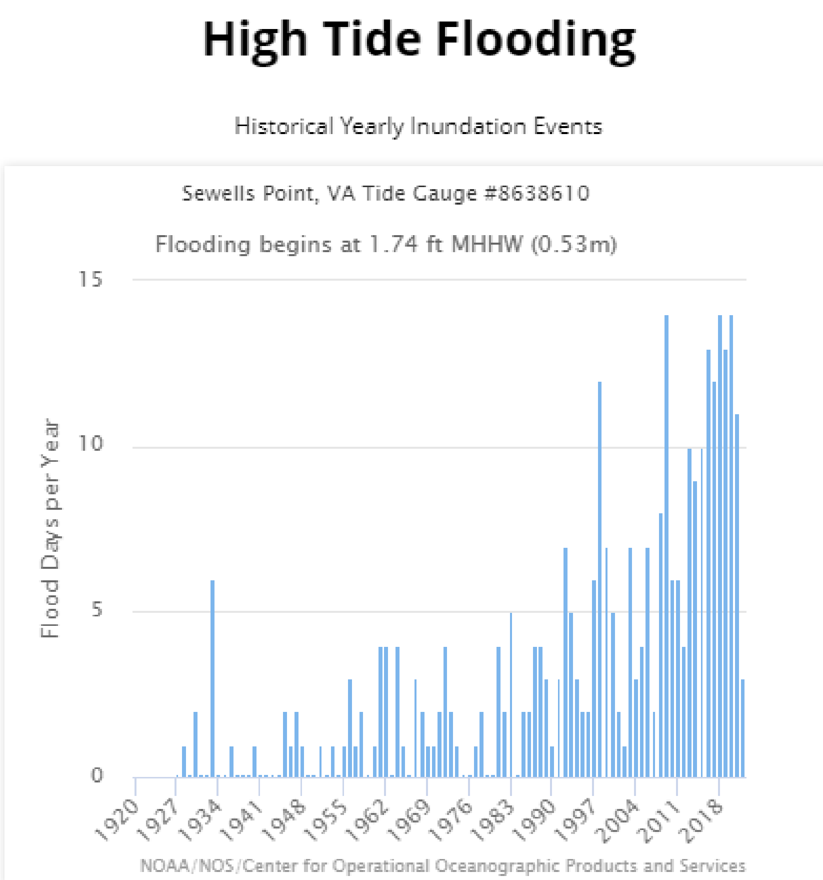
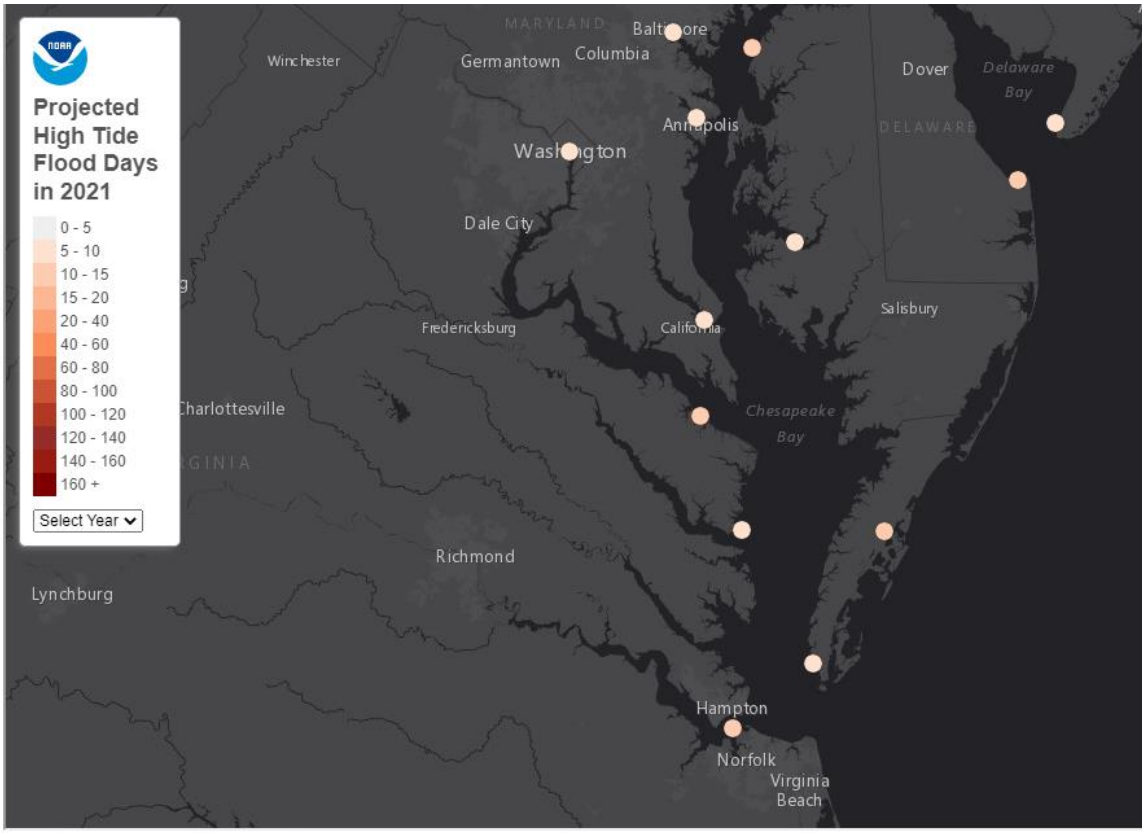


Figure 3-70 - Projected High Tide Flood Days in Virginia for 2021.



3.8.6.2 Location and Spatial Extent

Flooding can occur along all waterways in the state. Localized riverine flooding can occur even in areas not directly adjacent to a major body of water. Within Virginia's coastal watersheds, there are sections of the region that are low in elevation and subject to tidal flooding during hurricanes and severe nor'easters. Flood duration is typically shorter for hurricanes and tropical storms than for nor'easters because the storms tend to move faster and affect only 1 to 2 tidal cycles. The main impacts from flooding include:

- Inundation of low-lying residential neighborhoods and subsequent damage to structures, contents, garages, and landscaping; over time, mold and mildew from flooding can damage building components and mold spores can cause adverse health effects, including allergic reactions.
- Impassable road crossings and consequential risk for people and cars attempting to traverse flooded crossings.
- Damage to public and private infrastructure, possibly including but not limited to water and sewer lines, bridge embankments, and both small and large drainageways.
- Wave action responsible for shoreline damage, and damage to boats and facilities, including ships, ports and shipyards.
- Inundation of critical facilities, possibly including some fire stations, police facilities, public shelters, emergency operations centers (EOC), and several publicly owned buildings. Public shelter availability is limited by the expected severity of flooding.

- Recovery time needed to bring critical infrastructure, schools and employers back online. Of particular concern for Virginia's communities are transportation routes, including school buses, housing for displaced residents and debris management.

Many local communities already have outlined detailed response plans for activating their EOC, protecting critical facilities and taking specific drainage system actions when faced with an impending flood. Since power outages and threats to the water supply can result from both the wind and flood hazard (which may occur simultaneously in some parts of Virginia), residents are advised of appropriate precautions as part of these plans and specific known low-lying areas are evacuated to protect the safety of residents, tourists and responders, and to minimize loss of life.

When severe floods occur in an area, the regional economy can be severely impacted by the inability of flooded homeowners and renters to get back to work quickly, closed or debris-strewn transportation routes, and the closing of schools and businesses. Power outages and boil-water advisories are common and can affect many thousands of residents and businesses in a region for several days or even weeks. Loss of life due to people traversing flooded roads, becoming trapped in flooded structures, or curiosity-seekers is possible. Flooded businesses that decide to close, move or cease operations in the region have an impact on land values and the labor force, as does flood damage to the facilities of large port-related employers. Time spent repairing flood damage versus productive value-added labor is costly to employers.

When extreme rainfall occurs in tandem with sea level rise, the risk of compound flooding is significantly increased.

3.8.6.3 Significant Historical Events

Historical occurrences of flooding have been extensively recorded by local, state and federal agencies. Table 3-46 of significant flood events is based on available records from VDEM, FEMA, the NWS, and local plan narratives.

Table 3-46 - Historical Flood Events from 1862 through 2022

Period of Occurrence	Description
May 1771	A massive flood caused the third floor of the Capitol building in Richmond to collapse, killing 60 people and causing injury to 250.
March 1826	Greatest known flood on Clinch River in Tennessee and far southwest Virginia. (Cumberland Plateau PDC)
February 1862	The Clinch River crested at nearly 23 feet above gauge level at Cleveland. (Cumberland Plateau)
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)
September 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. This flood was due to the remnants of the Cedar Keys Hurricane.
June 1901	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 1902	As the Clinch River flooded, it caused landslides and washouts along railways running through the region. (Cumberland Plateau)

Period of Occurrence	Description
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 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 1907	The Clinch River reached 20 feet above gauge level and caused extensive crop damage (Cumberland Plateau)
January 1918	Clinch River Ice Tide. Major flooding occurred when a storm hit while the ground was covered with snow. (Cumberland Plateau)
May 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 1933	Flooding occurred due to storm surge in the Hampton Roads area from the Chesapeake-Potomac Hurricane, with surges of over 9 feet recorded in Portsmouth. (Chesapeake)
March 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 1937	Heavy rains caused widespread flooding. Damages to roads and bridges approached half a million dollars and agricultural losses exceeded $1 million.
October 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 1940	Because 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 1942	This flood even, due to a tropical storm, is considered one of the worst river floods 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 1955	Hurricane Connie and Hurricane Diane led to heavy rains resulted in flash flooding along the Piedmont and in the Shenandoah Valley
January 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 1962	The Ash Wednesday Storm of 1962 was a nor'easter that caused over $200 million (1962 dollars) in property damage and significant coastal erosion from North Carolina to Long Island[8].
March 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 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 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 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 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.

Period of Occurrence	Description
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)
November 1985	Election Day Flood described earlier in the discussion on federal disaster declarations.
September 1987	Henry County. Severe flooding primarily in the Bassett, Stanleytown, Collinsville, and Fieldale areas. Approximately 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 1992	A significant flood occurred in Giles County as the result of 6 inches of rainfall. (New River Valley)
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 1996	The Great Melt Down described earlier in the discussion on federal disaster declarations (Section 3.4).
September 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 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 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 1999	Hurricane Floyd described earlier in the discussion on federal disaster declarations (Section 3.4).
June 2000	Several roads within the county were washed out as a result of flash flooding in Southampton County. (City of Franklin)
September 2000	Fredericksburg - A flash flood hit the city after more than two 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 2001	Thunderstorms in Tazewell County caused flash flooding, which resulted in an estimated $15 Million in damages.
March 2002	Floods caused a state of emergency declaration for southwest Virginia. (Mt Rogers PDC).
April 2002	Severe storms and flooding occurred in Smyth, Washington, and Wythe Counties. (Mt Rogers PDC).
July 2002	A flash flood affected the Town of Pembroke (Giles County) causing $367,000 in damages and closing Route 460. (NRV PDC)
May 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 federal disaster declarations (Section 3.4).
2004	Tropical Depression Gaston described earlier in the discussion on federal disaster declarations (Section 3.4).
June 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 federal disaster declarations (Section 3.4).
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 stage is 12 feet).
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.

Period of Occurrence	Description
November 2009	Severe storms and flooding associated with Tropical Depression Ida and a November nor'easter described in the discussion of federal disaster declarations (Section 3.4). This should not be confused with Hurricane Ida that occurred in 2021.
August 2011	Flooding associated with Hurricane Irene described in the discussion of federal disaster declarations (Section 3.4).
September 2011	Flooding associated with remnants of Tropical Storm Lee described in the discussion of federal disaster declarations (Section 3.4).
October 2012	Hurricane Sandy caused heavy rainfall and flooding along Virginia's Eastern Shore. Severe coastal flooding and storm surge inundated many areas along the coast as the storm moved north, causing millions of dollars in damages to residences and businesses.
May 2014	A storm system with periods of moderate to heavy rainfall and the possibility of severe thunderstorms capable of producing damaging winds began moving through the Commonwealth late on May 15 and was forecast to exit the Commonwealth late 16 May. Bands of moderate to moderate to heavy rainfall moved out of Virginia with light rain showers forecast to continue until late this afternoon/early evening across areas of northwest Virginia, northern Virginia, central Virginia, and eastern Virginia. Over a 24-hour period, southwest and west central Virginia received 2 to 4 inches of rain, northwest and northern Virginia received 3 to 5 inches of rain, and central and eastern Virginia received 2 to 4 inches of rain which has resulted in flooding of multiple primary and secondary roads across Virginia. There were multiple urban area and small streams Flood Warnings in effect across Virginia.
September 2014	Areas of Southeast Virginia were impacted by rain from a low-pressure system that began on Monday, 8 September and to 9 September. Roadways and two apartment complexes were affected by flooding and rising waters. Rainfall amounts range from four to eight inches with locally higher amounts up to 10-12 inches.
March 2015	Snow melt and rainfall combined to cause flooding in areas of Southwest Virginia. The City of Norton, Dickenson County, Tazewell County, Buchanan County, and Wise County and the towns of Big Stone Gap, Pound, and Coeburn reported rivers, streams, and creeks approaching flood stage, with some flooding and rockslides occurring into roadways.
July 2015	Scattered thunderstorms began impacting much of the Commonwealth as a cold front moved into the area beginning July 5th. These storms brought 2-3 inches of rainfall in 24 hours to the southwestern portion of the state resulting in flooding in Tazewell County. Pocahontas, Boissevain, and Abbs Valley areas were the primary areas of impact. On July 13, 2015, scattered thunderstorms and a line of severe thunderstorms brought 2-4 inches of rainfall resulting in flash flooding in Shenandoah County and the surrounding area.
June 2016	The Governor issued a State of Emergency declaration for record flooding of the Jackson River Watershed. The Jackson River crested more than five feet above flood stage on June 23, 2016. Most of downtown Covington was evacuated, and shelters were established. This event was part of a large storm system that also devastated parts of neighboring West Virginia.
October 2016	Hurricane Matthew affected areas from Southern Florida to Southeast Virginia. Heavy rains spread inland through Virginia. 14.21 inches of rainfall was reported in the southeastern portion of the commonwealth. NCEI reports 21.2 million in property damage and 2.3 million in crop damage.
October 2018	Flash Flooding – NCEI reports 13.2M property damage in Pittsylvania, Danville, Halifax and Charlotte Counties.
June 2019	Flash Flooding - Slow moving thunderstorms produced intense rainfall of 4 to 6 inches resulting in flash flooding on June 7th. Impacted portions of Chesapeake and Norfolk.
August 2019	Flash Flooding - Thunderstorms produced heavy rain which caused flash flooding. Impacted portions of Norfolk, Chesapeake, and Virginia Beach
September 2019	Very strong northeast to north winds associated with Hurricane Dorian produced tidal anomalies between 2.5 and 3.5 feet over the southern Chesapeake Bay. This caused moderate coastal flooding over portions of the study area. Sewells Point reached 5.87 feet MLLW at 342 pm on September 6. Impacted portions of Norfolk, Virginia Beach, York County, and Surry County.
June 2020	Flash Flooding - In Portsmouth, total rainfall of 3.38 inches was reported, with 3.00 inches of rain reported in one hour. Several roads were flooded. Impacted York County and James City County.
July 2020	Flash Flooding - Total rainfall between 3.37 inches and 4.05 inches was reported across the area. Impacted Virginia Beach City.
August 2020	Coastal Flooding - Strong south to southeast winds associated with Tropical Storm Isaias resulted in moderate (perhaps some locally major) tidal flooding over portions of Virginia Beach adjacent to Back Bay.
September 2020	Flash Flooding - Post Tropical Cyclone Sally tracking northeast across the Southeast US and off the Mid Atlantic Coast produced heavy rain which caused flash flooding across portions of southeast Virginia. Impacted communities included James City County, Virginia Beach City, Isle of Wight County, and Portsmouth.

Period of Occurrence	Description
November 2020	Flood, Flash Flooding - Deep tropical moisture streaming northward into the mid-Atlantic region combined with the approach of a cold front and low pressure, produced heavy rain which caused flash flooding across portions of central and southeast Virginia. Impacted communities included: Isle of Wight County, Hampton, Norfolk, Chesapeake, York County, Surry County, Southampton County, Newport News, Williamsburg, James City County, Virginia Beach, Suffolk, Portsmouth, and Franklin.
January 2022	Coastal "Tidal or Nuisance" Flooding - A combination of higher astronomical tides and deepening surface low pressure tracking across North Carolina then northeast out to sea, produced very strong northeast or north winds which caused moderate (tidal) coastal flooding over portions of Accomack County adjacent to the Atlantic coast. Wachapreague reached 7.69 feet MLLW at 906 am on Monday, January 3.
January 2022	Flooding - Deep moisture from the Gulf of Mexico pooled ahead of a slow-moving cold front during January 1st into the early morning hours of January 2nd. Precipitable water values across the upper Clinch River Basin were observed to be more than 1.3 inches, which is several standard deviations above the normal value for early January in western Virginia. This deep moisture resulted in rainfall amounts ranging between 1.87 and 2.10 inches fell across the upper Clinch River basin along Highway 460, with close to 3 inches of rain observed near the community of Jewell Ridge in the northern portion of the basin. All this rain fell during a 7-to 8-hour period, with rainfall rates seldom exceeding 0.5 inches per hour. Antecedent conditions prior to the event were unusually dry, with low streamflows along the Clinch River and its tributaries, low soil moisture and ground that was not frozen due to unusually warm temperatures through the month of December. This rainfall resulted in minor flooding along the Clinch River.

Reducing the number of repetitive loss (RL) properties insured by the NFIP is a nationwide emphasis of FEMA. The NFIP defines an RL as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978.[lx] A repetitive loss property may or may not be currently insured by the NFIP. There are 6,893 RL properties in the Commonwealth as of 2021. The repetitive loss properties, clustered into repetitive loss areas with other known or suspected flood-prone parcels, are shown by VDEM Region within the 1-percent and 0.2-percent floodplains in Figure 3-71 to Figure 3-77.

Figure 3-71 - Repetitive Loss Areas within VDEM Region 1.

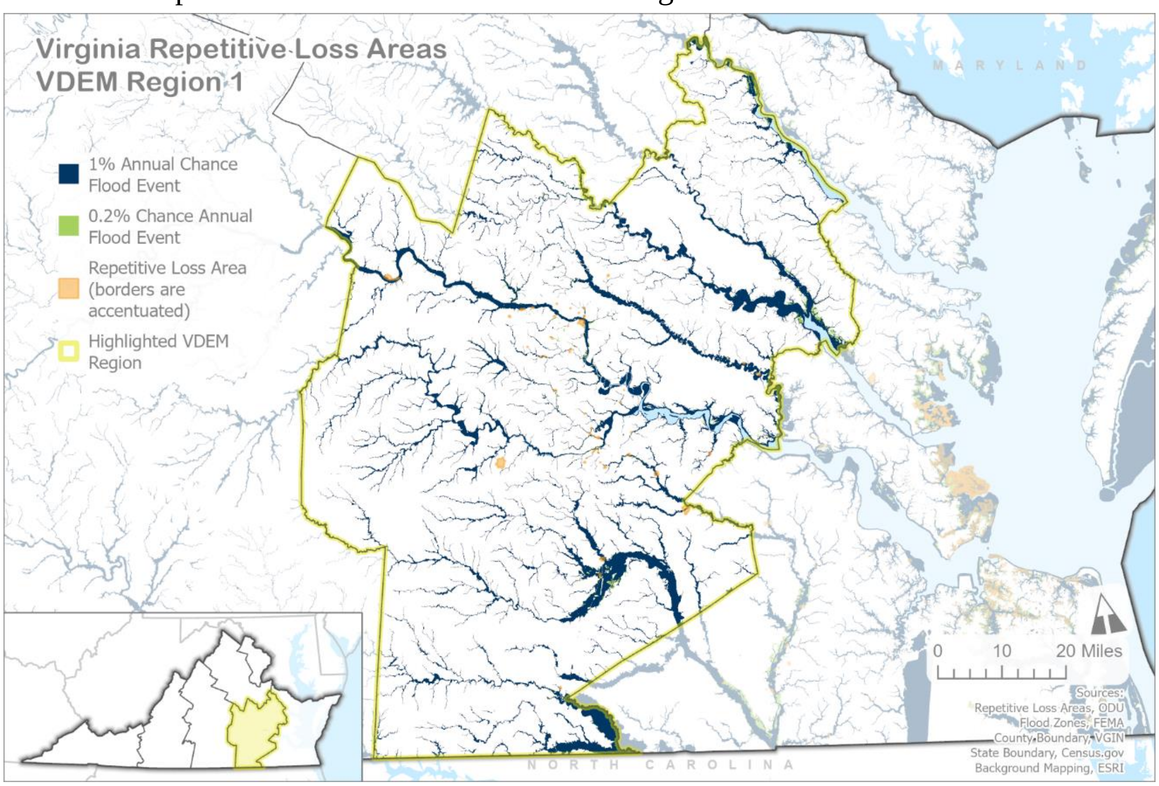


Figure 3-72 - Repetitive Loss Areas within VDEM Region 2.

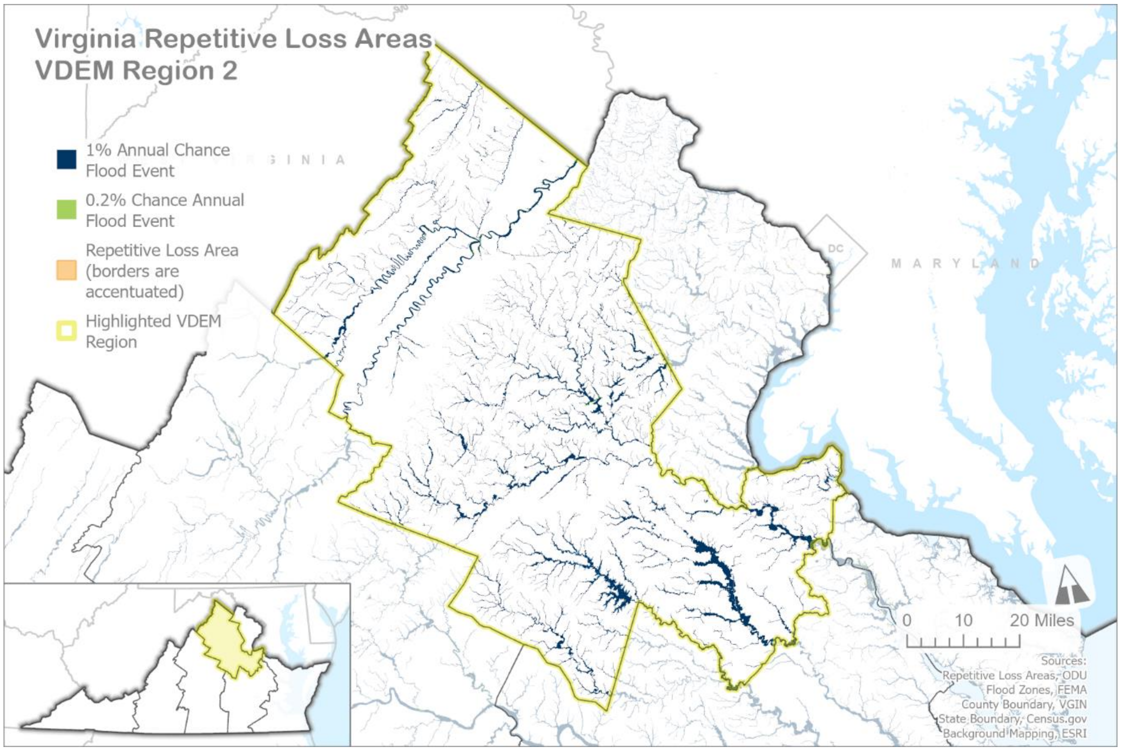


Figure 3-73 - Repetitive Loss Areas within VDEM Region 3.

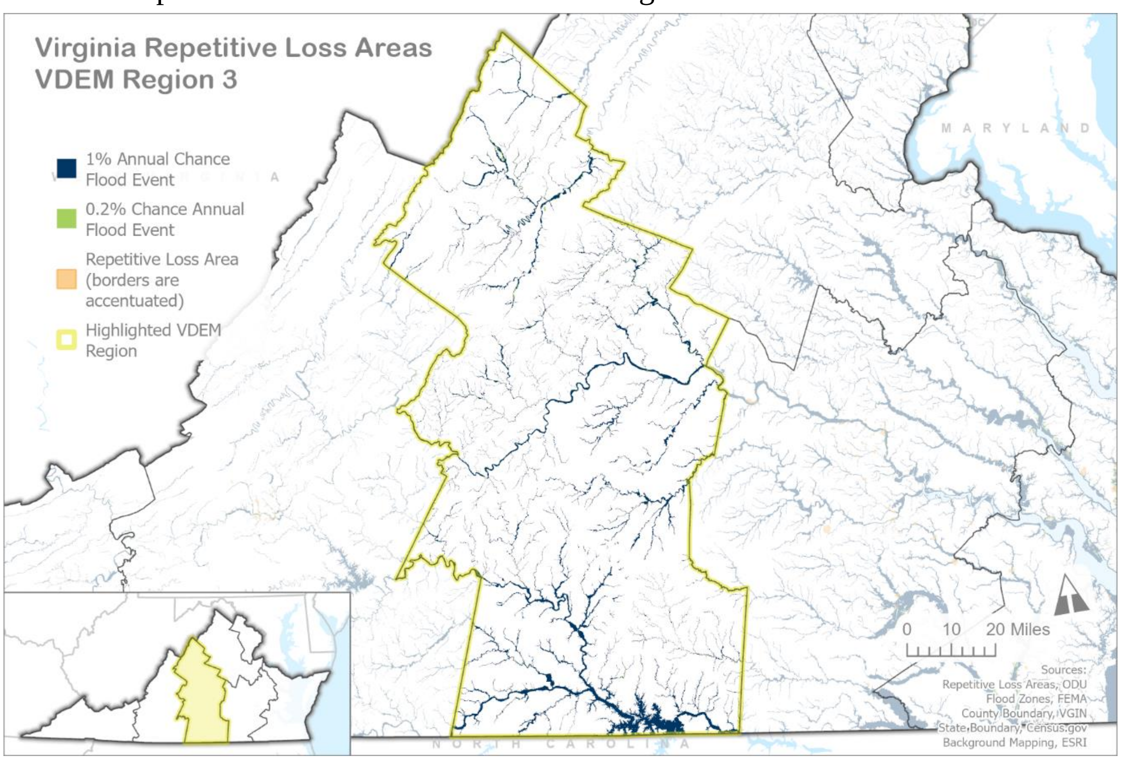


Figure 3-74 - Repetitive Loss Areas within VDEM Region 4.

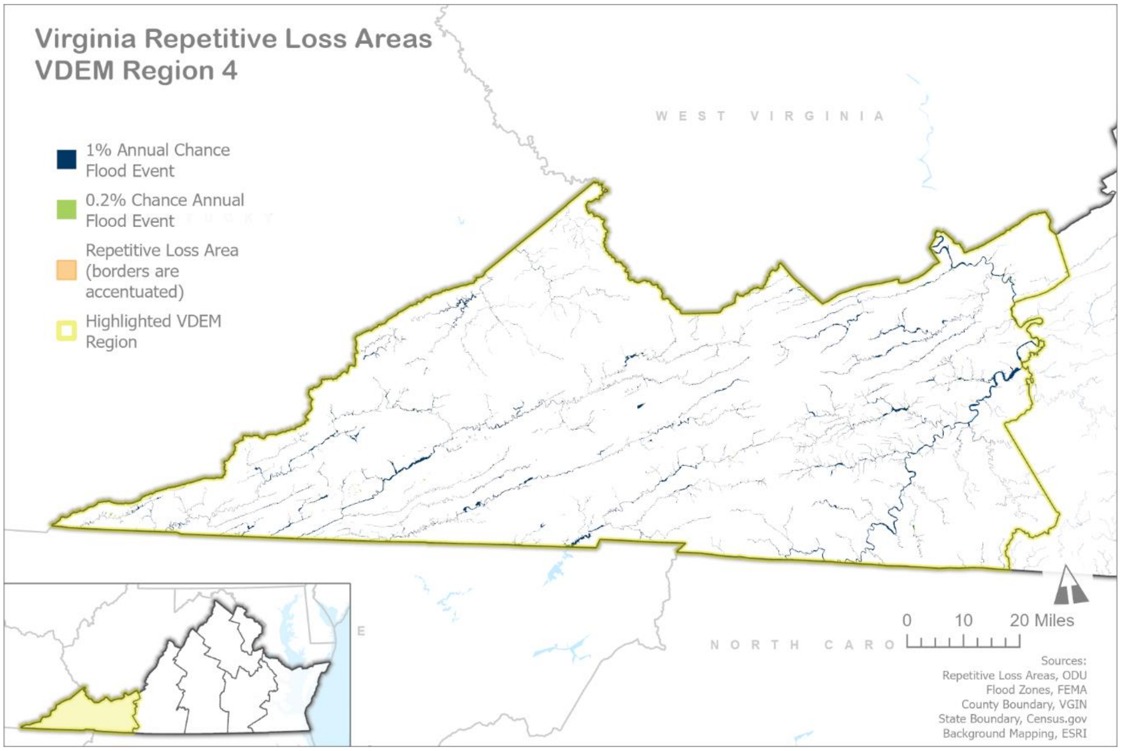


Figure 3-75 - Repetitive Loss Areas within VDEM Region 5.

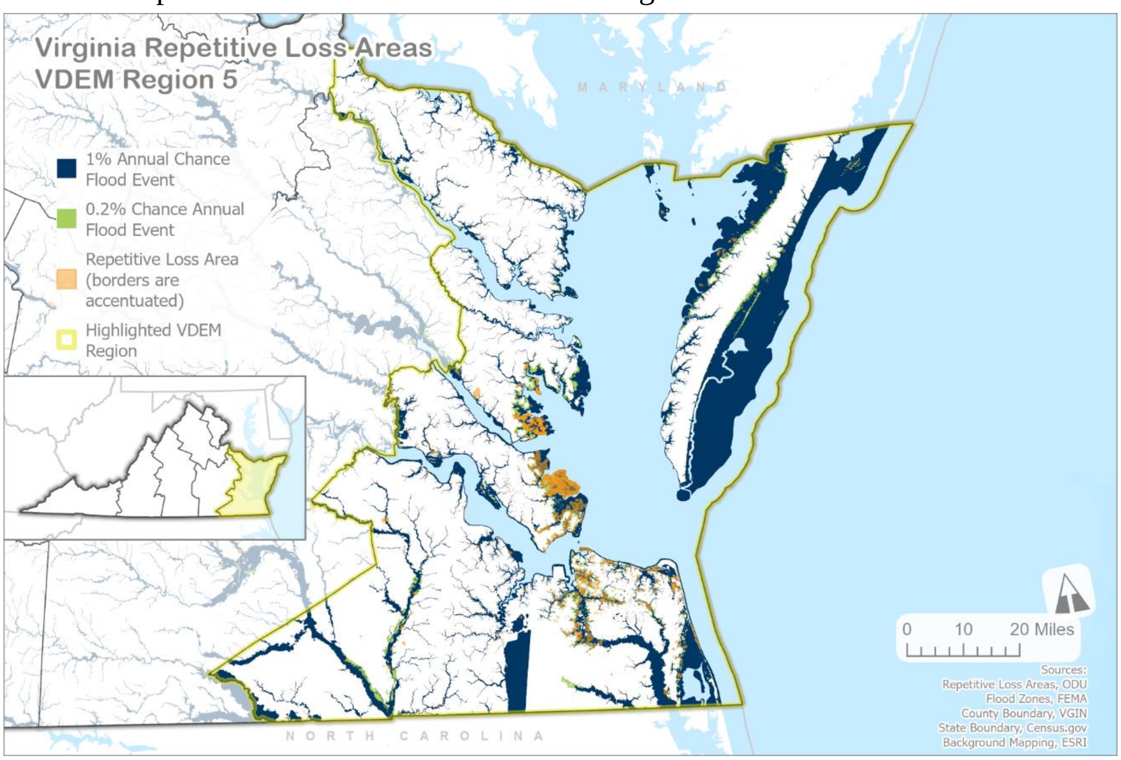


Figure 3-76 - Repetitive Loss Areas within VDEM Region 6.

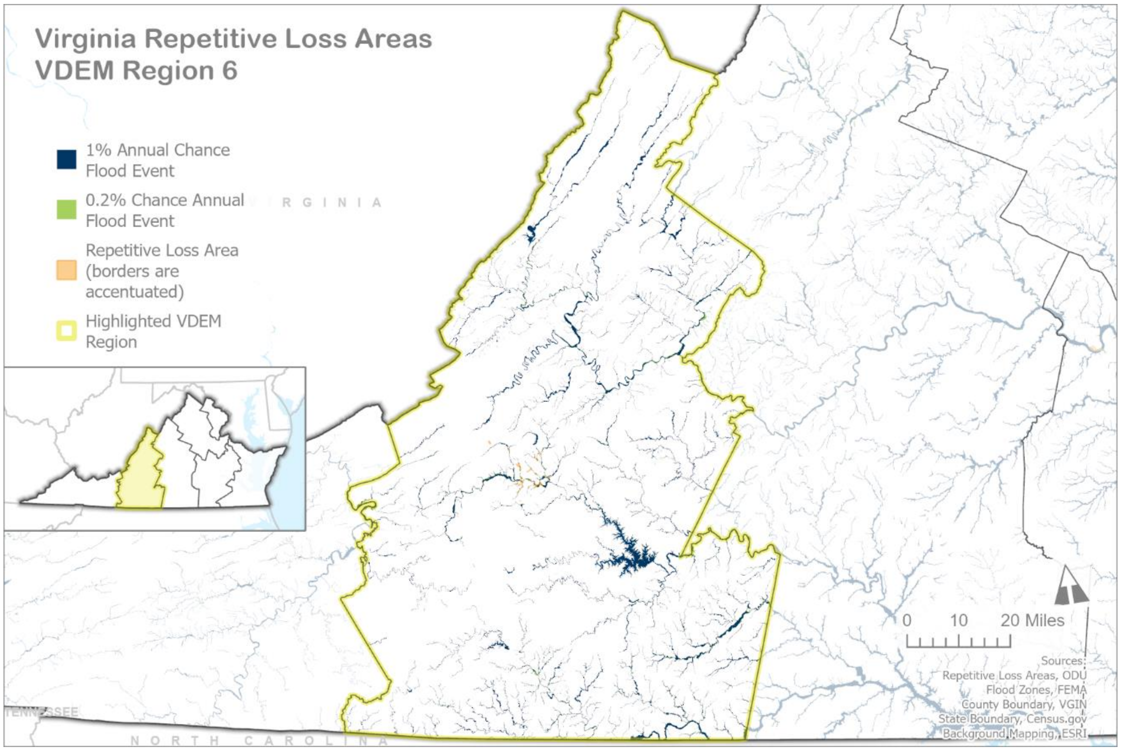


Figure 3-77 - Repetitive Loss Areas within VDEM Region 7.

Additional analyses conducted for the purposes of this HIRA identified the designated repetitive flood loss areas statewide with Relatively High or Very High NRI risk ratings for either coastal or riverine flooding. The communities affected include: Accomack County, Chincoteague, Tangier Island, Chesapeake, Isle of Wight County, James City County, Loudoun County, Petersburg, Colonial Heights, Poquoson, Portsmouth, Prince William County, Roanoke County, Stafford County, Surry County, Sussex County and Stony Creek, Suffolk, Manassas and Alexandria. Analysis to rank the state's repetitive flood loss areas by estimated percent of flood insurance coverage for parcels in FEMA-designated 100-year floodplains is ongoing. Preliminary results indicate that the socially vulnerable communities with repetitive flood loss areas having the lowest estimated percentage of insurance policies for flood-prone structures are: Sussex County (2%), Surry County (3%), Loudoun County and Stony Creek (6%), Prince William County (7%), Petersburg (8%), Accomack County (9%), and Roanoke County (10%).

NFIP data indicate that a total of 5,573 claims have been paid for a total of $66,420,200 between 1978 and 2021 (Table 3-47).

Table 3-47 - Total NFIP Policies and Claims Paid (1978- 2021), Alphabetical by Jurisdiction

Jurisdiction	Policy Count	Claims	Net Claim Payment (rounded)
Abingdon, Town of	19	7	$154,700
Accomac, Town of	2		$ -
Accomack County	1189	805	$9,609,800
Albemarle County	211	55	$463,500
Alexandria, City of	1105	427	$7,770,100
Alleghany County	152	206	$2,967,900
Altavista, Town of	5	10	$233,900
Amelia Count	5	12	$190,900
Amherst County	34	30	$1,333,600
Amherst, Town of	1	35	$132,100
Appalachia, Town of	13	12	$22,900
Appomattox County	5	9	$256,100
Appomattox, Town of	2		$ -
Arlington County	697	208	$1,627,200
Ashland, Town of	43	8	$22,000
Augusta County	202	166	$2,053,900
Bath County	28	17	$169,000
Bedford County	98	38	$313,400
Bedford, Town of	14	1	$18,300
Belle Haven, Town of	2		$ -
Berryville, Town of	20	7	$134,400
Big Stone Gap, Town of	25	62	$345,700
Blacksburg, Town of	29	9	$20,300
Blackstone, Town of	1	1	$2,600
Bland County	43	58	$691,500
Bluefield, Town of	40	105	$777,600
Boones Mill, Town of	4	3	$10,700
Botetourt County	136	210	$2,582,400

Jurisdiction	Policy Count	Claims	Net Claim Payment (rounded)
Boykins, Town of	5		$ -
Bridgewater, Town of	41	44	$425,600
Bristol, City of	35	19	$109,800
Broadway, Town of	9	12	$128,100
Brookneal, Town of	3	3	$37,800
Brunswick County	16	8	$13,600
Buchanan County	159	213	$1,506,600
Buchanan, Town of	21	57	$1,721,600
Buckingham County	12	9	$21,400
Buena Vista, City of	40	247	$4,352,900
Campbell County	40	20	$558,100
Cape Charles, Town of	167	14	$95,100
Caroline County	65	5	$22,200
Carroll County	23	21	$194,000
Cedar Bluff, Town of	19	11	$54,100
Charles City County	21	8	$51,300
Charlottesville, City of	92	46	$410,400
Chatham, Town of	1		$ -
Chesapeake, City of	7413	2578	$27,110,800
Chesterfield County	820	222	$3,380,600
Chilhowie, Town of	12	40	$226,700
Chincoteague, Town of	1590	141	$959,300
Christiansburg, Town of	19	14	$304,400
Claremont, Town of	15	34	$1,273,700
Clarke County	33	34	$596,100
Clarksville, Town of	1	1	$1,000
Cleveland, Town of	3	15	$95,400
Clifton Forge, Town of	14	9	$78,400
Clifton, Town of	4	3	$49,000
Clinchco, Town of	4		$ -
Clinchport, Town of		1	$ -
Coeburn, Town of	11	31	$453,200
Colonial Beach, Town of	160	88	$3,584,600
Colonial Heights, City of	73	81	$1,221,800
Columbia, Town of		9	$40,300
Courtland, Town of	24	5	$39,400
Covington, City of	92	200	$1,774,900
Craig County	41	96	$1,325,400
Craigsville, Town of	27	22	$246,000
Culpeper County	42	27	$577,700
Culpeper, Town of	26	6	$104,700
Cumberland County	8	4	$20,500
Damascus, Town of	19	10	$11,900
Danville, City of	83	146	$4,826,500
Dayton, Town of	8	2	$2,600

Jurisdiction	Policy Count	Claims	Net Claim Payment (rounded)
Dickenson County	16	85	$350,800
Dinwiddie County	31	2	$12,000
Drakes Branch, Town of		1	$1,700
Dublin, Town of	1		$ -
Dumfries, Town of	16	10	$34,800
Edinburg, Town of	5	9	$241,700
Elkton, Town of	23	8	$73,800
Emporia, City of	31	12	$21,000
Essex County	168	236	$6,192,000
Exmore, Town of	6	6	$82,700
Fairfax County	4041	1293	$14,154,400
Fairfax, City of	138	57	$952,100
Falls Church, City of	166	74	$657,000
Farmville, Town of	24	47	$744,400
Fauquier County	118	19	$119,700
Floyd County	17	22	$751,600
Fluvanna County	43	13	$189,900
Franklin County	76	33	$676,900
Franklin, City of	99	98	$5,312,400
Frederick County	102	54	$502,500
Fredericksburg, City of	115	42	$260,400
Front Royal, Town of	79	104	$1,476,600
Galax, City of		2	$3,200
Gate City, Town of	5	2	$63,400
Giles County	56	55	$1,075,900
Glade Spring, Town of	1	1	$4,300
Glasgow, Town of	20	92	$1,217,700
Gloucester County	1371	1346	$30,595,700
Goochland County	51	11	$126,600
Goshen, Town of	3	16	$910,400
Grayson County	23	6	$14,600
Greene County	60	27	$172,300
Greensville County	13	6	$28,100
Grottoes, Town of	26	6	$77,700
Grundy, Town of	28	105	$1,519,100
Halifax County	11	127	$565,700
Hallwood, Town of		1	$4,900
Hampton, City of	8417	5742	$74,815,600
Hanover County	185	28	$359,900
Harrisonburg, City of	78	30	$469,300
Haymarket, Town of	2	2	$1,700
Haysi, Town of	5	23	$101,100
Henrico County	787	304	$3,614,800
Henry County	73	178	$2,931,600
Herndon, Town of	61	16	$19,400

Jurisdiction	Policy Count	Claims	Net Claim Payment (rounded)
Highland County	17	6	$55,000
Honaker, Town of	3		$ -
Hopewell, City of	29	17	$145,900
Hurt, Town of		1	$275,000
Independence, Town of	1		$ -
Iron Gate, Town of	1	3	$100
Irvington, Town of	6	14	$268,200
Isle of Wight County	272	145	$4,729,400
James City County	875	360	$6,339,900
Jonesville, Town of		3	$9,700
Kilmarnock, Town of	2	1	$12,300
King And Queen County	53	23	$632,200
King George County	60	13	$48,900
King William County	10	6	$46,800
Lancaster County	504	372	$5,677,200
Lawrenceville, Town of	2	4	$20,800
Lebanon, Town of	7	2	$ -
Lee County	33	37	$264,200
Leesburg, Town of	90	10	$147,100
Lexington, City of	12	37	$407,200
Loudoun County	565	153	$1,839,100
Louisa County		3	$3,100
Lovettsville, Town of	4		$ -
Lunenburg County	1		$ -
Luray, Town of	26	52	$1,035,100
Lynchburg, City of	73	128	$3,575,600
Madison County	37	18	$126,600
Manassas Park, City of	16	8	$99,700
Manassas, City of	64	34	$241,500
Marion, Town of	13	30	$193,000
Martinsville, City of	7	25	$372,700
Mathews County	1206	1219	$21,367,600
Mc Kenney, Town of	1		$ -
Mecklenburg County	35	5	$10,400
Middleburg, Town of	4	1	$1,600
Middlesex County	320	227	$2,985,100
Middletown, Town of	4	1	$33,400
Monterey, Town of	2		$ -
Montgomery County	124	151	$1,487,400
Mount Jackson, Town of		4	$193,200
Mt. Crawford, Town of		2	$9,700
Narrows, Town of	10	9	$34,600
Nassawadox, Town of	2	1	$4,200
Nelson County	83	36	$239,800
New Castle, City of	2	4	$32,400

Jurisdiction	Policy Count	Claims	Net Claim Payment (rounded)
New Kent County	103	31	$517,300
New Market, Town of	2	2	$64,900
Newport News, City of	1646	994	$23,239,300
Norfolk, City of	8436	5935	$68,408,900
Northampton County	247	84	$1,009,800
Northumberland County	652	401	$7,168,400
Norton, City of	22	24	$146,600
Nottoway Count	1		$ -
Occoquan, Town of	20	19	$61,000
Onancock, Town of	29	2	$14,000
Onley, Town of	1		$ -
Orange County	53	16	$132,400
Orange, Town of	2		$ -
Page County	111	125	$2,380,500
Parksley, Town of	2		$ -
Patrick County	12	28	$294,300
Pearisburg, Town of	1	2	$29,300
Pembroke, Town of	12	4	$29,100
Pennington Gap, Town of	3	15	$432,100
Petersburg, City of	87	91	$824,600
Pittsylvania County	23	37	$457,600
Pocahontas, Town of	7	5	$247,000
Poquoson, City of	2964	4208	$71,836,300
Portsmouth, City of	3044	1688	$19,786,700
Pound, Town of	37	50	$230,800
Powhatan County	34	1	$4,900
Prince Edward County	4		$ -
Prince George County	74	29	$249,000
Prince William County	1099	428	$5,310,800
Pulaski County	48	59	$839,400
Pulaski, Town of	25	21	$183,600
Purcellville, Town of	14		$ -
Quantico, Town of	2		$ -
Radford, City of	8	2	$21,400
Rappahannock County	33	4	$4,200
Remington, Town of	26	1	$ -
Rich Creek, Town of	5		$ -
Richlands, Town of	55	128	$1,339,700
Richmond County	70	98	$1,948,000
Richmond, City of	399	461	$11,185,400
Ridgeway, Town of	1		$ -
Roanoke County	321	503	$5,217,600
Roanoke, City of	381	1080	$20,228,400
Rockbridge County	96	226	$3,362,600
Rockingham County	253	238	$4,458,300

Jurisdiction	Policy Count	Claims	Net Claim Payment (rounded)
Rocky Mount, Town of	1	1	-
Round Hill, Town of	2		-
Rural Retreat, Town of	5		-
Russell Count	39	42	$295,200
Salem, City of	263	745	$18,574,800
Saltville, Town of	4	1	$1,300
Saxis, Town of	36	38	$579,500
Scott County	48	30	$277,700
Scottsville, Town of	7	73	$905,900
Shenandoah County	123	197	$5,441,900
Shenandoah, Town of	1	2	$4,300
Smithfield, Town of	75	36	$603,200
Smyth County	83	87	$838,700
South Boston, Town of	8	46	$1,717,800
Southampton County	114	78	$2,974,800
Spotsylvania Count	285	38	$104,100
St. Charles, Town of	3	11	$92,600
St. Paul, Town of		2	$17,400
Stafford County	527	153	$1,297,100
Stanardsville, Town of	1	1	$14,000
Stanley, Town of	5	3	$2,700
Staunton, City of	98	46	$663,600
Stephens City, Town of	8		-
Stony Creek, Town of	16	22	$96,000
Strasburg, Town of	7	1	-
Stuart, Town of		13	$724,200
Suffolk, City of	868	218	$5,159,400
Surry County	24	45	$1,489,000
Sussex County	26	12	$46,700
Tangier, Town of	56	108	$1,278,500
Tappahannock, Town of	11	15	$196,000
Tazewell County	75	133	$1,950,600
Tazewell, Town of	18	33	$630,600
Timberville, Town of	4	2	$65,200
Toms Brook, Town of	2		-
Troutville, Town of	11	9	$14,200
Urbanna, Town of	15	12	$277,700
Vienna, Town of	107	33	$783,100
Vinton, Town of	23	83	$1,319,600
Virginia Beach, City of	17282	6159	$103,592,200
Wachapreague, Town of	73	29	$430,400
Wakefield, Town of	4		-
Warren County	105	322	$6,632,400
Warrenton, Town of	19	1	-
Washington County	76	59	$761,200

Jurisdiction	Policy Count	Claims	Net Claim Payment (rounded)
Waynesboro, City of	126	348	$6,143,300
Weber City, Town of	1	3	$101,300
West Point, Town of	69	78	$2,291,700
Westmoreland Count	239	147	$2,962,700
White Stone, Town of	2	9	$63,800
Williamsburg, City of	38	18	$118,900
Winchester, City of	80	10	$48,300
Windsor, Town of	5		-
Wise County	85	141	$942,100
Wise, Town of	19	42	$384,700
Woodstock, Town of	5	11	$165,300
Wythe County	51	17	$77,600
Wytheville, Town of	12	2	$48,500
York County	2885	1548	$33,861,900
Total:	**12,607**	**5,573**	**$66,420,200**

Over $376 million has been paid on the current list of non-mitigated repetitive loss properties in the Commonwealth (through 2021). Communities with over $1 million claims paid to communities are shown in Table 3-48 and those that are unpaid are shown in Table 3-49.

Table 3-48 - NFIP Policies and Claims Paid, >$1M Cumulative to Communities (1978- 2021)

Community	Total Paid (Rounded)	Community	Total Paid (Rounded)
Accomack County	$3,312,400	Middlesex County	$1,337,400
Alexandria, City Of	$3,479,900	Newport News, City Of	$17,413,600
Alleghany County	$1,046,300	Norfolk, City Of	$49,774,800
Botetourt County	$1,106,700	Northumberland County	$4,784,200
Buchanan, Town Of	$1,327,600	Poquoson, City Of	$44,125,700
Buena Vista, City Of	$2,665,400	Portsmouth, City Of	$13,159,100
Chesapeake, City Of	$21,665,500	Prince William County	$3,158,800
Chesterfield County	$1,253,100	Richmond County	$1,484,100
Colonial Beach, Town Of	$2,918,400	Richmond, City Of	$7,857,000
Danville, City Of	$3,460,500	Roanoke County	$2,551,600
Essex County	$2,298,600	Roanoke, City Of	$11,854,300
Fairfax County	$5,990,300	Rockbridge County	$1,648,400
Franklin, City Of	$1,077,300	Rockingham County	$1,851,300
Front Royal, Town Of	$1,060,900	Salem, City Of	$17,434,900
Gloucester County	$10,221,400	Shenandoah County	$3,410,300
Hampton, City Of	$52,537,300	South Boston, Town Of	$1,244,900
Henrico County	$1,855,500	Suffolk, City Of	$3,689,800
Henry County	$1,323,100	Tazewell County	$1,454,200
Isle Of Wight County	$1,763,300	Virginia Beach, City Of	$46,163,000
James City County	$2,403,800	Warren County	$4,013,800
Lancaster County	$3,643,500	Waynesboro, City Of	$5,390,100
Loudoun County	$1,281,400	Westmoreland County	$1,527,100
Lynchburg, City Of	$2,157,700	York County	$15,936,600
Mathews County	$10,028,600	**Total:**	**$401,143,500**

Table 3-49 - Repetitive Loss NFIP Claims >$1M Paid on Unmitigated Structures (1978- 2021)

Community	Repetitive Loss Claims > $1 Million	Community	Repetitive Loss Claims > $1 Million
Accomack County	$4,977,000	Northumberland County	$4,664,000
Alexandria City	$3,405,300	Poquoson City	$44,700,300
Buchanan County	$776,300	Portsmouth City	$13,324,300
Buena Vista City	$2,367,500	Prince William County	$3,340,600
Chesapeake City	$21,619,400	Richmond City	$7,676,000
Colonial Beach, Town of	$2,918,400	Richmond County	$816,000
Essex County	$2,245,100	Roanoke City	$11,799,500
Fairfax City	$590,700	Rockbridge County	$3,279,900
Gloucester County	$10,234,300	Rockingham County	$1,828,900
Hampton City	$51,955,000	Salem City	$17,409,100
Henrico County	$2,319,600	Shenandoah County	$3,320,200
Isle Of Wight County	$2,207,800	Suffolk City	$3,689,800
James City	$2,427,600	Tazewell County	$1,955,300
Lancaster County	$3,754,700	Virginia Beach City	$45,800,700
Lynchburg City	$2,161,600	Warren County	$4,425,900
Mathews County	$9,439,700	Waynesboro City	$5,223,900
Middlesex County	$1,450,600	Westmoreland County	$4,427,200
Newport News City	$17,368,800	York County	$15,972,900
Norfolk City	$49,889,800	**Total:**	**$385,763,700**

A Severe Repetitive Loss (SRL) property has at least four NFIP claim payments over $5,000 each (building and contents), or at least two separate claims payments with the cumulative amount exceeding the market value of the building. Table 3-50 shows non-mitigated, severe repetitive loss structures by participating community, and the total amount of claims paid on them (more than $1 million). Norfolk, Hampton, Chesapeake, and Virginia Beach have all seen increases in the number of severe repetitive loss structures from 2008 to the present day.

Table 3-50 - Severe Repetitive Loss – NFIP Claims +$1M Paid on Unmitigated Structures (1978-2021)

Jurisdiction	SRL Claims > $1 Million
Chesapeake, City of	$9,384,900
Gloucester County	$3,262,700
Hampton, City of	$16,863,400
Mathews County	$2,255,300
Norfolk, City of	$17,779,600
Poquoson, City of	$6,592,600
Portsmouth, City of	$3,855,100
Salem, City of	$15,331,300
Virginia Beach, City of	$20,241,300
York County	$2,330,900
Total:	**$97,897,100**

3.8.6.4 Probability of Future Occurrence

Flooding probability is in terms of designated zones on the FEMA Flood Insurance Rate Maps (FIRM). Table 3-51 describes the different flood hazard areas and their associated probabilities, and Figure 3-78 through 3-84 provide an overview of the Commonwealth's floodplains. Detailed viewing of the FIRM is available online through FEMA's Map Service Center or the Virginia DCR VFRIS.

Table 3-51 - FEMA Special Flood Hazard Area Designations and Probabilities

Flood Zone	Description
A	1% annual chance of flood. No Base Flood Elevations determined.
AE	1% annual chance of flood. Base Flood Elevations determined.
AH	Subject to 1% annual chance shallow flooding with flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
AO	Subject to 1% annual chance shallow flooding with flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); Base Flood Elevations undetermined.
V	Subject to 1% annual chance flood. Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
VE	Subject to 1% annual chance flood. Coastal flood zone with velocity hazard (wave action); wave heights above 3 feet; Base Flood Elevations determined.
X	Areas with 0.2% annual chance of flood or less; areas in 1% annual chance flood zone with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.
D	Areas in which flood hazards are undetermined, but possible.

Impact and Vulnerability

Populations and property are extremely vulnerable to flooding. Homes, businesses, public buildings, and critical infrastructure 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 a 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, cause power outages, and create health concerns such as mold.

Risk

For the 2023 update, the overall hazard ranking for flooding is HIGH, and considered the top hazard with regard to probability and impact to all jurisdictions in the Commonwealth.

For some buildings or facilities, even a slight chance of flooding is too great a threat because of the critical nature of the operations or programs that occur there. Typical critical facilities include hospitals, fire stations, police stations, storage of critical records, emergency operations centers and some important utilities. These facilities should be given special consideration when formulating mitigation action plans. If a critical facility must be located in a floodplain, design should include a higher level of protection to minimize impacts and allow functions to continue.

To assess more detailed risks due to flooding, this plan used FEMA flood zones to intersect state and critical facility locations. Jurisdictional risk was calculated in terms of annualized loss using assumptions borrowed from the FEMA benefit-cost analysis (BCA) modules. To ensure that this plan reflects the latest analyses available for Virginia, the planning team also examined the results of the *Virginia Coastal Resilience Master Plan – Phase One*, December 2021. Although this plan's results are somewhat duplicative, of the results of the later coastal study are included as a companion to the results for all flood types. Using a separate methodology as explained in detail in Appendix C, the Virginia Coastal Resilience Master Plan – Phase One, December 2021, shows average annual loss results that provide additional insights regarding the impacts of coastal flooding statewide. The analysis in the Coastal Resilience Master Plan does not address riverine flooding not caused by storm surge.

3.8.6.5 State Facility Risk

Table 3-52 shows the state facilities located in FEMA flood zones. Due to uncertainty in many of the state facility locations from the VAPS database, analysts were unable to conclusively determine the potential risk to some state facilities. Based on the current datasets, only a conservative estimate is possible. By intersecting the current VAPS spatial locations (individual building footprints, building groups, and geocoded points) with the digital flood mapping data, the number of buildings was determined, shown in Table 3-52. In cases where a building footprint, building group polygon, or geocoded point intersected multiple flood zones, the building was assigned to the more severe flood zone. Therefore, it is more appropriate to describe the results of this analysis as showing proximity to the floodplain, rather than a specific determination of a building's (or group of buildings') flood zone status. Figure 3-78 through Figure 3-84 show the location of these assets in relation to the identified SFHA.

Table 3-52 - State Facilities in FEMA SFHAs, by VDEM Region 2021

Flood Zones	VDEM Region 1	VDEM Region 2	VDEM Region 3	VDEM Region 4	VDEM Region 5	VDEM Region 6	VDEM Region 7
A	19	10	1	109	10	13	33
AE	288	7	19	77	136	49	10
AH/AO	0	0	0	0	1	0	0
VE	0	0	0	0	0	0	0
X / 500-year	21	0	2	0	58	5	2
Total	**321**	**17**	**22**	**208**	**205**	**67**	**45**

As shown in Table 3-53, 885 state facilities are within an identified floodplain. However, focusing just on the subset of state facilities for which individual building footprints were processed, it is possible to target specific facilities more closely for mitigation activities. An analysis of these buildings revealed 797 buildings in a 1-percent-annual-chance floodplain, and 88 buildings in a 0.2-percent annual chance floodplain. Several state agencies, such as the Virginia Department of Transportation, have significantly more facilities in the SFHA than others.

Table 3-53 - Agencies with Multiple Building Footprints Identified in SFHA

Agency	Number of Buildings
Virginia Department of Transportation	92
Virginia Department of Forestry	22
Virginia Department of Corrections	448
Department of Wildlife Resources	33
Virginia Department of Conservation and Recreation	118

Figure 3-78 - State Facilities in the SFHA, VDEM Region 1.

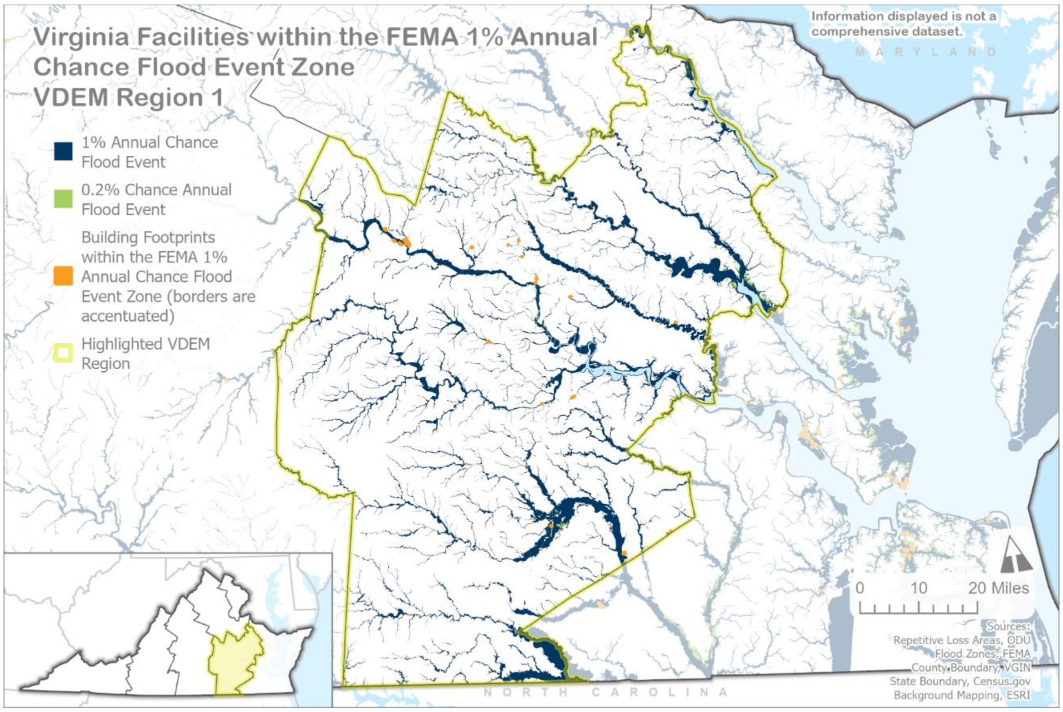


Figure 3-79 - State Facilities in SFHA – VDEM Region 2

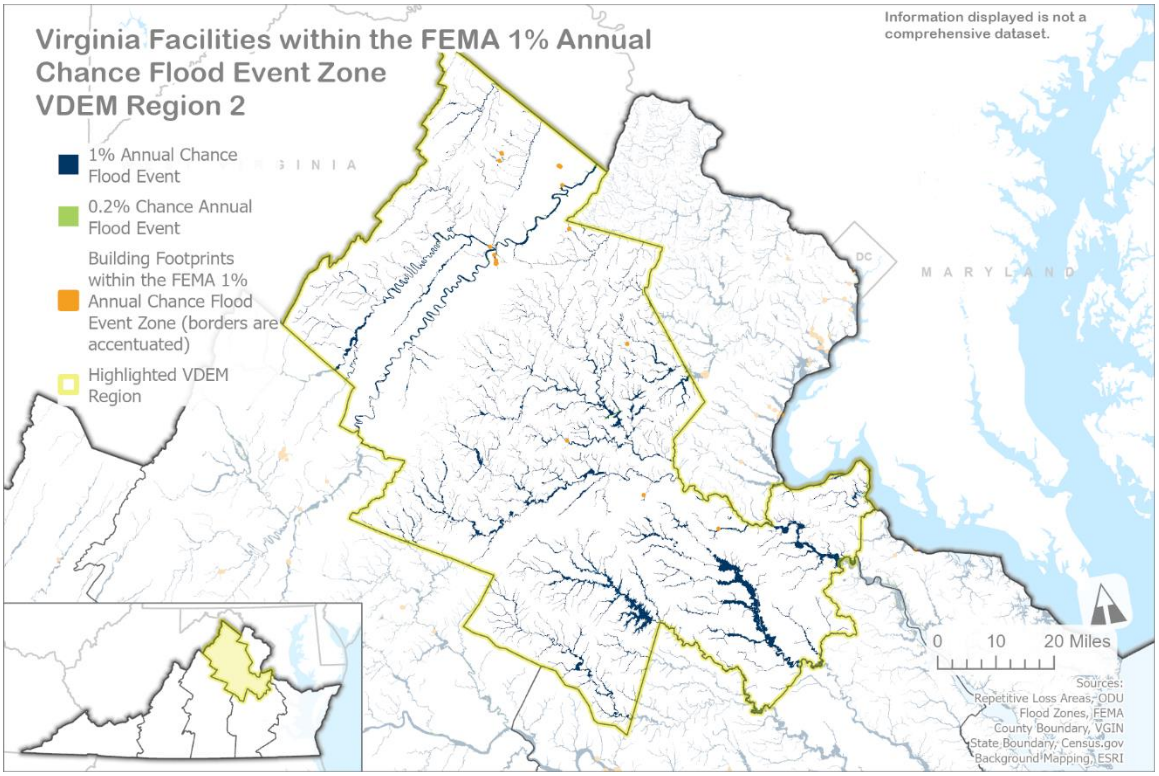


Figure 3-80 - State Facilities in SFHA – VDEM Region 3

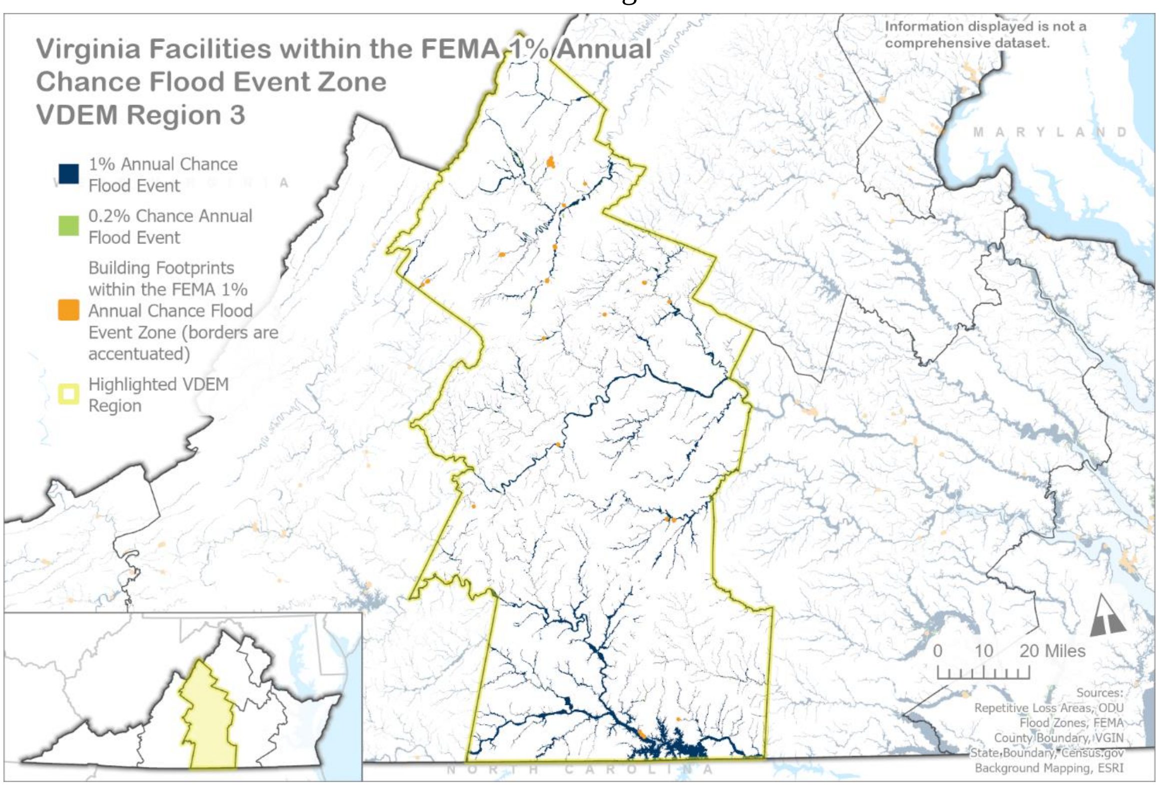


Figure 3-81 - State Facilities in SFHA – VDEM Region 4

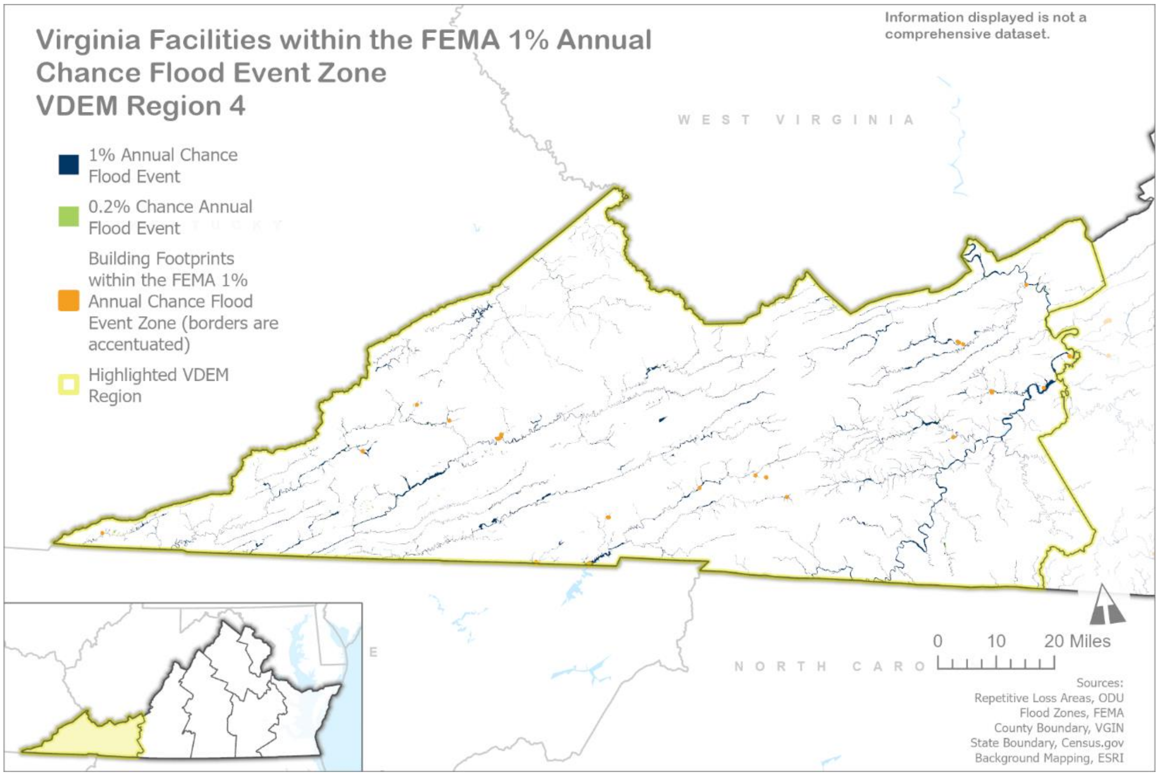


Figure 3-82 - State Facilities in SFHA – VDEM Region 5

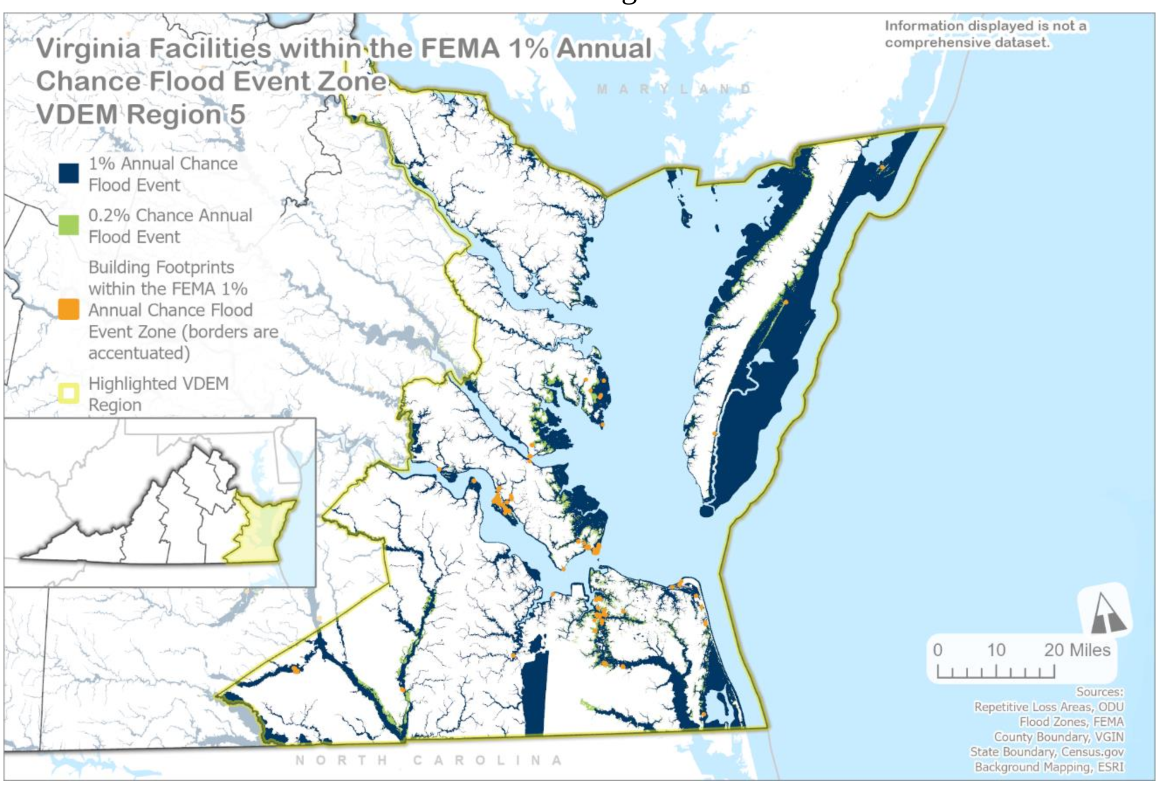


Figure 3-83 - State Facilities in SFHA – VDEM Region 6

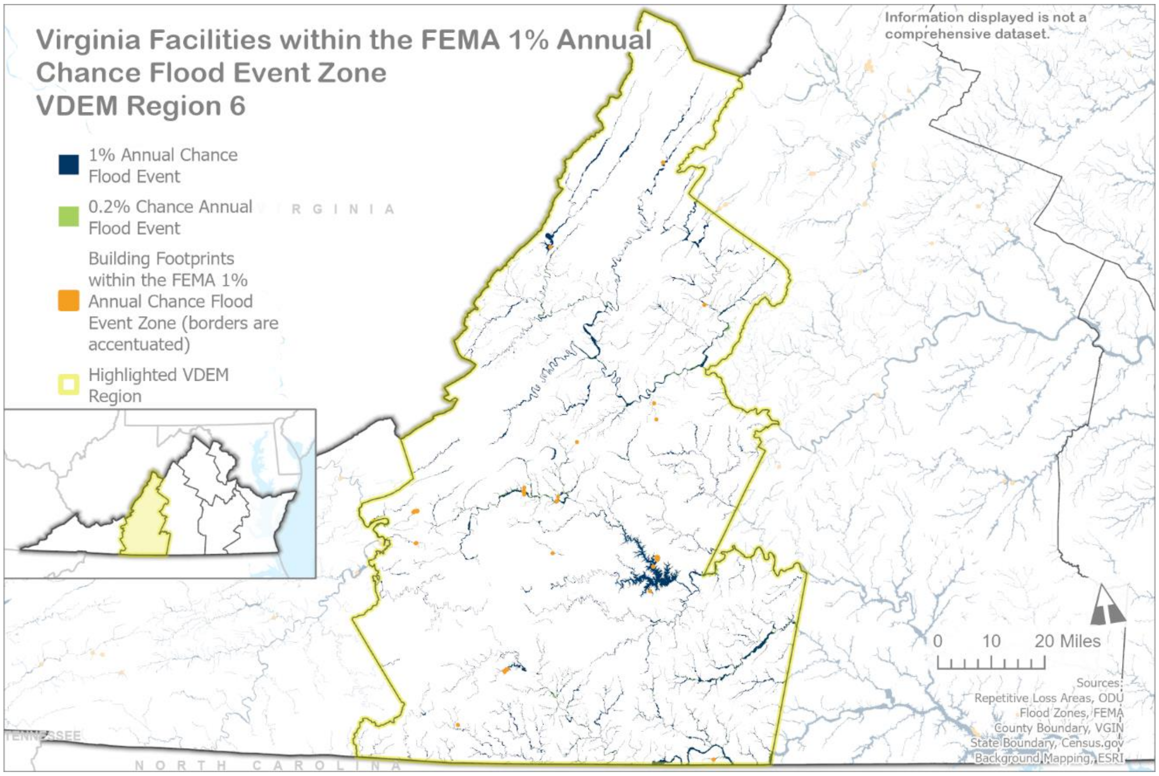
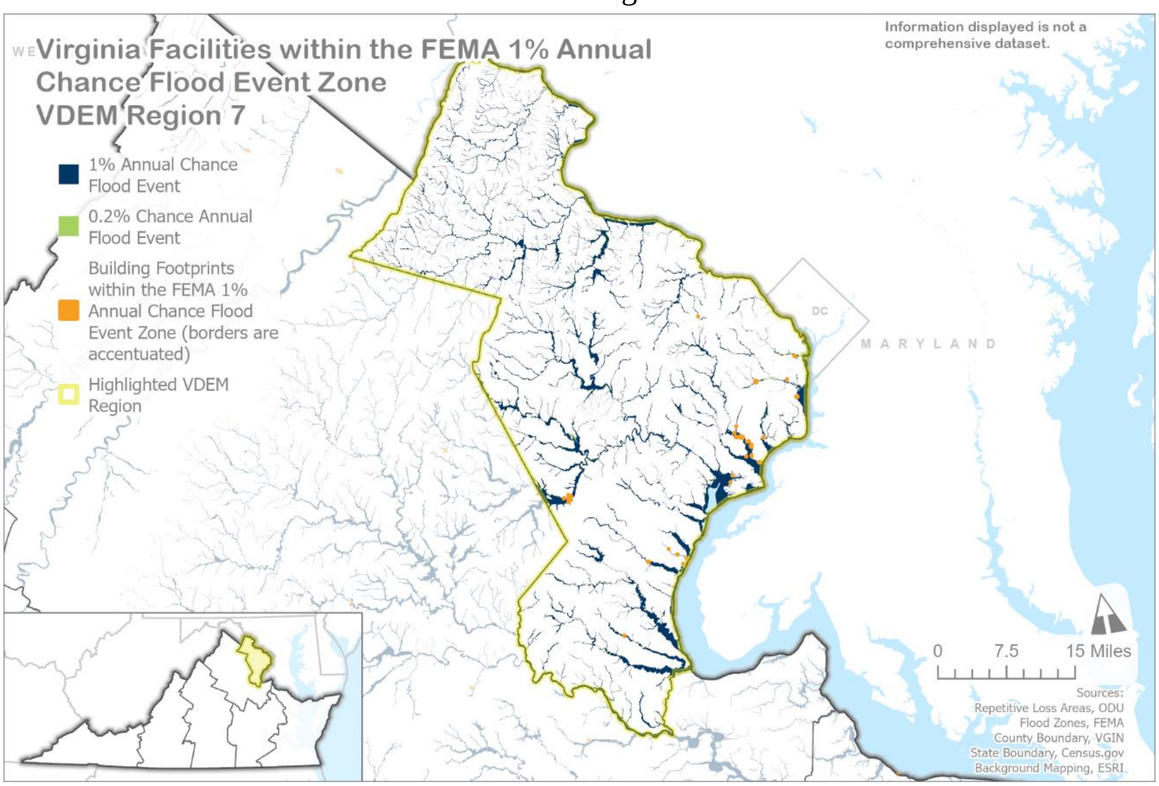


Figure 3-84 - State Facilities in SFHA – VDEM Region 7



In order to determine the characteristics of at risk assets to flooding as part of Governor's Executive Order 24, the Department of General Services compiled detailed data on each asset's location relative to FEMA 100-, 500-year floodplains, V Zones, and delineated floodways. The database also contains information on base flood elevation, construction type, number of floors, square footage and in rare cases, elevation of the lowest finished floor. However, this database does not contain valuation data for the structure or contents and the database from the Department of Treasury that contains valuation data cannot be merged with the DGS database. To monetize the risk from flooding to state assets and to highlight the potential dollar losses, Table 3-54 provides important summary data for the top 24 highest valued state assets in the 100-year floodplain gathered by comparing asset location with FEMA FIRM data. USACE depth-damage curves appropriate to the asset and contents were applied to estimate damages from a flood resulting in one-foot of water above grade against the building. Although this methodology does not capture all potential losses from flooding to state assets and assumes all buildings are constructed at grade, it uses available data to approximate flood costs that may be most damaging for the Commonwealth with regard to structures and contents.

Table 3-54 - Characteristics of Virginia's Highest Value Flood-prone Assets

Agency	Building Description	Jurisdiction	Building Value	Contents Value	Flood Zone	Structure Damage – 1 foot flooding	Contents Damage – 1 foot flooding	Total Damages
Deerfield Correctional Center	1 Building Containing 3 Housing Units	Southampton County	$26,726,854	$1,235,709	A	$4,062,482	$12,357	$4,074,839
	Kitchen/Dining-Food Svc 001-00006 & 0006a	Southampton County	$14,560,114	$734,796	A	$2,184,017	$191,047	$2,375,064
James Madison University	Chesapeake Avenue Parking Deck	Harrisonburg, City of	$14,044,947	$0	AE	$1,404,495	$0	$1,404,495
James River Correctional Center	New Dairy	Goochland County	$13,850,000	$3,801,308	AE, Floodway	$1,523,500	$722,248	$2,245,748
Old Dominion University	Webb University Center	Norfolk, City of	$53,756,543	$5,888,113	AE	$8,063,481	$2,060,840	$10,124,321
	Student Recreation Center	Norfolk, City of	$45,352,822	$2,810,399	AE	$6,802,923	$983,640	$7,786,563
	Diehn Performing Arts Center	Norfolk, City of	$31,321,138	$2,798,287	AE	$4,698,171	$979,401	$5,677,571
	Facilities Management	Norfolk, City of	$21,391,955	$3,660,003	AE	$3,208,793	$1,281,001	$4,489,794
	Gresham Hall	Norfolk, City of	$19,940,115	$1,584,286	AE	$2,991,017	$554,500	$3,545,517
	Rogers Hall	Norfolk, City of	$18,994,709	$1,442,340	AE	$2,849,206	$504,819	$3,354,025
Pocahontas State Correctional Center	Programs Building	Tazewell County	$12,469,327	$6,865,183	AE	$1,870,399	$2,402,814	$4,273,213
Powhatan Correctional Center	Doc Powhatan Cc Warehouse	Goochland County	$2,406,844	$18,742,088	AE, Floodway	$361,027	$6,559,731	$6,920,758
	Doc Powhatan Cc R&C Cell Bldg C-4	Goochland County	$13,474,955	$159,731	AE, Floodway	$2,021,243	$55,906	$2,077,149
	Doc Powhatan Cc Cell Bldg C-1	Goochland County	$13,241,702	$259,180	AE, Floodway	$1,986,255	$90,713	$2,076,968
Radford University	Dedmon Center	Radford, City of	$47,183,829	$28,045,616	AE	$7,077,574	$9,815,966	$16,893,540
Tidewater Community College	Stanley C. Walker Technologies Bldg	Norfolk, City of	$14,730,384	$5,094,161	AH	$2,209,558	$1,782,956	$3,992,514
	Stanley C. Walker Technologies Bldg	Norfolk, City of	$14,730,384	$5,094,161	AH	$2,209,558	$1,782,956	$3,992,514
Virginia Tech	Virginia Tech Carilion School Of Medicine And Research Institute	Roanoke, City of	$95,917,112	Not provided	AE	$14,387,567	Not calculated	$14,387,567
	Vt/Carilion Biomedical Research Expansion	Roanoke, City of	$83,574,000	$6,122,000	AE	$12,536,100	$2,142,700	$14,678,800
	Davidson Hall	Montgomery County	$67,733,571	$111,526	A	$10,160,036	$39,034	$10,199,070
	Owens Hall	Montgomery County	$30,348,886	$8,934,574	A	$4,552,333	$3,127,101	$7,679,434
	Architecture Annex	Montgomery County	$4,073,662	$22,466,492	A	$611,049	$7,863,272	$8,474,322
	Graduate Life Center At Donaldson Brown	Montgomery County	$22,123,936	$1,453,801	A	$3,318,590	$508,830	$3,827,421
	Eggleston Hall	Montgomery County	$21,241,510	Not provided	A	$3,186,227	Not calculated	$3,186,227

3.8.6.6 Critical Facility Risk

Critical facility point locations were intersected with the FEMA SFHAs to determine what flood zones for each facility. Loss estimations were not calculated for critical facilities due to the limited data available for analysis. As shown in Table 3-55, a limited number of critical facilities are in the FEMA SFHA. Utilities have the highest number of facilities in the floodplain.

Table 3-55 - Critical Facilities in FEMA-Identified Flood Zones, 2021

Flood Zones	Hazmat	Comm or Armory	Animal Health or Research	Utility	Food Service/ Storage	Fuel Storage / Distribution	Medical	Public Safety/ Security	Special Population
A	2	2	2	21	3	5	2	16	1
AE	12	4	3	22	4	16	4	19	2
AH / AO	0	0	1	0	0	0	0	0	0
VE	0	0	0	0	0	0	0	0	0
X	2	1	1	5	0	4	0	1	0
V / VE	0	0	0	0	0	0	0	0	0
Total	**16**	**7**	**7**	**48**	**7**	**25**	**6**	**36**	**3**

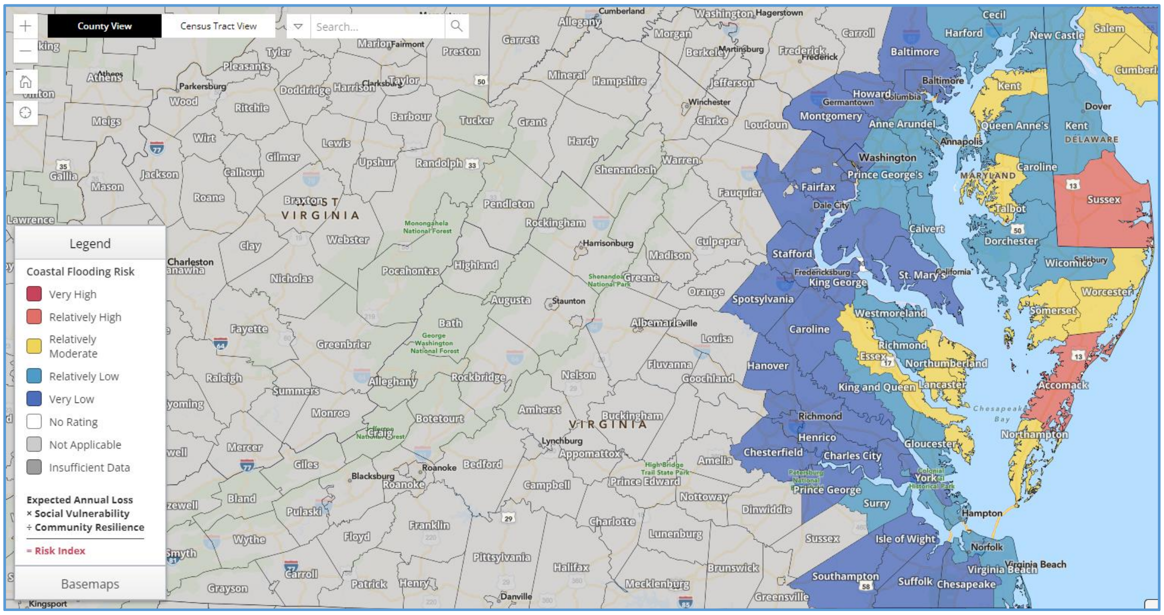
3.8.6.7 National Risk Index

The National Risk Index (NRI) includes three components: a *natural hazards component* (**Expected Annual Loss**), a *consequence enhancing component* (**Social Vulnerability**), and a *consequence reduction component* (**Community Resilience**). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for drought are reviewed for each community (county tract).

Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index.

For the purposes of this SHMP/HIRA update the qualitative summary for flooding are reviewed for each community (county tract). These have been divided into Coastal and Riverine Flooding to align with the NRI data (Figure 3-85).

Figure 3-85 - Coastal Flood Risk Map – NRI Risk Index



As shown in Figure 3-865, coastal flooding is of greatest risk to areas along the open coast and within portions of the Chesapeake Bay in areas such as Northumberland, Lancaster, and Essex. Although Norfolk and Hampton Roads have higher exposure to the Chesapeake Bay and the Atlantic Ocean, factors such as community resilience and social vulnerability appear to be minimizing overall risk calculations. Table 3-56 and Table 3-57 highlight the top risk communities for the identified flood hazard in Virginia.

Table 3-56 - Coastal Flooding – NRI Highest Risk Rating

County/City	Coastal Flood Risk Rating
Accomack County	Relatively High
Lancaster County	Relatively Moderate
Northumberland County	Relatively Moderate
Mathews County	Relatively Moderate
Northampton County	Relatively Moderate
Middlesex County	Relatively Moderate
Essex County	Relatively Moderate

As shown in Figure 3-86, the greatest risks for riverine flooding are spread over a more geographically diverse area, with relatively moderate flooding risk shown in western portions of Virginia like Buchanan and Tazewell counties, and in areas along the coast such as the City of Norfolk and Accomack.

Figure 3-86 - Riverine Flood Risk Map – NRI Risk Index

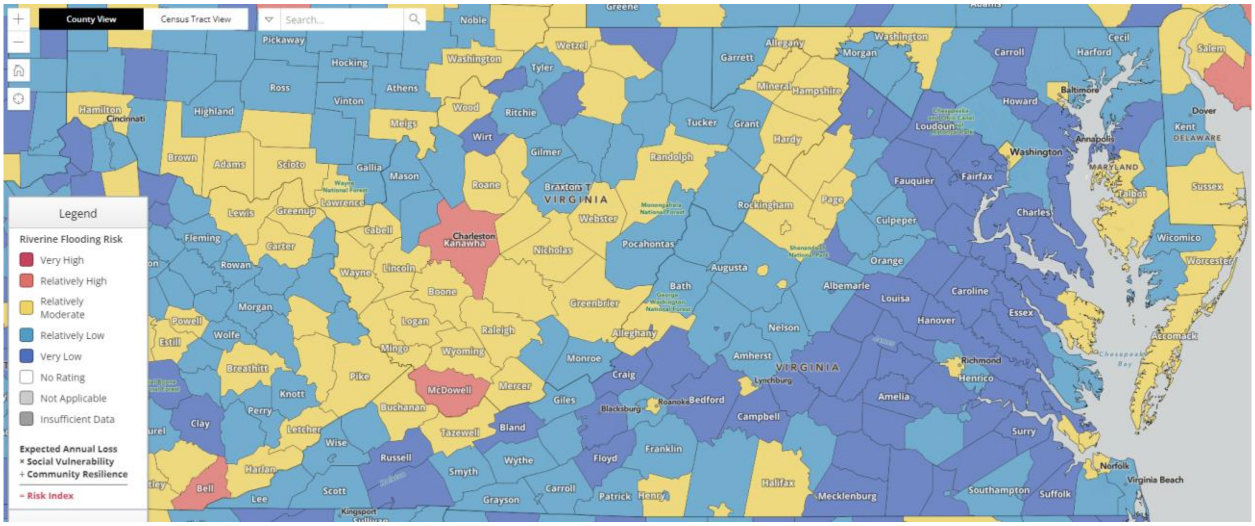


Table 3-57 - Riverine Flooding – NRI Highest Risk Rating

County/City	Riverine Flood Risk Rating
Norfolk City	Relatively Moderate
Shenandoah County	Relatively Moderate
Halifax County	Relatively Moderate
Lancaster County	Relatively Moderate
Richmond City	Relatively Moderate
Accomack County	Relatively Moderate
Northampton County	Relatively Moderate
Hampton City	Relatively Moderate
Portsmouth City	Relatively Moderate
Roanoke City	Relatively Moderate
Newport News City	Relatively Moderate
Northumberland County	Relatively Moderate

The National Risk Index is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies. For additional details on the NRI for each community identified in the table below please visit https://hazards.fema.gov/nri/ for additional risk details for each community.

3.8.6.8 Flood Risk to Energy Pipelines

Transmission pipelines and supporting infrastructure are vulnerable to damage during flood events. Increased stream flow rates during flood events can erode banks at places where pipelines cross streams, potentially undermining the structural supports of the pipeline, and causing the pipeline to sag or break. Flood waters that inundate pipelines may also be carrying debris or watercraft which can impact the pipeline, resulting in damage. Exposed pipelines inundated by flood waters may be damaged by floating debris, which can result in material being discharged into the environment creating a water quality or public health issue. Damage to pipelines, or even precautionary measures to minimize potential damage, could halt normal pipeline operations. This could include the loss of critical energy supplies to the regions impacted by the same flooding event, thereby complicating response and recovery activities.

3.8.6.9 Comparison with Local Plan Critical Facility Risk

Each local hazard mitigation plan provided some type of numerical analysis regarding critical facilities located within the SFHA; in total, these plans identified approximately 500 critical (or essential) facilities in a floodplain. The available data and analysis methods used in the local plans vary. 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. As discussed previously, many of the local plans did not provide spatial data for their critical facilities.

Future Conditions

Future vulnerability will be determined, in part, by local officials. Flood hazard and SLOSH maps are available to indicate what areas of the region are most vulnerable to these hazards. These planning tools are used to help guide development away from hazardous areas. Local officials are responsible for enforcing local floodplain management regulations, flood damage prevention ordinances, and other forms of development policies that restrict new development in flood hazard areas.

In its June 2021 report entitled *The Impact of Climate Change on Virginia's Coastal Areas*, the Virginia Academy of Science, Engineering, and Medicine (VASEM), laid out the consequences of climate change for Virginians. VASEM is a nonprofit organization consisting of members of the National Academies of Science, Engineering, and Medicine who reside or work in Virginia, as well as other Virginians who are leaders in these fields. The most immediate consequence of climate change is sea level rise. Additional consequences related to flooding include more recurrent flooding (higher frequency of occurrence for damaging floods), extreme rainfall and inundation of septic systems. The report projects that, particularly in urban areas, recurrent flooding will have a disproportional impact on racial and ethnic minorities, the poor, the elderly, renters, non-native English speakers, and those with mobility challenges. Exposure to a growing number of flood-prone facilities regulated for toxic and hazardous substances as sea levels rise is another concern, particularly on the James River between Richmond and Hampton Roads. Impacts in rural areas are more likely to be centered on soil quality, such as water-logged soils in flood-prone areas, increased salinity due to saltwater intrusion, and septic system failures that affect public health.[lxi]

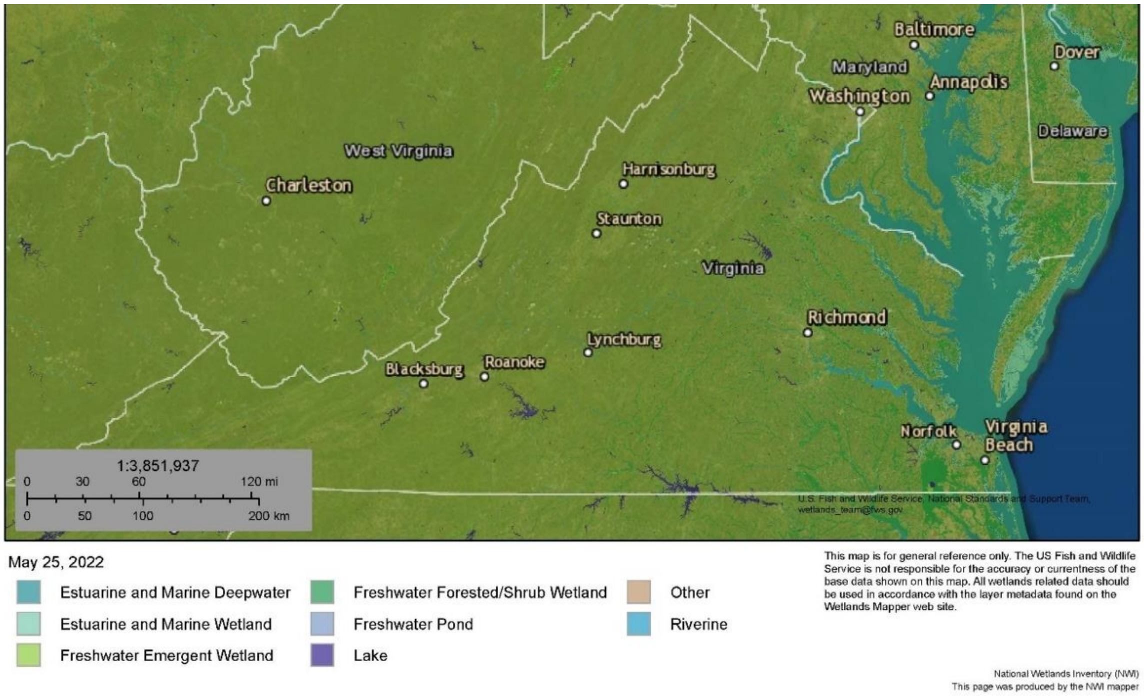
Changes in climate increase the probability of some types of weather. Recent trends in heavy rains are consistent with increasing temperatures; such occurrences are expected to become more frequent over time. As temperatures increase, more rain has fallen during heavy rain events. Very heavy precipitation events – the heaviest one percent of heavy rain events – now drop 67-percent more rain in the Northeast and 31-percent more in the Midwest than they did 50 years ago. This happens because warmer air holds more moisture than cooler air.

Recent climate studies show that rain events are becoming more frequent, with increasing rainfall amounts occurring in shorter periods of time. Warm air has the capacity to hold more water than cold air, and if the current trend of rising temperature continues, then this increases the probability and frequency of future heavy rainfall events. As a result, areas that already experience flooding are likely to experience more frequent flooding, and areas that have been historically less susceptible to flooding will face an increased risk.

If temperatures continue to increase as they have in the previous decades, the expectation is that the amount of rainfall that will fall during the heaviest rain events will increase between 20 and 40 percent by the end of the century. This means that areas that are currently vulnerable to heavy precipitation – and flooding – will see an increase in the frequency and severity of heavy precipitation and flooding events.[lxii]

In addition to floodplains, a variety of wetland types within Virginia's watersheds help store floodwaters, reduce erosion and filter pollutants. Wetlands are the transition area between aquatic and terrestrial habitats, where the water table is usually at or near the land surface or where the land is covered by shallow water. Primarily a low, marshy area, a wetland is saturated or even submerged all or part of the year, with soils that support unique plant and animal life. Virginia has many different types of wetlands, including salt marshes, estuarine wetlands along freshwater portions of tidal streams, interdunal swales, pocosins, palustrine wetlands in freshwater floodplains, freshwater swamps, bogs, fens, wet meadows, and isolated wetlands. Both coastal and freshwater wetlands work as a natural measure to help slow down rising water that may cause flooding, which is accomplished by acting as a giant sponge, absorbing and holding water during storms or periods of heavy precipitation. Fast-moving water is slowed by vegetation and temporarily stored in wetlands. Wetlands also filter pollutants carried by stormwater, which can be trapped by wetland vegetation. These excess nutrients are then used by the plants to promote growth. Additionally, wetlands are resting, nesting, breeding, and spawning areas for many species of fish, shellfish, as well as other plant and animal life. More than one half of all threatened and endangered species depend on wetlands at one point of their life cycle. See Figure 3-87 which summarizes the location of various types of wetlands within the Commonwealth of Virginia.

Figure 3-87 - Wetlands Map, Virginia



Source: US Fish and Wildlife Service, National Wetlands Inventory, NWI Mapper. [National Wetlands Inventory (usgs.gov)]

All wetlands provide a multitude of ecosystem services and provisions to the surrounding communities and their landscapes, though coastal wetlands present unique benefits. Flood damages from major storm events on coastal communities can be reduced by coastal wetlands in ways that even open water or solid land cannot, because of their unique soil and hydrological characteristics.[lxiii] Serving as the front line of defense against storm damage and sea level rise, coastal wetlands serve as buffers from environmental and climate catastrophes. The presence of coastal wetlands is crucial for preserving shorelines from environmental degradation, such as natural erosion and seasonal, low-intensity storms as well as climate change impacts, such as sea level rise. Coastal wetlands absorb the erosive energy of waves on a regular basis, reducing further erosion. The vegetation provides a buffer to the shoreline from the wave action while the root systems provide support to help hold the soil together. This is especially beneficial during seasonal storms or major storm events. Once plant material is removed or destroyed, the erosion potential increases dramatically. Climate change related studies show accelerated sea level rise along the coastal US.[lxiv, lxv] Wetlands along the coast are proving increasingly vital as climate change impacts are felt in coastal communities and these existing wetlands absorb energy from such major storms. It has been concluded in climate change related research that coastal wetland such as marshes can reduce both storm surge flood depth and property damage under current and future wetland condition and under projected sea level rise.[lxvi]

Recent data shows that approximately four percent of Virginia's land mass is occupied by wetlands. Approximately one quarter of this wetland area is tidal, and the other three quarters non-tidal. Due to human activities and development leading to the draining or filling of wetlands, Virginia has experienced a 42-percent loss of wetland area in the past 200 years. When any type of wetland is filled in or drained, the areas designed by nature to control floodwaters from damaging storms, extreme high tides, and extreme precipitation are lost.

Jurisdictional Risk

Annualized damages for flooding within each jurisdiction were calculated based on NCEI crop and property damages. Based on this analysis, the Commonwealth can expect approximately $13,537,000 in damages per year for flood related events. NCEI annualized damages have been calculated by taking the total damages per jurisdiction and dividing by the period of record (66 years). NCEI loss values are only based on reported past damages, regardless of if the structure is in a designated SFHA. The NCEI database cannot possibly track all instances of flooding, and there is some variability in the reporting. However, it remains the most complete data set available for use.

Table 3-58 provides the annualized loss from flooding for each jurisdiction, based on NCEI data. All values for incorporated towns are included within the county.

Table 3-58 - Jurisdictional Annualized Losses from Flooding (1950-2021)

Jurisdiction Name	Property Damage	Crop Damage	Total Damages	Annualized Losses
Accomack	$13,375,000	$-	$13,375,000	$241,561
Albemarle	$272,000	$900,000	$1,172,000	$21,167
Alexandria, City of	$718,000	$-	$718,000	$12,968
Alleghany	$10,760,000	$-	$10,760,000	$194,332
Amelia	$8,000	$-	$8,000	$144
Amherst	$870,000	$-	$870,000	$15,713
Appomattox	$1,120,000	$100,000	$1,220,000	$22,034
Arlington	$4,123,000	$-	$4,123,000	$74,464
Augusta	$13,190,000	$2,100,000	$15,290,000	$276,147
Bath	$7,107,000	$-	$7,107,000	$128,357
Bedford	$625,000	$155,000	$780,000	$14,087
Bedford, City of (former)	$10,000	$-	$10,000	$181
Bland	$1,066,000	$-	$1,066,000	$19,253
Botetourt	$3,050,000	$-	$3,050,000	$55,085
Bristol, City of	$110,000	$-	$110,000	$1,987
Brunswick	$300,000	$-	$300,000	$5,418
Buchanan	$29,365,000	$-	$29,365,000	$530,350
Buckingham	$615,500	$-	$615,500	$11,116
Buena Vista, City of	$830,000	$-	$830,000	$14,990
Campbell	$1,548,000	$520,000	$2,068,000	$37,349
Caroline	$122,000	$-	$122,000	$2,203
Carroll	$2,428,000	$-	$2,428,000	$43,851
Charles City	$-	$-	$-	$-
Charlotte	$1,252,000	$320,000	$1,572,000	$28,391
Charlottesville, City of	$5,000	$-	$5,000	$90
Chesapeake, City of	$21,235,000	$800,000	$22,035,000	$397,965
Chesterfield	$5,060,000	$50,000	$5,110,000	$92,290
Clarke	$2,534,000	$1,205,000	$3,739,000	$67,529

Jurisdiction Name	Property Damage	Crop Damage	Total Damages	Annualized Losses
Colonial Heights, City of	$1,200,000	$-	$1,200,000	$21,673
Covington, City of	$3,005,000	$-	$3,005,000	$54,272
Craig	$230,000	$500	$230,500	$4,163
Culpeper	$683,000	$800,000	$1,483,000	$26,784
Cumberland	$-	$-	$-	
Danville, City of	$3,040,000	$1,200,000	$4,240,000	$76,577
Dickinson	$2,024,000	$-	$2,024,000	$36,555
Dinwiddie	$2,901,000	$420,000	$3,321,000	$59,979
Emporia	$405,000	$55,000	$460,000	$8,308
Essex	$1,695,000	$20,000	$1,715,000	$30,974
Fairfax	$14,104,000	$26,000	$14,130,000	$255,196
Fairfax, City of	$2,506,000	$-	$2,506,000	$45,260
Falls Church, City of	$620,000	$-	$620,000	$11,198
Fauquier	$3,233,000	$20,000	$3,253,000	$58,751
Floyd	$3,568,000	$-	$3,568,000	$64,440
Fluvanna	$-	$-	$-	
Franklin	$1,134,000	$100,000	$1,234,000	$22,287
Franklin, City of	$4,453,000	$700,000	$5,153,000	$93,066
Frederick	$2,623,000	$250,000	$2,873,000	$51,888
Fredericksburg, City of	$110,000	$-	$110,000	$1,987
Galax, City of	$74,000	$-	$74,000	$1,336
Giles	$5,386,000	$-	$5,386,000	$97,274
Gloucester	$2,203,000	$750,000	$2,953,000	$53,333
Goochland	$-	$-	$-	
Grayson	$682,000	$-	$682,000	$12,317
Greene	$435,500	$80,000	$515,500	$9,310
Greensville	$1,650,000	$800,000	$2,450,000	$44,248
Halifax	$13,443,000	$5,220,000	$18,663,000	$337,065
Hampton, City of	$17,550,000	$-	$17,550,000	$316,964
Hanover	$2,067,000	$-	$2,067,000	$37,331
Harrisonburg, City of	$12,610,000	$8,054,000	$20,664,000	$373,204
Henrico	$2,605,000	$-	$2,605,000	$47,048
Henry	$3,264,000	$-	$3,264,000	$58,950
Highland	$1,185,000	$50,000	$1,235,000	$22,305
Hopewell, City of	$-	$-	$-	
Isle of Wight	$4,360,000	$4,580,000	$8,940,000	$161,462
James City	$605,000	$400,000	$1,005,000	$18,151
King and Queen	$617,000	$-	$617,000	$11,143
King George	$257,500	$-	$257,500	$4,651
King William	$1,257,000	$-	$1,257,000	$22,702
Lancaster	$1,870,000	$-	$1,870,000	$33,773
Lee	$1,103,000	$-	$1,103,000	$19,921
Lexington, City of	$858,000	$-	$858,000	$15,496
Loudoun	$2,138,000	$180,000	$2,318,000	$41,864
Louisa	$-	$-	$-	
Lunenburg	$50,000	$-	$50,000	$903

Jurisdiction Name	Property Damage	Crop Damage	Total Damages	Annualized Losses
Lynchburg, City of	$55,000	$20,000	$75,000	$1,355
Madison	$1,538,000	$2,750,000	$4,288,000	$77,444
Manassas, City of	$31,000	$-	$31,000	$560
Manassas Park, City of	$11,000	$-	$11,000	$199
Martinsville, City of	$110,000	$-	$110,000	$1,987
Mathews	$6,654,000	$-	$6,654,000	$120,175
Mecklenburg	$178,000	$-	$178,000	$3,215
Middlesex	$9,310,000	$-	$9,310,000	$168,144
Montgomery	$2,181,000	$5,000	$2,186,000	$39,480
Nelson	$1,165,000	$50,000	$1,215,000	$21,944
New Kent	$653,000	$-	$653,000	$11,794
Newport News, City of	$15,400,000	$-	$15,400,000	$278,133
Norfolk, City of	$40,140,000	$-	$40,140,000	$724,953
Northampton	$2,100,000	$-	$2,100,000	$37,927
Northumberland	$20,430,000	$-	$20,430,000	$368,978
Norton	$1,156,000	$-	$1,156,000	$20,878
Nottoway	$18,000	$-	$18,000	$325
Orange	$768,300	$1,050,000	$1,818,300	$32,840
Page	$8,716,000	$6,411,000	$15,127,000	$273,203
Patrick	$5,316,000	$-	$5,316,000	$96,010
Petersburg, City of	$650,000	$200,000	$850,000	$15,352
Pittsylvania	$8,296,000	$2,957,000	$11,253,000	$203,236
Poquoson	$78,525,000	$-	$78,525,000	$1,418,209
Portsmouth, City of	$24,120,000	$-	$24,120,000	$435,622
Powhatan	$-	$-	$-	
Prince Edward	$-	$-	$-	
Prince George	$1,625,000	$1,100,000	$2,725,000	$49,215
Prince William	$776,000	$50,000	$826,000	$14,918
Pulaski	$230,000	$-	$230,000	$4,154
Radford, City of	$750,000	$-	$750,000	$13,545
Rappahannock	$892,500	$40,000	$932,500	$16,842
Richmond	$25,454,000	$200,000	$25,654,000	$463,327
Richmond, City of	$20,201,000	$-	$20,201,000	$364,842
Roanoke	$3,464,000	$-	$3,464,000	$62,562
Roanoke, City of	$4,248,000	$-	$4,248,000	$76,721
Rockbridge	$6,318,000	$-	$6,318,000	$114,107
Rockingham	$25,335,000	$10,554,000	$35,889,000	$648,177
Russell	$449,000	$-	$449,000	$8,109
Salem, City of	$3,100,000	$-	$3,100,000	$55,988
Scott	$264,000	$-	$264,000	$4,768
Shenandoah	$52,806,000	$7,450,000	$60,256,000	$1,088,260
Smyth	$2,459,000	$-	$2,459,000	$44,411
Southampton	$2,105,000	$500,000	$2,605,000	$47,048
Spotsylvania	$170,500	$-	$170,500	$3,079
Stafford	$408,000	$-	$408,000	$7,369
Staunton, City of	$10,017,000	$1,600,000	$11,617,000	$209,810

Jurisdiction Name	Property Damage	Crop Damage	Total Damages	Annualized Losses
Suffolk	$1,945,000	$-	$1,945,000	$35,128
Surry	$1,460,000	$750,000	$2,210,000	$39,914
Sussex	$4,560,000	$1,050,000	$5,610,000	$101,320
Tazewell	$30,054,000	$-	$30,054,000	$542,793
Virginia Beach, City of	$10,609,000	$-	$10,609,000	$191,605
Warren	$49,837,000	$2,511,000	$52,348,000	$945,437
Washington	$336,000	$-	$336,000	$6,068
Waynesboro, City of	$8,705,000	$1,600,000	$10,305,000	$186,115
Westmoreland	$415,000	$55,000	$470,000	$8,488
Williamsburg, City of	$55,000	$-	$55,000	$993
Winchester, City of	$-	$-	$-	
Wise	$1,626,000	$-	$1,626,000	$29,367
Wythe	$271,500	$-	$271,500	$4,903
York	$78,690,000	$-	$78,690,000	$1,421,189
Totals:	**$822,659,300**	**$70,758,500**	**$893,417,800**	**$16,135,667**

The appendix of this report compares flooding annualized loss and ranking to other hazards that impact Virginia. As stated earlier in the section, flooding is considered the top hazard with regard to probability and impact to 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 considered in the current ranking algorithm. The geographic extent parameter is based on the percent of the jurisdiction in the SFHA. The NCEI annualized crop and property damages were used to maintain consistency between the hazards. As discussed earlier, the NCEI annualized loss values are lower than what was calculated for the annualized loss. Section 3.7 of this chapter describes each of the parameters used in the ranking for each hazard. Table 3-59 describes the parameters used for calculating risk due to flooding. Most 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.

Table 3-59 - Flood Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Medium-High	Low	High	Medium-High	Medium
Albemarle	Medium-High	Medium	Low	Medium-Low	Medium-High	High	Medium-Low	Medium
Alexandria, City of	Medium-High	High	Low	Medium-Low	Low	High	Medium-Low	Medium
Alleghany	Low	Low	Medium	Medium	Low	Medium	Medium-High	Medium-Low
Amelia	Low	Low	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Amherst	Medium	Medium	Low	Medium-Low	Low	Medium-High	Medium-Low	Medium-Low
Appomattox	Low	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Arlington	High	High	Medium-Low	Medium	Low	Medium-High	Medium	Medium
Augusta	Medium-High	Medium	Medium-Low	Medium-High	High	High	Medium-High	Medium-High
Bath	Low	Low	Low	Medium-High	Low	Medium	Medium-High	Medium-Low
Bedford	Medium-High	Medium	Low	Medium-Low	Low	High	Medium-Low	Medium
Bland	Low	Low	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Botetourt	Medium	Medium	Low	Medium-Low	Low	High	Medium-Low	Medium-Low
Bristol, City of	Low	Medium-High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Brunswick	Medium	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Buchanan	Medium	Low	Medium-High	High	Low	High	High	Medium
Buckingham	Low	Low	Low	Medium-Low	Low	High	Medium-Low	Medium-Low
Buena Vista, City of	Low	Medium-High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Campbell	Medium	Medium	Low	Medium-Low	Medium	High	Medium-Low	Medium
Caroline	Medium	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Carroll	Medium	Medium	Low	Medium-Low	Low	High	Medium-Low	Medium-Low
Charles City	Low	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Charlotte	Low	Low	Low	Medium-Low	Medium-Low	High	Medium-Low	Medium-Low
Charlottesville,City of	Medium	High	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Chesapeake, City of	High	Medium-High	Low	High	Medium-High	High	High	High
Chesterfield	High	Medium-High	Low	Medium	Low	Medium-High	Medium	Medium
Clarke	Low	Medium	Low	Medium-Low	High	High	Medium	Medium
Colonial Heights, City of	Medium	High	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Covington, City of	Low	Medium-High	Low	Medium-Low	Low	Low	Medium-Low	Medium-Low
Craig	Low	Low	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Culpeper	Medium	Medium	Low	Medium-Low	Medium-High	High	Medium-Low	Medium
Cumberland	Low	Low	Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Danville, City of	Medium	Medium-High	Low	Medium-Low	High	High	Medium	Medium
Dickinson	Low	Low	Low	Medium-Low	Low	Medium-High	Medium-Low	Medium-Low
Dinwiddie	Medium	Low	Low	Medium-Low	Medium-Low	Medium	Medium	Medium-Low
Emporia	Low	Medium-High	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Essex	Low	Low	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Fairfax	High	High	Medium-Low	Medium-Low	Low	High	Medium-High	Medium-High
Fairfax, City of	Medium	High	High	Medium-Low	Low	Medium-High	Medium-Low	Medium
Falls Church, City of	Low	High	Low	Medium-Low	Low	Medium-High	Medium-Low	Medium-Low
Fauquier	Medium-High	Medium	Low	High	Low	High	Medium-Low	Medium
Floyd	Low	Low	Low	Medium	Low	Medium-Low	Medium	Medium-Low
Fluvanna	Medium	Medium	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Franklin	Medium	Medium	Low	Medium-Low	Low	High	Medium-Low	Medium
Franklin, City of	Low	Medium-High	Low	Medium-Low	Medium	Medium	Medium	Medium
Frederick	Medium-High	Medium	Medium-Low	Medium-Low	Low	High	Medium-Low	Medium
Fredericksburg, City of	Medium	High	Low	Medium-Low	Low	Medium	Medium-Low	Medium
Galax, City of	Low	Medium-High	Low	High	Low	Medium	Medium-Low	Medium
Giles	Low	Low	Low	Medium-Low	Low	High	Medium	Medium
Gloucester	Medium	Medium	Low	Medium-Low	Medium-High	Medium-High	Medium-Low	Medium
Goochland	Medium	Medium	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium
Grayson	Low	Low	Low	Medium-Low	Low	High	Medium-Low	Medium
Greene	Medium	Medium	Low	Medium-Low	Low	High	Medium-Low	Medium
Greensville	Low	Low	Low	Medium-Low	Medium-High	Medium-Low	Medium-Low	Medium
Halifax	Medium	Low	Low	High	High	High	High	Medium
Hampton, City of	Medium-High	High	Low	High	Low	High	High	Medium-High
Hanover	Medium-High	Medium	Medium-Low	Medium-Low	Low	Medium-High	Medium-Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Harrisonburg, City of	Medium	High	Low	High	High	Medium	High	Medium-High
Henrico	High	Medium-High	Medium-Low	Medium-Low	Low	Medium-High	Medium-Low	Medium-Low
Henry	Medium	Medium	Medium-Low	Medium-Low	Low	High	Medium-Low	Medium
Highland	Low	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Hopewell, City of	Medium	High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Isle of Wight	Medium	Medium	Low	Medium-High	High	Medium-High	Medium-High	Medium
James City	Medium-High	Medium-High	Low	Medium-Low	Medium-Low	Medium	Medium-Low	Medium
King and Queen	Low	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
King George	Medium	Medium	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
King William	Low	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Lancaster	Low	Medium	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Lee	Medium	Low	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Lexington, City of	Low	High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Loudoun	High	Medium-High	Low	Medium	Low	High	Medium-Low	Medium
Louisa	Medium	Medium	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Lunenburg	Low	Low	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Lynchburg, Cityof	Low	Medium-High	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Madison	Low	Low	Low	Medium	High	High	Medium	Medium-Low
Manassas, City of	Medium	High	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Manassas Park, City of	Low	High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Martinsville, City of	Low	Medium-High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Mathews	Low	Medium	Low	Medium-High	Low	Medium-High	Medium-High	Medium
Mecklenburg	Medium	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Middlesex	Low	Medium	Low	Medium-High	Low	Medium	Medium-High	Medium-Low
Montgomery	Medium-High	Medium	Medium-Low	Medium-Low	Low	High	Medium-Low	Medium
Nelson	Low	Low	Low	Medium-Low	Low	High	Medium-Low	Medium-Low
New Kent	Low	Medium	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Newport News, City of	High	High	Low	Medium-High	Low	High	Medium-High	Medium-High
Norfolk, City of	High	High	Low	High	Low	High	High	Medium-High

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Northampton	Low	Medium	Low	Medium-Low	Low	Medium	Medium-Low	Medium-Low
Northumberland	Low	Low	Low	High	Low	Medium	High	Medium-Low
Norton	Low	Medium-High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Nottoway	Low	Low	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Orange	Medium	Medium	Low	Medium-Low	High	High	Medium-Low	Medium
Page	Medium	Medium	Low	Medium-High	High	High	Medium-High	Medium-High
Patrick	Medium	Low	Low	Medium	High	High	Medium	medium
Petersburg, City of	Medium	Medium-High	Low	Medium-Low	Medium-Low	Medium	Medium-Low	Medium
Pittsylvania	Medium-High	Medium	Low	Medium-High	High	High	Medium-High	Medium-High
Poquoson	Low	Medium-High	Low	High	Low	Medium-Low	High	Medium
Portsmouth, City of	Medium-High	High	Low	High	Low	High	High	Medium-High
Powhatan	Medium	Medium	Low	Medium-	Low	Medium	Medium-Low	Medium-Low
Prince Edward	Medium	Medium	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium-Low
Prince George	Medium	Medium	Low	Medium-Low	High	Medium-High	Medium-Low	Medium
Prince William	High	Medium-High	Low	Medium-Low	Low	High	Medium-Low	Medium
Pulaski	Medium	Medium	Low	Medium-Low	Low	High	Medium-Low	Medium
Radford, City of	Low	Medium-High	Low	Medium-Low	Low	Low	Medium-Low	Medium
Rappahannock	Low	Low	Low	Medium-Low	Low	High	Medium-Low	Medium
Richmond	Low	Low	Low	High	Low	Medium	High	Medium
Richmond, City of	High	High	Medium-Low	High	Low	Medium	High	Medium-High
Roanoke	Medium-High	Medium-High	Low	Medium	Low	High	Medium	Medium
Roanoke, City of	Medium-High	High	Low	Medium	Low	High	Medium	Medium
Rockbridge	Medium	Low	Low	Medium	Low	High	Medium	Medium
Rockingham	Medium-High	Medium	Low	High	High	High	High	High
Russell	Medium	Low	Low	Medium-Low	Low	Medium	Medium-Low	Medium
Salem, City of	Medium	High	Low	Medium-Low	Low	Medium	Medium-Low	Medium
Scott	Medium	Low	Medium-Low	Medium-Low	Low	Medium	Medium-Low	Medium
Shenandoah	Medium	Medium	Medium-High	High	High	High	High	High
Smyth	Medium	Medium	Low	Medium-Low	Low	Medium-High	Medium-Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Southampton	Low	Low	Medium-Low	Medium-Low	Medium	Medium-High	Medium-Low	Medium
Spotsylvania	Medium-High	Medium	Low	Medium-Low	Low	Medium-High	Medium-Low	Medium
Stafford	Medium-High	Medium-High	Low	Medium-Low	Low	Medium-High	Medium-Low	Medium
Staunton, City of	Medium	Medium-High	Low	Medium	High	Medium	Medium-High	Medium
Suffolk	Medium-High	Medium	Low	Medium-Low	Low	Medium-High	Medium-Low	Medium
Surry	Low	Low	Low	Medium-Low	Medium-High	Medium-High	Medium-Low	Medium
Sussex	Low	Low	Low	Medium	High	Medium-High	Medium	Medium
Tazewell	Medium	Medium	Low	High	Low	High	High	Medium-High
Virginia Beach, City of	High	High	Low	Medium-High	Low	High	Medium-High	Medium-High
Warren	Medium	Medium	Medium-Low	High	High	High	High	High
Washington	Medium	Medium	Low	Medium-Low	Low	Medium	Medium-Low	Medium
Waynesboro, Cityof	Medium	Medium-High	Medium-Low	Medium	High	Medium	Medium-High	Medium
Westmoreland	Low	Medium	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium
Williamsburg, City of	Low	Medium-High	Low	Medium-Low	Low	Medium	Medium-Low	Medium
Winchester, City of	Medium	High	Low	Medium-Low	Low	Medium	Medium-Low	Medium
Wise	Medium	Medium	Low	Medium-Low	Low	Medium	Medium-Low	Medium
Wythe	Medium	Medium	Low	Medium-Low	Low	High	Medium-Low	Medium
York	Medium-High	Medium-High	Low	High	Low	High	High	Medium

3.8.6.10 Local Plan Risk Assessment

Each of the 20 local hazard mitigation 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 (11);
- NCEI statistics (3); or,
- GIS intersections using FEMA FIRMs and Parcel/Census Data (6).

Local hazard mitigation plan hazard analysis and loss estimations vary considerably. Table 3-60 and 3-61 provide a summary of the local plans that provided annualized flood losses. None of the annualized loss values for the local plans are the same as the values calculated for this revision. The statewide plan utilized a broad method to be able to calculate loss on the same scale for all the jurisdictions in the Commonwealth, and for the most part, the statewide methodology results in lower annualized loss estimates.

Table 3-60 - Local Plan Annualized Losses – Flooding, Updated post 2016

Planning District Commission/Jurisdiction	Annualized Flood Loss
Richmond-Crater	$95,063
Southside	$35,451,000 + $6,716,639 (vehicles)
Commonwealth	-
Northern Shenandoah Valley	-
Rappahannock-Rapidan	$17,515,000
Thomas Jefferson	$1,400,000
George Washington	-
Cumberland Plateau	-
Lenowisco	-
Mount Rogers	-
Accomack-Northampton	-
Hampton Roads	$44,261,424
Northern Neck	$1,317,887
Middle Peninsula	$40,909,000
West Piedmont	$379,594
Central Virginia	-
New River Valley	-
Roanoke Valley-Allegheny	-
Central Shenandoah	$66,991,000
Northern Virginia	$255,477

Table 3-61 - Local Plan Annualized Losses - Flooding 2010-2016

Planning District Commission/Jurisdiction	Annualized Flood Loss
Accomack-Northampton (2012)	$2,788,820
Commonwealth Regional Council (2016)	$335,846
Central Shenandoah Valley (2013)	$3,681,938
Cumberland Plateau (2013)	$2,900,000
George Washington Regional Commission (2017)	$148,896,000
Hampton Roads (2017)	$14,690,196
LENOWISCO (2013)	No estimated losses provided
Middle Peninsula (2016)	$18,102,000
Mount Rogers (2011)	No estimated losses provided
New River Valley (2011)	$248,883
Northern Neck (20110	$6,625,524
Northern Shenandoah Valley (2012)	$6,857,556
Northern Virginia (2016)	$1,061,851,000
Rappahannock-Rapidan (2012)	$1,884,727
Region 2000 (2013)	$2,094,999
Richmond-Crater (2011)	$6,474,812
Roanoke Valley-Alleghany (2013)	$3,635,903
Southside (2013)	$2,821,224,000
Thomas Jefferson (2012)	$1,400,000
West Piedmont (2016)	$8,628,034

A total of 16 local plans provided an estimate of the number of structures located within the SFHA and an estimate of the structure value at risk (within the SFHA). Table 3-62 below provides a summary of the number and value of the structures at risk due to flooding from the local plan results. Some plans only provided information for structures and facilities located within the one percent annual chance floodplain, while others provided information for the 1% annual chance and 0.2-percent-annual-chance floodplains. Other local plans did not report the number of buildings and building value within the SFHA at all. The total structure value at risk (buildings within an SFHA), from local plan analysis, was $10,186,947,112. For comparison, the total building value that lies within an SFHA used for the statewide annualized loss estimate was $65,646,246,000.

Table 3-62 - Number and Value of Structures at Risk Due to Flooding

Jurisdiction	Structures at Risk	Structure Value at Risk
Accomack-Northampton (2016)	NA	NA
Central Shenandoah Valley (2020)	9,736	$34,224,000
Commonwealth Regional Council (2016)	NA	NA
Cumberland Plateau (2018)	6,045	$290,718,650
George Washington (2017)	117,370	$41,936,363,000
Hampton Roads (2022)	560,000	$204 Billion
Lenowisco (2021)	5,427	$396,430,000
Middle Peninsula (2021)	46,146	$19,730,852
Mount Rogers (2018)	1,352	$123,003,282
New River Valley (2017)	N/A	$18,444,377
Northern Neck (2016)	3,571	$465,807,800
Northern Shenandoah Valley (2018)	NA	$343,934,309
Northern Virginia (2017)	NA	NA
Rappahannock-Rapidan (2018)	10,141	$188,472,700
Region 2000 (2018)	NA	$346,443,566
Richmond-Crater (2022)	NA	NA
Roanoke Valley-Alleghany Region (2019)	NA	NA
Southside (2020)	61	$37,724,000
Thomas Jefferson (2018)	1,505	$188,858,478
West Piedmont (2021)	4,855	$8,628,034

3.8.6.11 Comparison with Local Ranking

Each of the 20 local plans discussed repetitive loss properties in their hazard mitigation plan. Each plan also includes mitigation strategy actions to address repetitive loss properties and NFIP compliance.

All 20 local hazard mitigation plans ranked flooding in their HMPs, 19 ranked flooding as a high risk and only 1 ranked flooding as medium, the Commonwealth Regional Council. The local plan ranking average for flood was high. For comparison, the 2023 statewide analysis ranked flooding as a high hazard and is consistent with local plans.

3.8.6.12 Local Plan Changes in Development

Most 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. A few plans exclusively note that they prohibit construction in the floodplain. New development in the SFHA would presumably increase loss estimates over time unless there are concurrent changes to remove or protect other structures.

Community Lifelines Impacted by Flooding

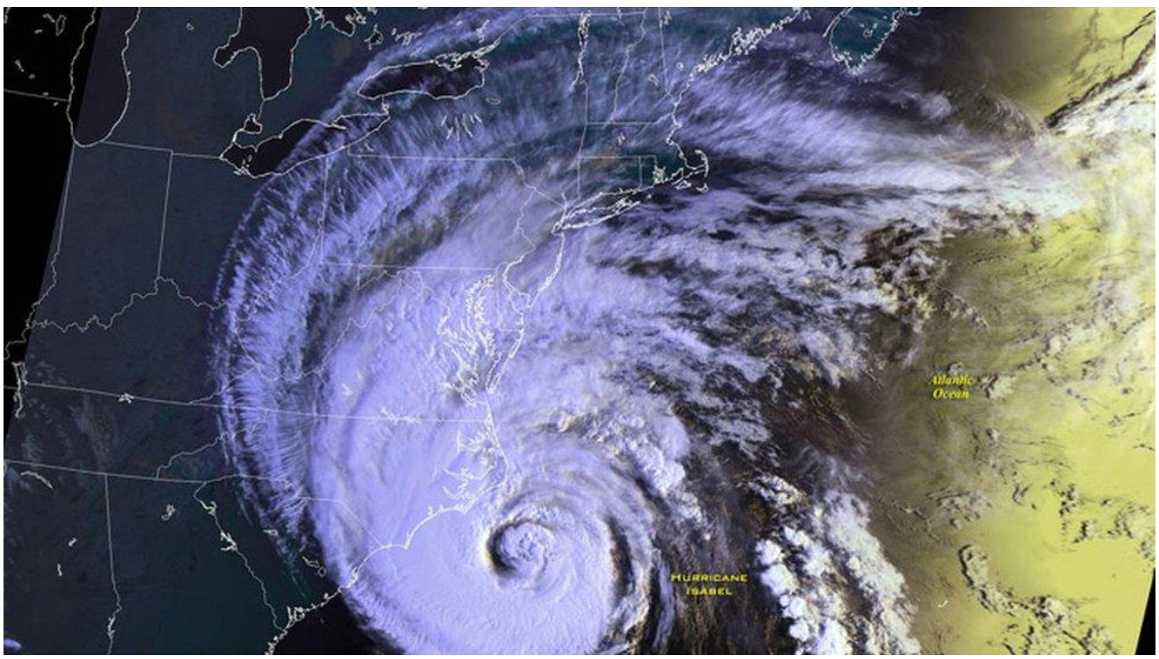
Based on the hazard analysis and description of vulnerability and impacts of flooding in Virginia, flooding impacts all the community lifelines which are:

- Food, Water, Shelter
- Energy
- Health and Medical
- Safety and Security
- Communications
- Transportation
- Hazardous Materials

3.8.7 Hurricanes

3.8.7.1 Background

Hurricanes and tropical storms are characterized by closed circulation developing around a low-pressure center in which the winds rotate counterclockwise in the Northern Hemisphere and with an eye diameter averaging 10 to 30 miles. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation, and tornadoes. Coastal areas are particularly vulnerable to storm surge, wind-driven waves, and tidal flooding which can prove more destructive than cyclone wind[1].



Source: WHSV- Hurricane Isabel prior to making landfall in September 2003

Many areas of the Coastal Virginia Tidewater region are flat, and intense prolonged rainfall tends to accumulate without ready drainage paths. Of concern with extreme rainfall is the Chowan River Basin, which has relatively no elevation and results in flood events like back-to-back Hurricanes Dennis and Floyd, which devastated the City of Franklin and other communities along the Blackwater River. Extreme rainfall in the higher elevations can also result in secondary hazards, such as landslides and debris flow as witnessed in Nelson County during Hurricane Camille. High winds are also associated with hurricanes, with two significant effects: widespread debris due to damaged and downed trees and building debris; and power outages. The Tidewater region, including areas on tidal-influenced tributaries, is vulnerable to hurricanes and their effects.

Most hurricanes form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico between June and November. The climatological peak of the Atlantic hurricane season is September 10th. These storms form from strong low-pressure systems originating in the tropics, which cause the updraft of warm ocean water. Typically, these systems result in strong damaging winds and high seas that can cause flooding. In the Atlantic, once a tropical cyclone reaches maximum sustained winds of 74 miles per hour, it is defined as a hurricane. Below this level, it is defined as either a tropical storm or tropical depression.

When a hurricane or tropical system approaches a coastline, it can be broken into four quadrants, each of which are dangerous. Based on the direction of movement of a hurricane during landfall, the most destructive section of the storm is usually in the eyewall area to the right of the eye. Known as the right-front quadrant (RFQ), this section of the storm tends to have higher winds, seas, and storm surge. As a storm moves into more shallow waters, the waves lessen, but water levels rise, bulging up on the storm's RFQ in what is called the storm surge, as shown in

Figure **3-88**.

Storm surge and wind driven waves can devastate a coastline and bring ocean water several miles inland. Once inland, the hurricane's band of thunderstorms can produce torrential rains and sometimes tornadoes. A foot or more of rain may fall in less than a day causing flash floods and mudslides. The rain eventually drains into the large rivers, which may still be flooding days after the storm has passed. The storm's driving winds can topple trees, utility poles, and damage buildings. Communication and electricity can be lost for days, or weeks and roads are impassable due to fallen trees and debris.

Figure 3-88 – Hurricane - Front Left Quadrant (FLQ) and Right-Front Quadrant (RFQ)

The Saffir-Simpson Hurricane Wind Scale is a 1-5 rating based on the hurricane's present intensity. This rating is used to give an estimate of the potential property damage expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline in the landfall region. Hurricane intensity is classified by the Saffir-Simpson Hurricane Wind Scale which rates hurricane intensity on a scale of one to five, with five being the most intense. The wind scale, recently revised to remove storm surge ranges, flooding impact and central pressure statements, is shown in Table 3-63. As a hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour (mph), the system is designated a tropical storm, given a name, and is monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 mph the storm is deemed a hurricane.

Using NOAA’s Maximum of Maximum storm (MOM) surge (Figure 3-89) for Category 1-4 hurricane events within the Chesapeake, there is a significant increase in the inland extent of the surge under stronger hurricane conditions. Virginia currently does not plan for a Category 5 hurricane. Note that all winds are expressed using the US 1-minute average.

Table 3-63 - Saffir-Simpson Hurricane Wind Scale

Category	Maximum Sustained Wind Speed (Mph)	Damage Summary
1	74–95	Very dangerous winds will produce some damage.
2	96–110	Extremely dangerous winds will cause extensive damage.
3	111–129	Devastating damage will occur
4	130–156	Catastrophic damage will occur.
5	157 +	Catastrophic damage will occur.

Source: National Hurricane Center

Categories 3, 4, and 5 are classified as "major" hurricanes, and while hurricanes within this range comprise only 20% of total tropical cyclones making landfall, they account for over 70 percent of the damage in the US. Table 3-64 describes the damage that could be expected for each hurricane category.

Table 3-64 - Hurricane Damage Classifications

Storm Category	Damage Level	Description Of Damages
1	Minimal	Well-constructed frame homes could have damage to roofs, shingles, vinyl siding and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	Moderate	Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	Extensive	Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	Extreme	Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	Catastrophic	A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

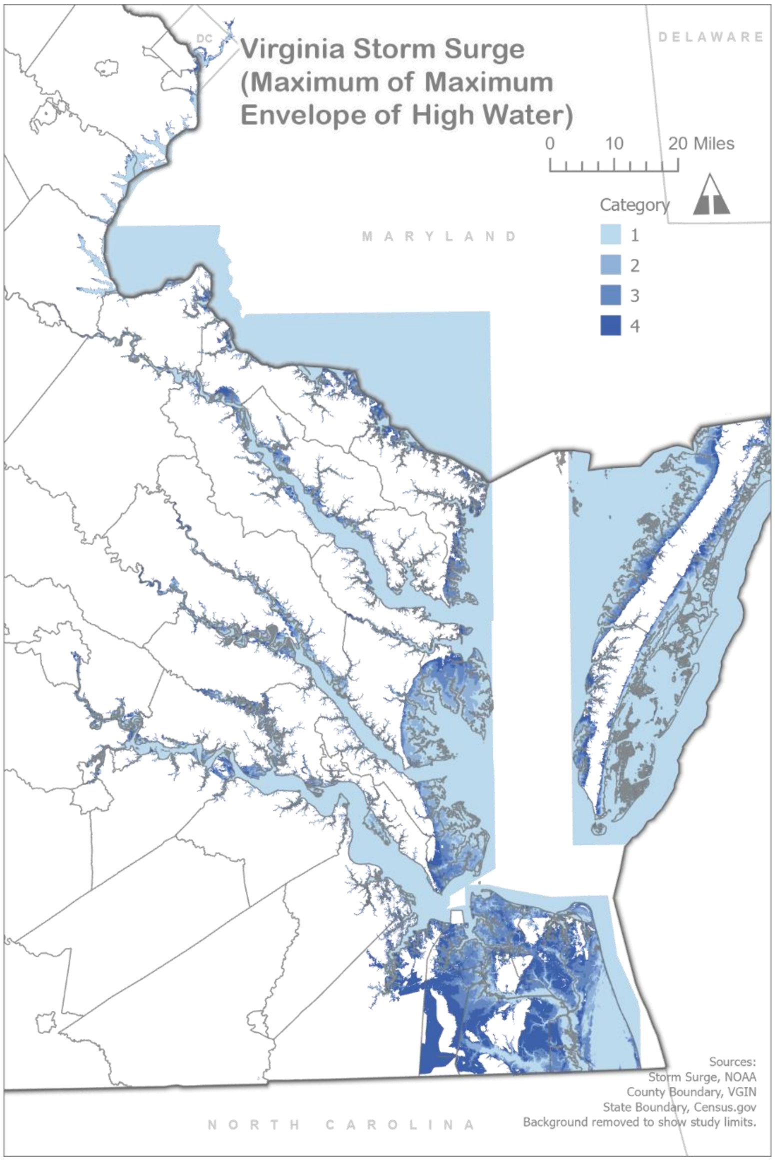
Damage during hurricanes may also result from spawned tornadoes and inland flooding associated with heavy rainfall that usually accompanies these storms. For the purposes of this report, the storm surge impacts in the region are discussed under the Flooding hazard.

Table 3-65 provides a detailed description of each hurricane category, potential damage caused, and the name and strength of hurricanes as they passed near or through Virginia.

Table 3-65 - Historical Hurricane Events

Category	Wind Speeds (US 1-min average)	Damage Potential	Damage Description (Wind only)	Historical Hurricane Category in Virginia (* indicates a Federal Disaster Declaration)
Tropical Depression Tropical Storm	<38 mph (TD) <33 kt <62 km/hr 39-73 mph (TS) 34-63 kt 63 – 118 km/hr	Negligible	Wind effects: Scattered trees down, scattered power outages, some roads blocked due to downed trees and power lines. For example, neighborhoods could lose power for several days. This damage description is more likely associated with a tropical storm than a tropical depression.	Hurricane Diane (8/17/1955) Hurricane Camille (8/20/1969) Tropical Storm Doria (8/27/1971) Tropical Storm Agnes (6/21/1972)* Hurricane Hugo (9/9/1989) Hurricane Bertha (7/12-13/1996) Hurricane Fran (9/5-6/1996)* Hurricane Danny (7/24/1997) Hurricane Dennis (9/4-5/1999)* Hurricane Charley (8/14/2004) Hurricane Gaston (8/29/2004) Hurricane Frances (9/8/2004) Hurricane Ivan (9/17/2004) Hurricane Jeanne (9/28/2004) Tropical Storm Ernesto (9/1/2006)* Tropical Storm Lee (9/8-9/2011)* Hurricane Matthew (10/9/2016) *
1	74 – 95 mph 64-82 kt 119-153 km/hr	Minimal	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, and vinyl siding and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.	Chesapeake-Potomac Hurricane of 1933 Hurricane Hazel (10/15/1954) Hurricane Charley (9/17/1986 Hurricane Bonnie (8/27/1998)* Hurricane Floyd (9/15-16/1999)* Hurricane Isabel (9/18/2003)* Hurricane Irene (8/27/2011) *
2	96 – 110 83-95 kt 154-177 km/hr	Moderate	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.	Hurricane Donna (9/12/1960) Hurricane Gloria (9/27/1985) Hurricane Sandy (10/26-11/8/2012) *
3 (major)	111 – 129 mph 96 - 112 kt 178 - 208 km/hr	Extensive	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.	The Great Hurricane (9/14/1944)
4 (major)	130 – 156 mph 113-136 kt 209-251 km/hr	Extreme	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.	Hurricane Helene (9/27-28/1958)
5 (major)	> 157 mph > 137 kt >252 km/hr	Catastrophic	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.	Meteorologists consider the water off the Virginia coast too cool to support a Category 5 storm.

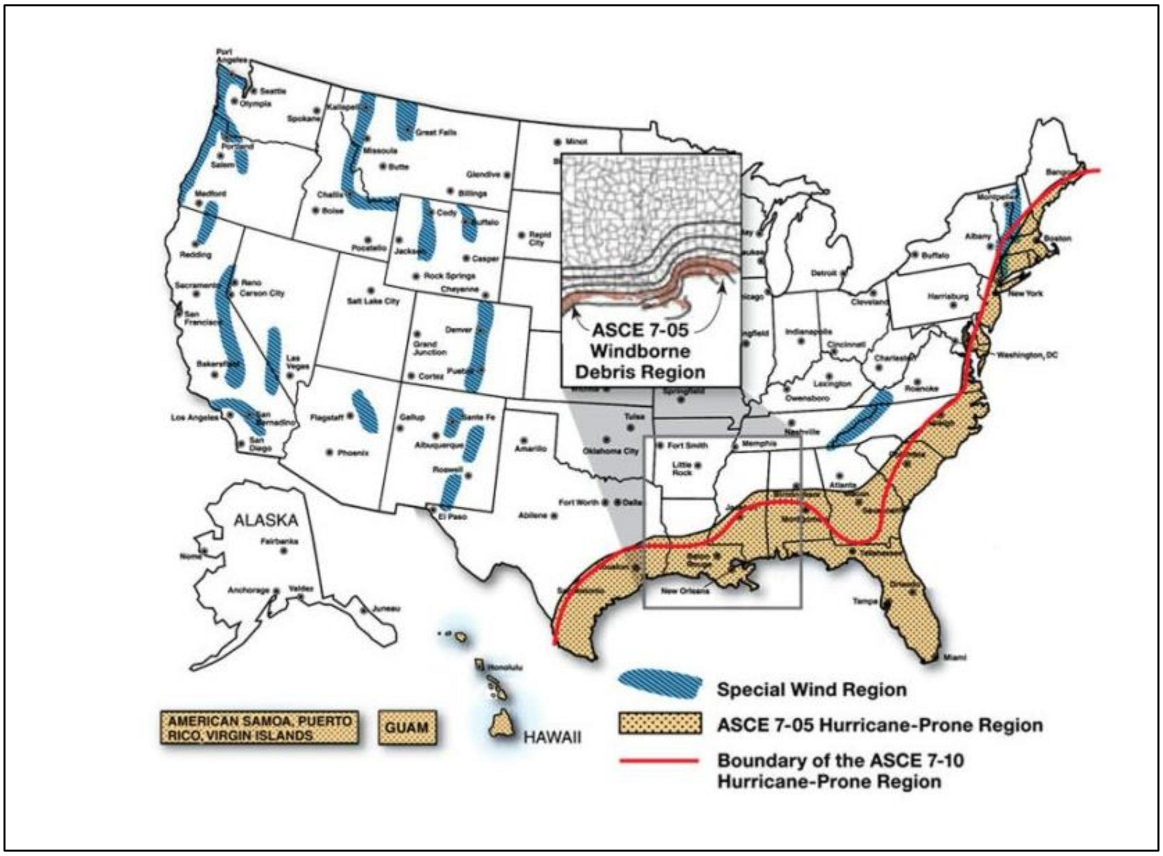
Figure 3-89 - Chesapeake Bay Maximum of the Maximum (MOM) Storm Surge for Category 1-4 Hurricane, NOAA



3.8.7.2 Location and Spatial Extent

Hurricane impacts can be felt throughout the entire Commonwealth. Typically, the two dominant impacts by hurricane are flooding (coastal or riverine) and wind. Hurricanes can make landfall south of Virginia, so winds in Hampton Roads start from the northeast and then shift as the storm moves north. In addition, hurricanes can come up from the South Atlantic and brush the coast of Virginia. They can move up from the Gulf over land through various terrain, including mountainous areas, although this may lessen the high wind field, still pose a hazard to structures outside of the ASCE 7-05 hurricane-prone region that typically occurs along the coast (Figure 3-90). Structures inland, for example mobile homes, outside of the ASCE 7-05 hurricane-prone region may not be constructed to withstand this type of event.

Figure 3-90 - ASCE Hurricane Prone Regions within the U.S.



Source: Office of Energy Efficiency & Renewable Energy. [Hurricane-Prone Regions of the United States with ASCE 7-05 and 7-10 Boundaries | Building America Solution Center (pnnl.gov)]

3.8.7.3 Significant Historical Events

The NWS began keeping weather records on January 1, 1871. Prior to that, information on past hurricanes that impacted Virginia were taken from ships logs, accounts from local citizens, newspapers, and other sources. There are several historical references to major storms that affected coastal Virginia in the 1600's and 1700's. Some of these storms were strong enough to alter land masses, including the widening of the Lynnhaven River (September 6, 1667) and formation of Willoughby Spit (October 19, 1749). These reports also indicate severe flooding caused by these storms (12-15 feet of flooding in some cases).

As expected, most hurricanes affect eastern Virginia due to its proximity to the coast. However, it is not uncommon for hurricanes and tropical storms to track through the state and impact non-coastal jurisdictions. NCEI includes information on hurricane events and their effects. The events included in Table 3-66 summarize some of the major non-rotational wind events that have historically affected Virginia. Federally declared hurricane and other non-rotational wind related events are listed in Section 3.4. Figure 3-90 shows the paths of historical hurricanes that have passed through Virginia.

Table 3-66 - Historical Tropical Storm Events (1749-2021)

Year	System Name	Description
1749	None	A tremendous hurricane created Willoughby Spit, south of Hampton. The Bay rose 15 feet above normal. In Williamsburg, a family drowned as floodwaters carried their house away. At Hampton, water rose to four feet deep in the streets; many trees were uprooted or snapped in two. Bodies washed ashore from shipwrecks for days afterward.
1769	None	A strong hurricane struck near Williamsburg causing “inconceivable” damages to homes and crops. Many ships on the Chesapeake were damaged by storm winds and waves.
1806	Great Hurricane of 1806	A slow-moving storm completed the creation of Willoughby Spit, damaged warships, and damaged a seawall.
1878	Gale of ‘78	A strong hurricane moved quickly from the Bahamas up the North Carolina Coast through the eastern portion of the state, completely submerging Cobb and Smith Islands in the Chesapeake Bay. (Middle Peninsula).
1933	Chesapeake-Potomac Storm of ‘33	Record high tides in many locations; approximately 9.8 feet above mean lower low water. There were four casualties on the Peninsula: two in Hampton, one in James City County, and one in York County. At Buckroe Beach in Hampton, and at Yorktown, martial law was declared, and National Guard troops were brought in to prevent looting. Flooding was severe in low- lying parts of Hampton (Fox Hill and Buckroe), York County (Goodwin Neck), and Newport News (Small Boat Basin). Jamestown Island was severely damaged.
1954	Hurricane Hazel	Hurricane Hazel inflicted strong winds on Hampton and blew apart at least one anemometer there. There was one casualty on the Peninsula in the Dare section of York County.
1955	Hurricanes Connie and Diane	Five days after Hurricane Connie, Diane made landfall in North Carolina as a Category 1 and moved North across Central Virginia. Five to ten inches of rain fell along the Blue Ridge Mountains. Hurricane Connie and Diane are attributed to the record rainfall in August of that year. Statewide damages totaled $1.5 million.
1957	Nor’easter	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)
1969	Hurricane Camille	Hurricane Camille described earlier in the discussion on federal disaster declarations and in flooding.
1972	Hurricane Agnes	Hurricane Agnes is described earlier in the discussion on federal disaster declarations and in flooding.
1996	Hurricane Fran	Hurricane Fran described earlier in the discussion on federal disaster declarations.
1998	Nor’easter	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)
1999	Hurricane Floyd	Hurricane Floyd described earlier in the discussion on federal disaster declarations.
2003	Hurricane Isabel	Hurricane Isabel described earlier in the discussion on federal disaster declarations.
2004	Tropical Depression Gaston	Tropical Depression Gaston described earlier in the discussion on federal disaster declarations.
2006	Nor’easter	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 stage is 12 feet).
2006	Tropical Storm Ernesto	Tropical Storm Ernesto described in the discussion of federal disaster declarations.
2009	Nor’easter and Remnants of Tropical Depression Ida	Nor’easter and remnants of Tropical Depression Ida described in the discussion of federal disaster declarations. Not to be confused with Hurricane Ida that occurred in 2021.
2011	Hurricane Irene	Hurricane Irene described in the discussion of federal disaster declarations.
2011	Remnants of Tropical Storm Lee	Tropical Storm Lee described in the discussion of federal disaster declarations.

Year	System Name	Description
2012	Hurricane Sandy	Hurricane Sandy described in the discussion of federal disaster declarations.
2016	Hurricane Matthew	Hurricane Matthew described in the discussion of the federal disaster declarations.
2018	Hurricane Florence	Hurricane Florence described in the discussion of the federal disaster declarations.
2018	Hurricane Michael	Hurricane Michael described in the discussion of the federal disaster declarations.

Figure 3-91 - Virginia Hurricane History (1852-2021)

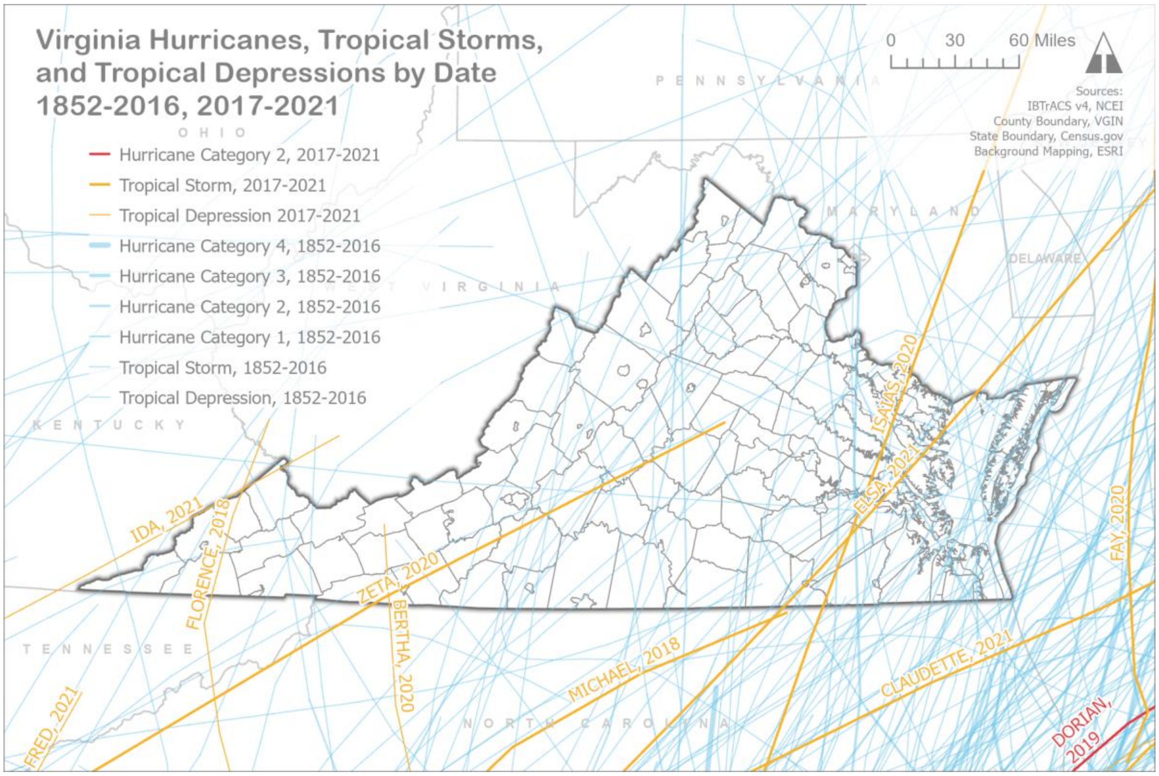


Figure 3-92 shows Hurricane Hazel and Figure 3-93 shows Hurricane Camille. These are included to provide examples of historical hurricane events that affected Virginia. These figures identify the main path of the storms and the peak gusts that jurisdictions may have experienced. Hazus was used to simulate these historical occurrences. These figures were originally created for the 2013 version of this plan but remain useful. While Camille did cause severe inland winds, the resulting rainfall, flash flooding, debris flows and riverine flooding contributed most significantly to the damages sustained.

Figure 3-92 - Historical Occurrence: 1954 - Hurricane Hazel Peak Gusts

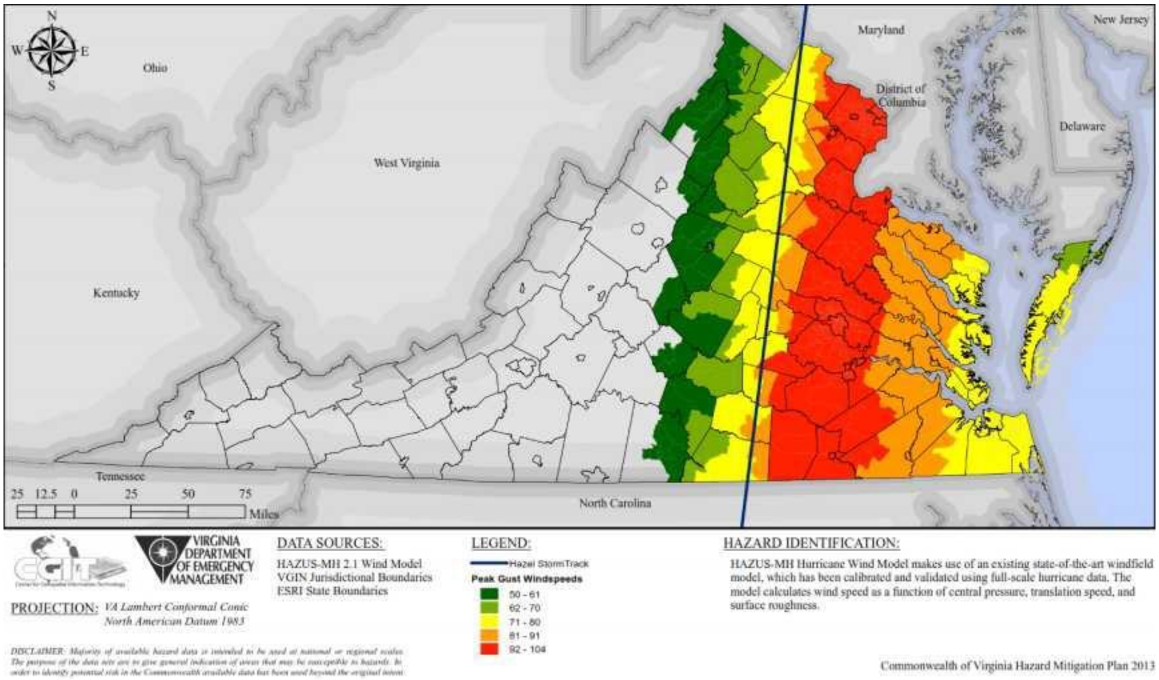
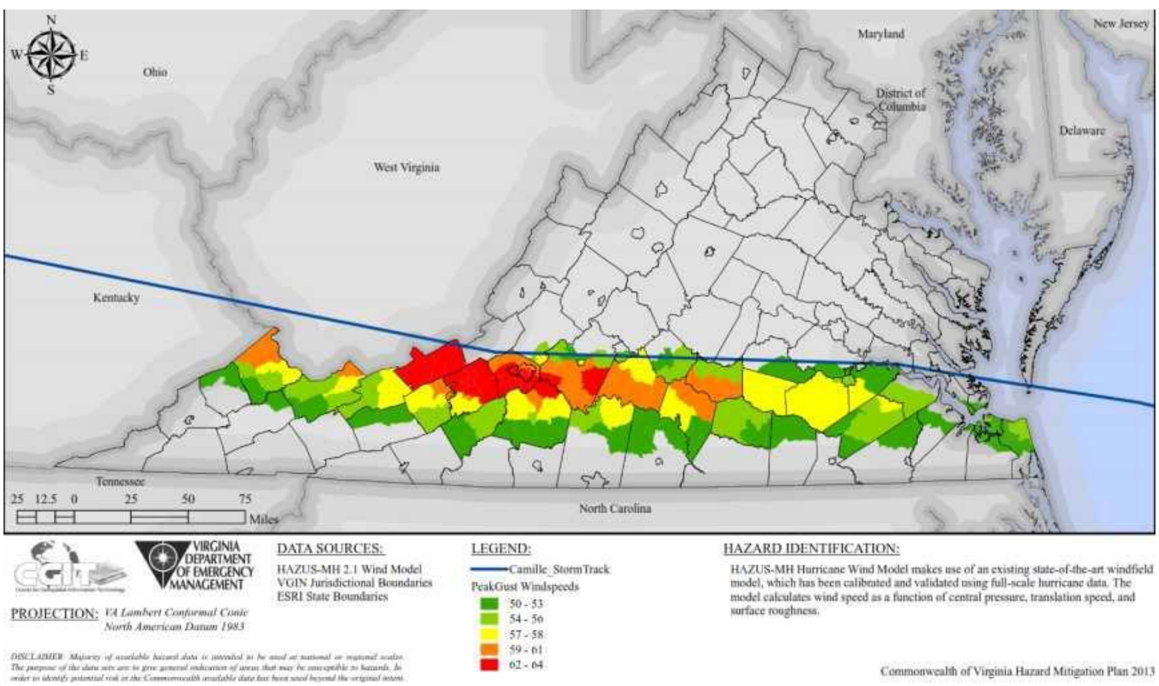


Figure 3-93 - Historical Occurrence: 1969 - Hurricane Camille Peak Gusts



3.8.7.4 Probability of Future Occurrence

FEMA's Hazus Level 1 hurricane model was used to estimate annualized losses for the Commonwealth. Hazus allows users to estimate hurricane winds and potential damage and loss to residential, commercial, and industrial buildings. The model makes use of state-of- the-art wind field models, calibrated and validated using full-scale hurricane data. Wind speed has been calculated as a function of central pressure, translation speed, and surface roughness.

Hazus was used to determine the 100-year probabilistic return period for each VDEM region. Geographic extent has been based off these values for determining risk and ranking. This represents the wind peak gusts that have a one percent annual probability of occurrence. The one-percent annual probability wind speed is the estimated 3-second gust in open terrain at ten meters above ground at the center of each census tract. Figure 3-94 through Figure 3-100 illustrate the 100-year probabilistic return period wind speeds for each VDEM region.

Figure 3-94 - 1-Percent-Annual-Chance Wind Speeds – VDEM Region 1c

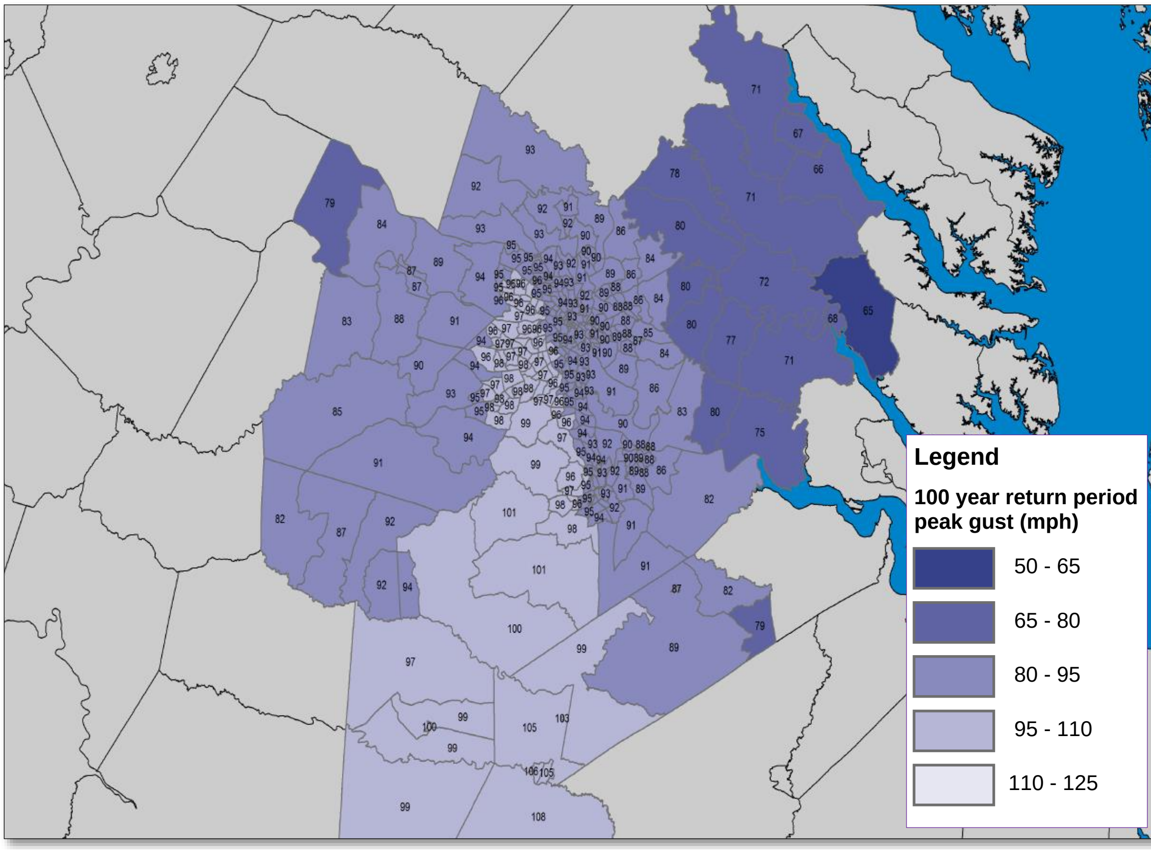


Figure 3-95 - Hazus – 1-Percent-Annual-Chance Wind Speeds – VDEM Region 2

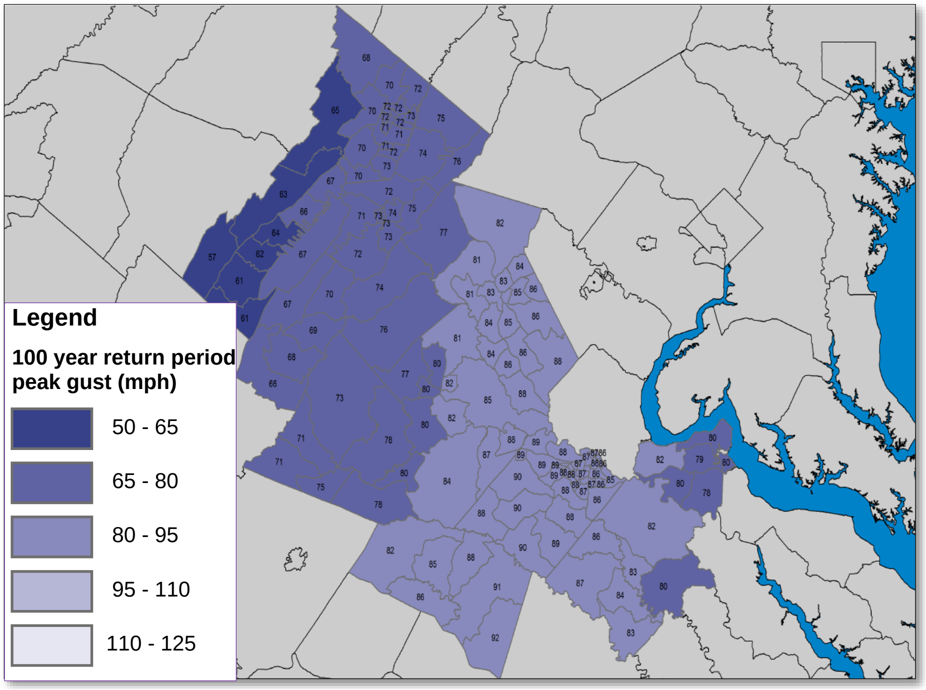


Figure 3-96 - Hazus – 1-Percent-Annual-Chance Wind Speeds – VDEM Region 3

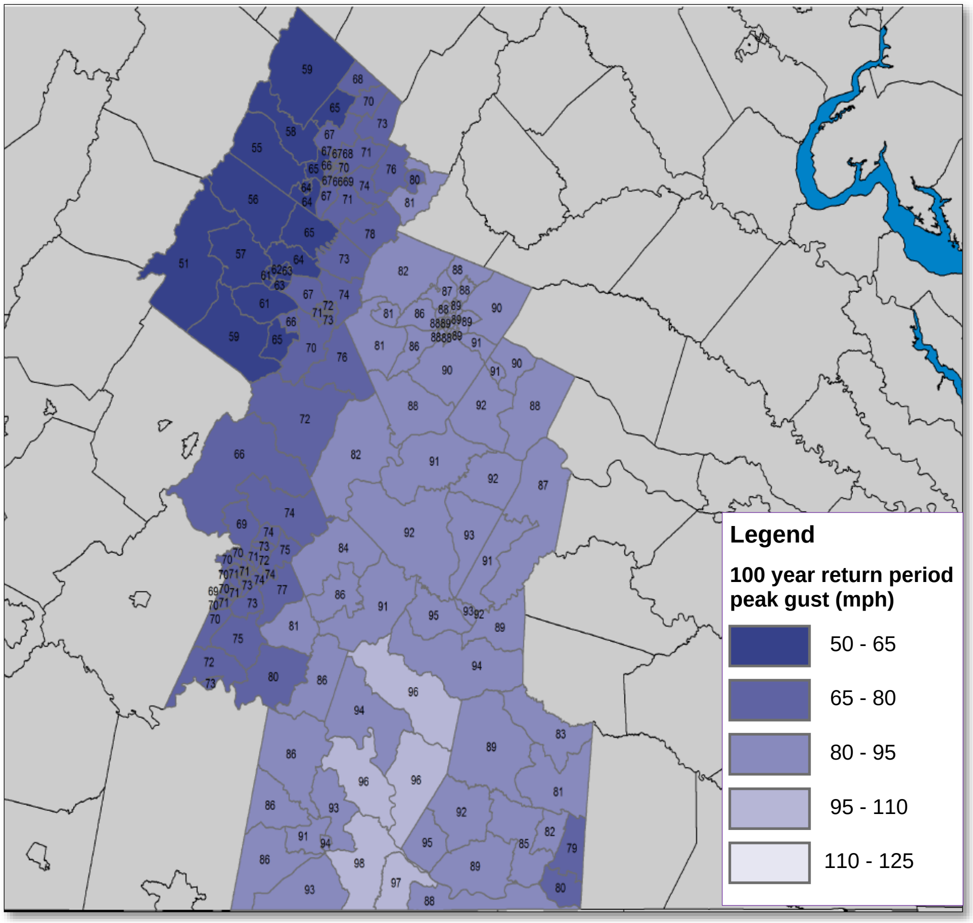


Figure 3-97 - Hazus – 1-Percent-Annual-Chance Wind Speeds – VDEM Region 4

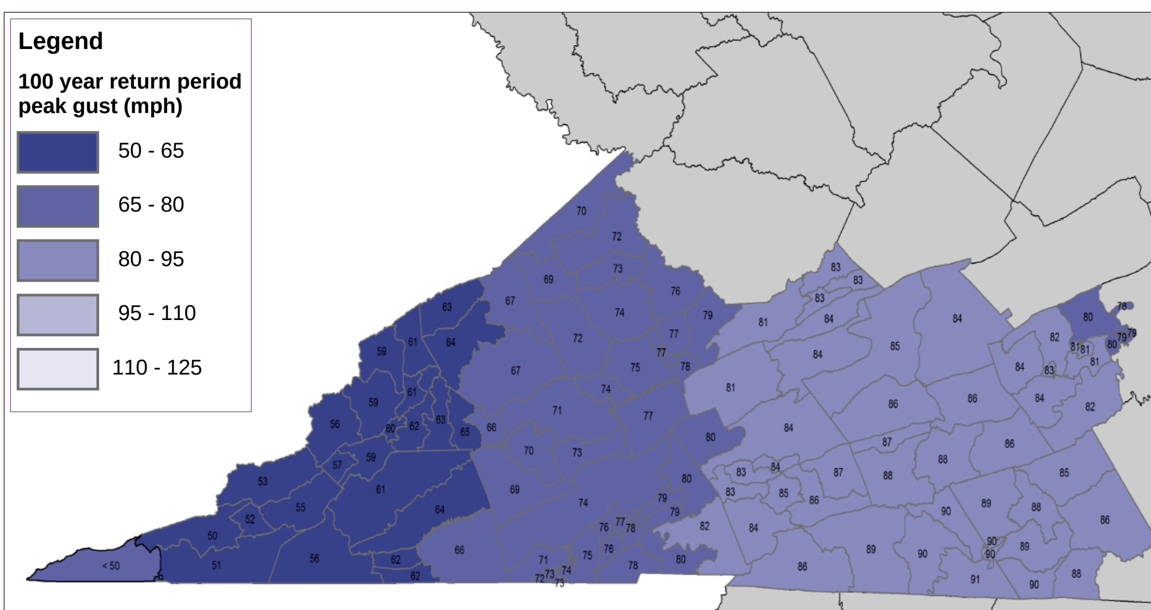


Figure 3-98 - Hazus – 1-Percent-Annual-Chance Wind Speeds – VDEM Region 5

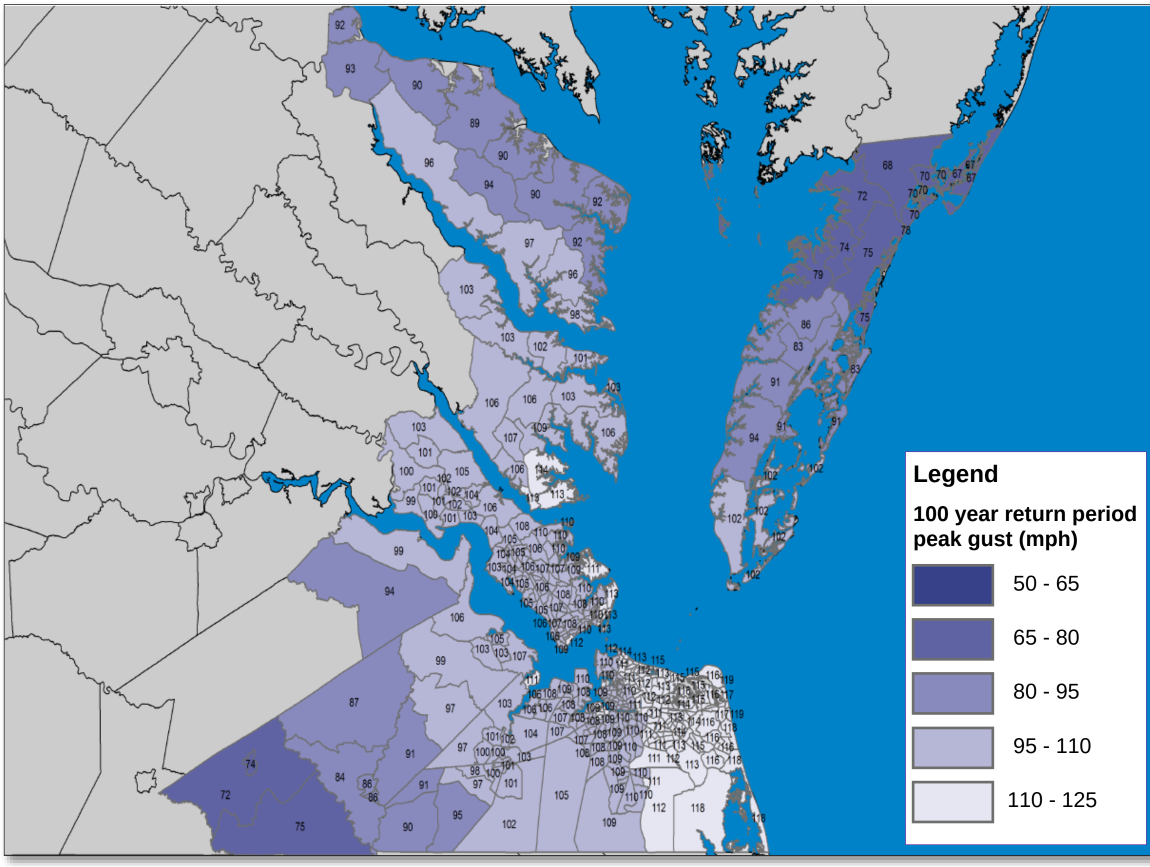


Figure 3-99 - Hazus – 1-Percent-Annual-Chance Wind Speeds – VDEM Region 6

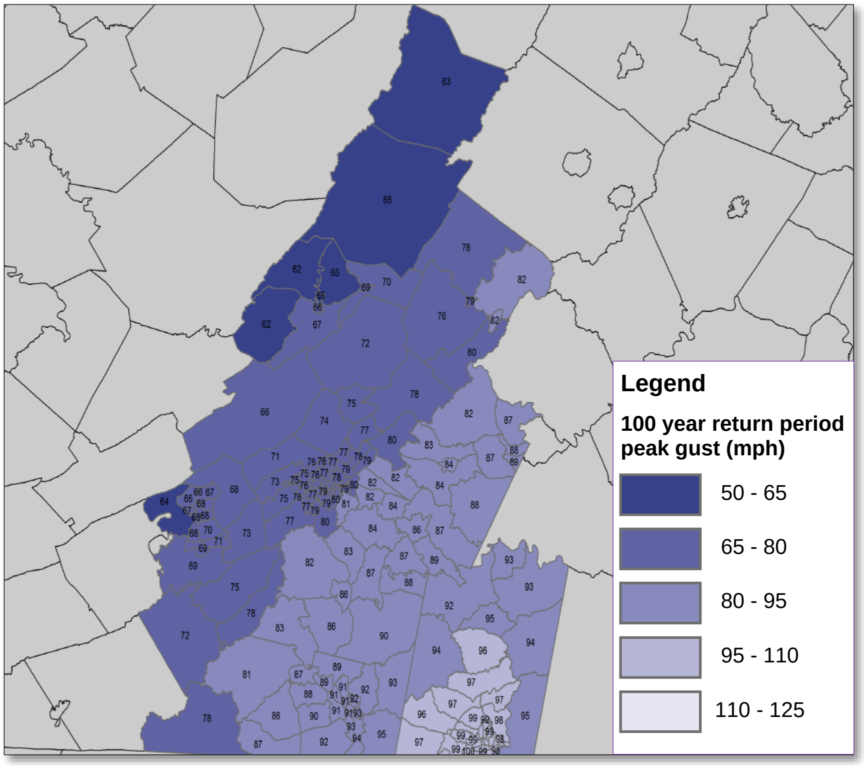
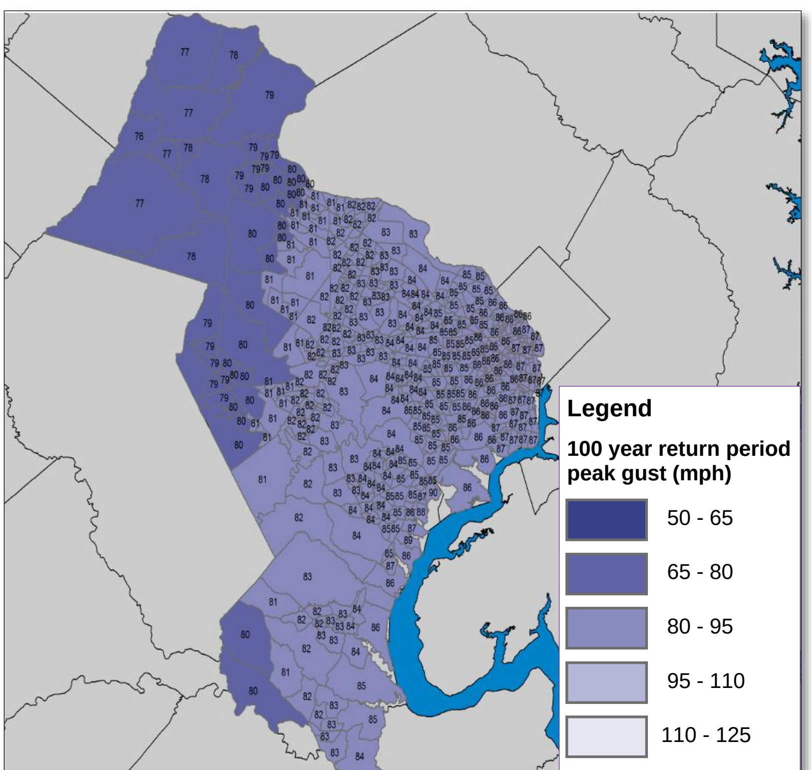


Figure 3-100 - Hazus – 1-Percent-Annual-Chance Wind Speeds – VDEM Region 7



Impact and Vulnerability

Vulnerability and impact were quantified in terms of population and property for hurricane winds using Hazus modeling. The *Hurricane Description* section illustrates the potential impacts, including injuries and damages to property, based on different hurricane category events.

The high winds associated with hurricanes may also disrupt the distribution of gasoline, kerosene, diesel fuel, fuel oils, propane and other petroleum products. This disruption could cause major problems for organizations and businesses that rely on such supplies. Additionally, such a disruption could affect backup power generation.

Risk

For the 2023 plan, the overall hazard ranking for Hurricane is high.

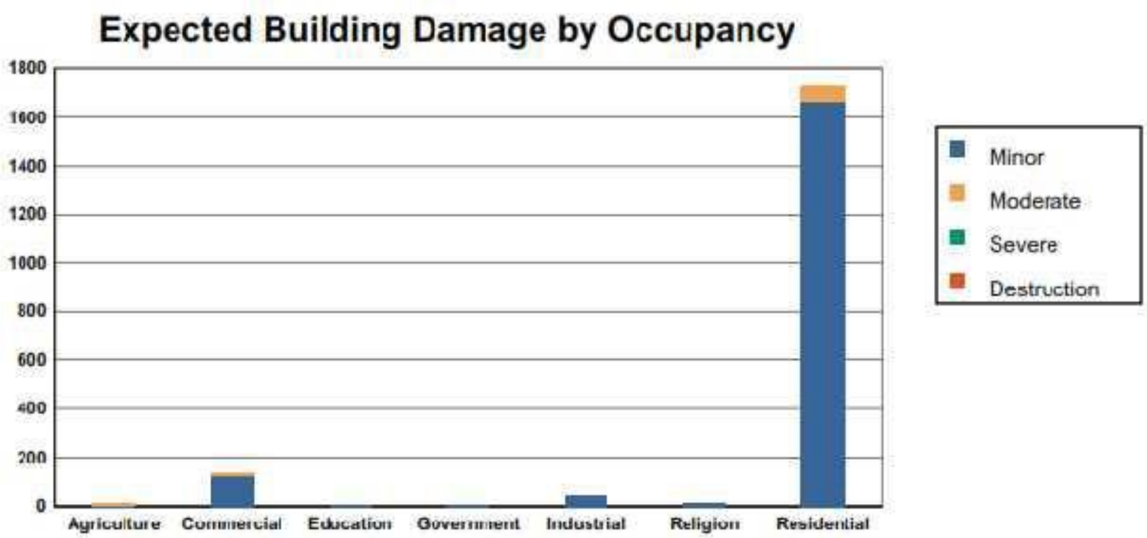
Hazus was used to model the impacts of a 1-percent-annual-chance hurricane for each of the VDEM regions. The results are summarized below and include an indication of building damages, debris, social impacts and economic impacts.

3.8.7.5 Hurricane Hazus Model – 1-Percent-Annual-Chance Return Period for VDEM Region 1

Building Damages

Hazus estimated that at least 65 buildings would be at least moderately damaged by the event; this is less than one percent of the buildings in Virginia. No buildings would be damaged beyond repair. Figure 3-101 shows the distribution of damage by type of occupancy. As the figure shows, most building damage is expected to be in residential structures.

Figure 3-101 - VDEM Region 1 Hurricane Scenario – Expected Building Damage by Occupancy (1-Percent-Annual-Chance Probabilistic Event)



Essential Facility Damage

Hazus estimated that 5,926 beds would be available for use by patients already in the hospital and those injured by the hurricane. After seven days, 100 percent of the beds would be in service. Within 30 days, 100 percent would be available.

Debris Generated

Hazus estimated that a total of 566,447 tons of debris would be generated by the event. Of that amount, 90 percent would be other tree debris, one percent would be brick/wood, and nine percent would be eligible tree debris. Assuming a load of 25 tons per truck, this would equate to 290 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced as a result of the scenario event. The model estimated that no households would be displaced, and no people would seek temporary shelter in the region.

Economic Losses

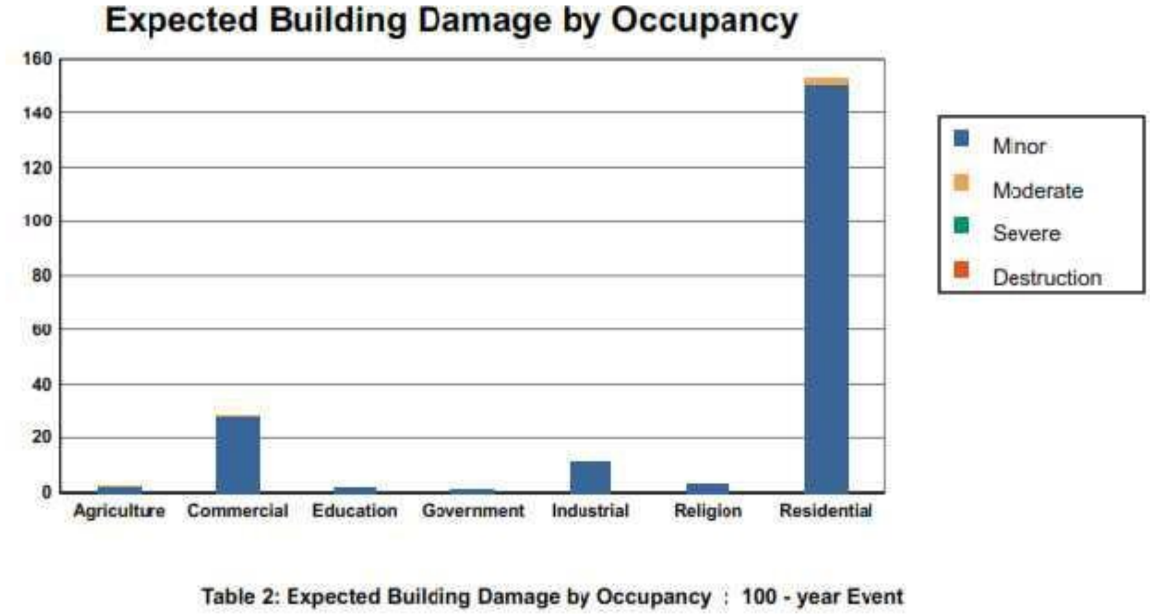
Finally, Hazus estimated economic losses for the scenario event. Hazus estimated losses at $177.7 million, which represents less than one percent of the total replacement value of the region's buildings. No losses were related to business interruption in the scenario region. 98 percent of the losses were sustained by residential structures.

3.8.7.6 Hurricane Hazus Model - 1-Percent-Annual-Chance Return Period for VDEM Region 2

Building Damages

Hazus estimated that at least two buildings would be at least moderately damaged by the event; this is less than one percent of the buildings in Virginia. No buildings would be damaged beyond repair. Figure 3-102 shows the distribution of damage by type of occupancy.

Figure 3-102 - VDEM Region 2 Hurricane Scenario – Expected Building Damage by Occupancy (1-Percent-Annual-Chance Probabilistic Event)



Essential Facility Damage

Hazus estimated that the region has 1,078 hospital beds for use before the hurricane. On the day of the event, Hazus estimated that 1,078 beds would be available for use by patients already in the hospital and those injured by the hurricane. After seven days, 100 percent of the beds would be in service.

Debris Generated

Hazus estimated that a total of 144,237 tons of debris would be generated by the event. Of that amount, 92 percent would be other tree debris, four percent would be brick/wood, and four percent eligible tree debris. Assuming a load of 25 tons per truck, this would equate to 19 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced as a result of the scenario event. The model estimated that no households would be displaced, and no people would seek temporary shelter in public shelters. However, per the VA HES, mobile home parks in the zones may result in some people seeking temporary shelter due to the wind threat from a hurricane.

Economic Losses

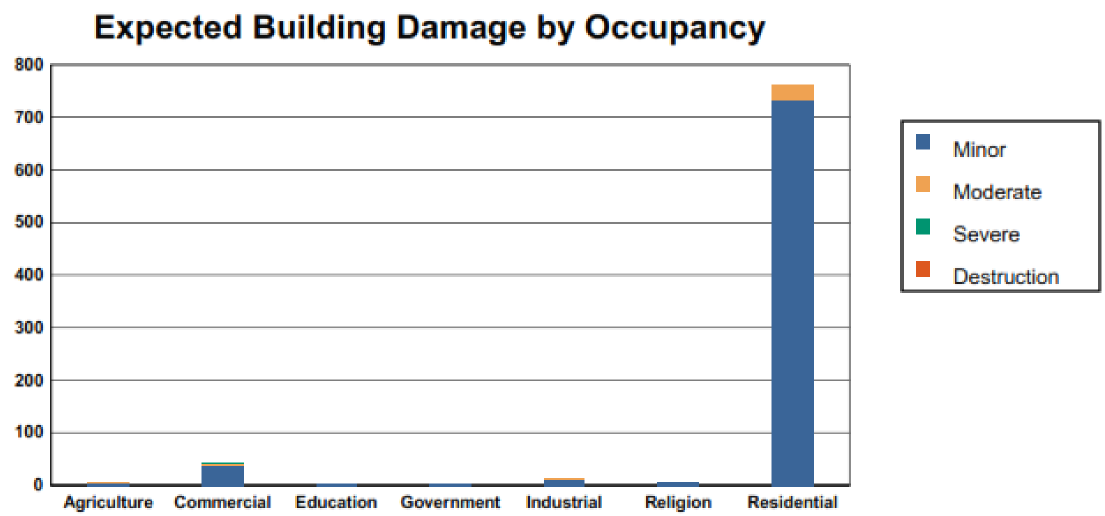
Finally, Hazus estimated economic losses for the scenario event. Hazus estimated losses at $38.9 million, which represents one half percent of the total replacement value of the region's buildings. None of the losses were related to business interruption in the scenario region. 99 percent of the losses were sustained by residential structures.

3.8.7.7 Hurricane Hazus Model- 1-Percent-Annual-Chance Return Period for VDEM Region 3

Building Damages

Hazus estimated that at least 30 buildings would be at least moderately damaged by the event; this is less than one percent of the buildings in Virginia. No buildings would be damaged beyond repair. Figure 3-103 shows the distribution of damage by type of occupancy.

Figure 3-103 - VDEM Region 3 Hurricane Scenario – Expected Building Damage by Occupancy (1-Percent-Annual-Chance Probabilistic Event)



Essential Facility Damage

Hazus estimated that the region has 3,769 hospital beds for use before the hurricane. On the day of the event, Hazus estimated that 3,769 beds would be available for use by patients already in the hospital and those injured by the hurricane. After seven days, 100 percent of the beds would be in service.

Debris Generated

Hazus estimated that a total of 581,703 tons of debris would be generated by the event. Of that amount, 93 percent would be other tree debris, five percent would be brick/wood, and two percent eligible tree debris. Assuming a load of 25 tons per truck, this would equate to 78 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced as a result of the scenario event. The model estimated that one household would be displaced, but that no people would seek temporary shelter in public shelters. However, per the VA HES, mobile home parks in the zones may result in some people seeking temporary shelter due to the wind threat from a hurricane.

Economic Losses

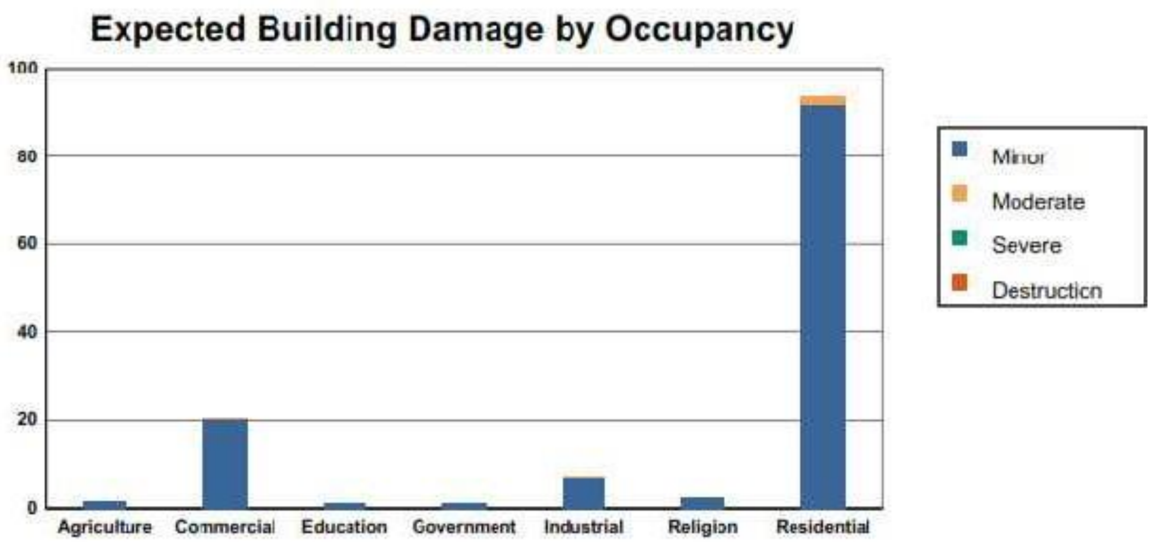
Finally, Hazus estimated economic losses for the scenario event. Hazus estimated losses at $50 million, which represents approximately one-half percent of the total replacement value of the region's buildings. No losses were related to business interruption in the scenario region. 99 percent of the losses were sustained by residential structures.

3.8.7.8 Hurricane Hazus Model- 1-Percent-Annual-Chance Return Period for VDEM Region 4

Building Damages

Hazus estimated that at least two buildings would be at least moderately damaged by the event; this is less than one percent of the buildings in Virginia. No buildings would be damaged beyond repair. Figure 3-104 shows the distribution of damage by type of occupancy.

Figure 3-104 - VDEM Region 4 Hurricane Scenario – Expected Building Damage by Occupancy (1-Percent-Annual-Chance Probabilistic Event)



Essential Facility Damage

Hazus estimated that the region has 1,920 hospital beds for use before the hurricane. On the day of the event, Hazus estimated that 1,920 beds would be available for use by patients already in the hospital and those injured by the hurricane. After seven days, 100 percent of the beds would be in service.

Debris Generated

As part of the model, Hazus estimated the amount of debris that would be generated by the event. The types of debris considered were brick/wood, reinforced concrete/steel, eligible tree debris, and other tree debris. Hazus estimated that a total of 699 tons of debris would be generated by the event. Of that amount, 33 percent would be other tree debris, 65 percent would be brick/wood, and two percent eligible tree debris. Assuming a load of 25 tons per truck, this would equate to 12 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced as a result of the scenario event. The model estimated that no households would be displaced, and no people would be expected to seek temporary shelter in public shelters. However, per the VA HES, mobile home parks in the zones may result in some people seeking temporary shelter due to the wind threat from a hurricane.

Economic Losses

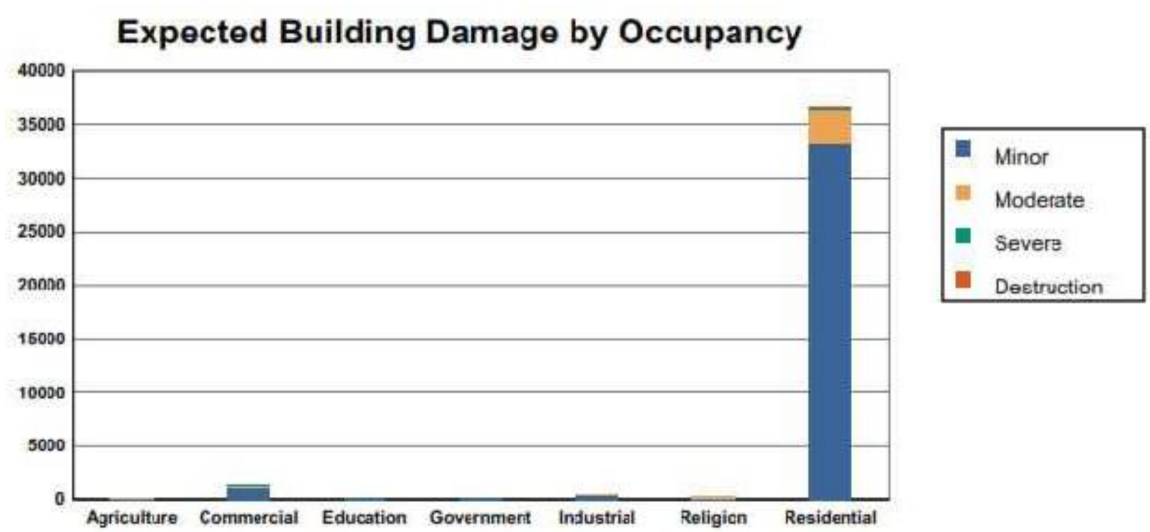
Finally, Hazus estimated economic losses for the scenario event. Hazus estimated losses at $7.7 million, which represents less than one half percent of the total replacement value of the region's buildings. One percent of the losses were related to business interruption in the scenario region. 95 percent of the losses were sustained by residential structures.

3.8.7.9 Hurricane Hazus Model- 1-Percent-Annual-Chance Return Period for VDEM Region 5

Building Damages

Hazus estimated that at least 3,611 buildings would be at least moderately damaged by the event; this is more than one percent of the buildings in Virginia. 38 buildings would be damaged beyond repair. Figure 3-105 shows the distribution of damage by type of occupancy. As the figure shows, most building damage was found to be in residential structures.

Figure 3-105 - VDEM Region 5 Hurricane Scenario – Expected Building Damage by Occupancy (1-Percent-Annual-Chance Probabilistic Event)



Essential Facility Damage

Hazus estimated that the region has 5,844 hospital beds for use before the hurricane. On the day of the event, Hazus estimated that 5,391 beds would be available for use by patients already in the hospital and those injured by the hurricane. After seven days, 100 percent of the beds would be in service.

Debris Generated

Hazus estimated that a total of 1,550,298 tons of debris would be generated by the event. Of that amount, 77 percent would be other tree debris, eight percent would be brick/wood, and 15 percent eligible tree debris. Assuming a load of 25 tons per truck, this would equate to 4,924 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced as a result of the scenario event. The model estimated that 838 households would be displaced. Of these, 205 people would be expected to seek temporary shelter in public shelters. Based on the 2010 Census population of 1,782,229, this equates to one- tenth percent of the region's population. Per the VA HES, mobile home parks may also result in additional people seeking temporary shelter due to the wind threat from a hurricane.

Economic Losses

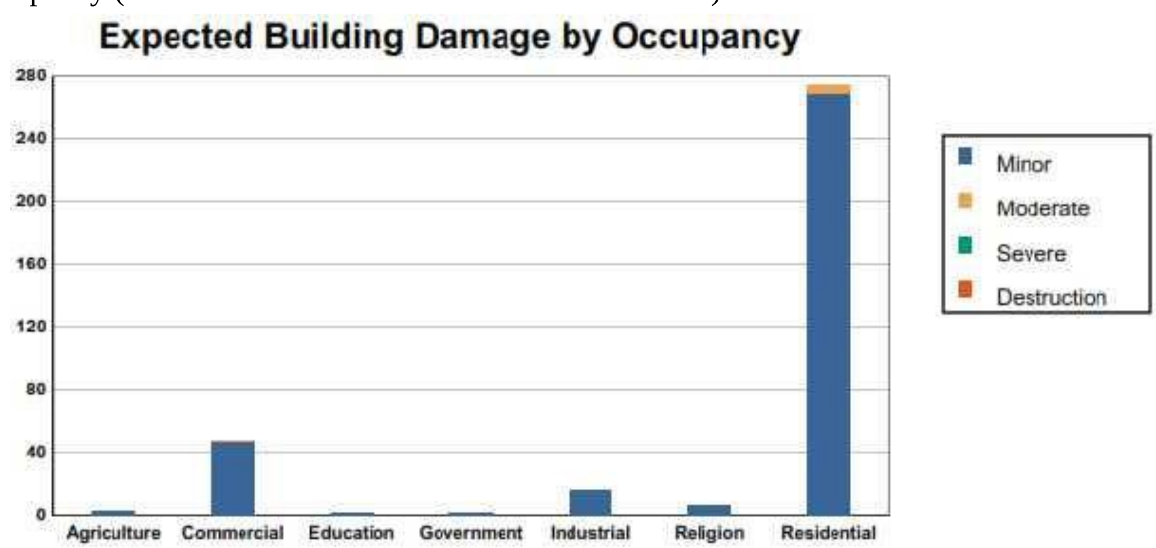
Finally, Hazus estimated economic losses for the scenario event. Hazus estimated losses at $1.845 billion, which represents almost one percent of the total replacement value of the region's buildings. One percent of the losses were related to business interruption in the scenario region. 96 percent of the losses were sustained by residential structures.

3.8.7.10 Hurricane Hazus Model- 100 Year Return Period for VDEM Region 6

Building Damages

Hazus estimated that at least five buildings would be at least moderately damaged by the event; this is a negligible percentage of the buildings in Virginia. No buildings would be damaged beyond repair. Figure 3-106 shows the distribution of damage by type of occupancy.

Figure 3-106 - VDEM Region 6 Hurricane Scenario – Expected Building Damage by Occupancy (1-Percent-Annual-Chance Probabilistic Event)



Essential Facility Damage

Hazus estimated that the region has 2,717 hospital beds for use before the hurricane. On the day of the event, Hazus estimated that 2,717 beds would be available for use by patients already in the hospital and those injured by the hurricane. After seven days, 100 percent of the beds would be in service.

Debris Generated

Hazus estimated that a total of 46,413 tons of debris would be generated by the event. Of that amount, 86 percent would be other tree debris, almost three percent would be brick/wood, and 11.2 percent eligible tree debris. Assuming a load of 25 tons per truck, this would equate to 51 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced as a result of the scenario event. The model estimated that no households would be displaced, and no residents would be expected to seek temporary shelter in public shelters. However, per the VA HES, mobile home parks in the zones may result in some people seeking temporary shelter due to the wind threat from a hurricane.

Economic Losses

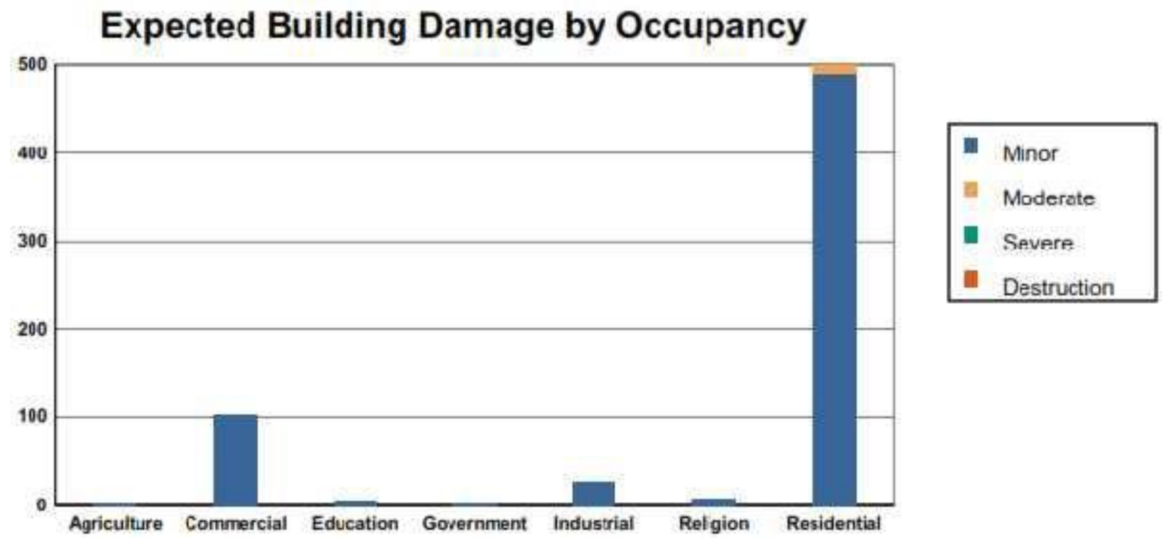
Finally, Hazus estimated economic losses for the scenario event. Hazus estimated losses at $28.1 million, which represents approximately one quarter percent of the total replacement value of the region's buildings. One percent of the losses were related to business interruption in the scenario region. 97 percent of the losses were sustained by residential structures.

3.8.7.11 Hurricane Hazus Model- 1-Percent-Annual-Chance Return Period for VDEM Region 7

Building Damages

Hazus estimated that at least ten buildings would be at least moderately damaged by the event; this a negligible percentage of the buildings in Virginia. No buildings would be damaged beyond repair. Figure 3-107 shows the distribution of damage by type of occupancy.

Figure 3-107 - VDEM Region 7 Hurricane Scenario – Expected Building Damage by Occupancy (1-Percent-Annual-Chance Probabilistic Event)



Essential Facility Damage

Hazus estimated that the region has 2,857 hospital beds for use before the hurricane. On the day of the event, Hazus estimated that 2,857 beds would be available for use by patients already in the hospital and those injured by the hurricane. After seven days, 100 percent of the beds would be in service.

Debris Generated

Hazus estimated that a total of 23,340 tons of debris would be generated by the event. Of that amount, 58 percent would be other tree debris, 7.5 percent would be brick/wood, and 34.4 percent eligible tree debris. Assuming a load of 25 tons per truck, this would equate to 70 truckloads of debris from this scenario.

Social Impacts

Hazus estimated the number of households and people that would be expected to be displaced as a result of the scenario event. The model estimated that no households would be displaced, and that no people would be expected to seek temporary shelter in public shelters. However, per the VA HES, mobile home parks in the zones may result in some people seeking temporary shelter due to the wind threat from a hurricane.

Economic Losses

Finally, Hazus estimated economic losses for the scenario event. Hazus estimated losses at $95.1 million, which represents approximately one quarter percent of the total replacement value of the region's buildings. One percent of the losses were related to business interruption in the scenario region. 97 percent of the losses were sustained by residential structures.

Risk

HAZUS losses and damages for each of the VDEM regions is summarized below. Table 3-67 highlights the building damages (moderate), tons of debris generated, number of displaced households, and estimated losses calculated to 2022 values. Overall, VDEM Region 5 has the greatest estimated losses due to hurricanes as this region covers the areas along the open coast and the Chesapeake Bay, including Virginia Beach, Norfolk, and Hampton which are at higher risk to impacts of hurricanes (wind and storm surge).

Table 3-67 - HAZUS Hurricane Risk Summary, 100-Year Event

VDEM Region	1	2	3	4	5	6	7
Buildings Moderately Damaged	65	2	30	2	3,611	5	10
Tons of Debris Generated	566,447	144,237	581,703	669	1,550,298	46,413	23,340
Displaced Households	0	0	1	0	838	0	0
Estimated Losses (2022 dollars)	$206.7 million	$45.3 million	$58.2 million	$9 million	$2.2 billion	$32.7 million	$95.1 million

3.8.7.12 State Facility Risk

For this plan update and Hazus scenario, hurricane-related losses to state facilities were not recalculated because the lack of building valuation data prevented improvements to the older data.

Table 3-68 shows the non-rotational wind risk to state facilities from the 2013 plan. Values have been updated to 2022 based on inflation.

Table 3-68 - Non-rotational wind risk to state facilities (based on 2013 data updated to 2022 values)

Hurricane Risk	Number of State Facilities		Building Value at Risk*	
	Count in Risk	Cumulative Count	Value in Risk Zone	Cumulative Value
High	313	313	$326,180,720	$326,180,720
Medium-High	3,264	3.577	$8,320,434,538	$8,646,615,258
Medium-Low	7,204	10,781	$22,611,526,713	$31,258,141,971
Low	2,212	12,993	$3,957,681,871	$35,215,823,843
Total	**12,993**		**$35,215,823,843**	

*Building value for all facilities not available
Building values at risk is based on what was available from VAPS.

3.8.7.13 Critical Facility Risk

Detailed information about the critical facilities was not available for this revision of the plan as discussed previously.

3.8.7.14 Hurricane Risk to Energy Pipelines

Strong wind associated with hurricanes can affect pipelines by damaging supporting infrastructure such as power and telephone and satellite communications. Some pipelines require above ground facilities like pump stations for their operations. Wind can damage these facilities, causing pipelines to be shutdown. In addition, severe wind events can make pipeline operation sites inaccessible, making it more difficult to fix the damaged equipment and restore operations. In some cases, pipeline operators may proactively shutdown pipeline operations prior to the onset of severe weather, to mitigate potential damages; this may cause supply interruptions. Flooding associated with hurricanes can also negatively impact pipeline infrastructure.

3.8.7.15 National Risk Index

The National Risk Index (NRI) includes three components: a *natural hazards component* (**Expected Annual Loss**), a *consequence enhancing component* (**Social Vulnerability**), and a *consequence reduction component* (**Community Resilience**). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index. For the purposes of this SHMP/HIRA update the qualitative summary for hurricane are reviewed for each community (county tract).

As shown in Figure 3-108, the greatest risk rating for hurricane identified along the open coast and portions of the Chesapeake Bay in areas like Northumberland, Lancaster, and Hampton.

Figure 3-108 - Hurricane Risk Map – NRI Risk Rating

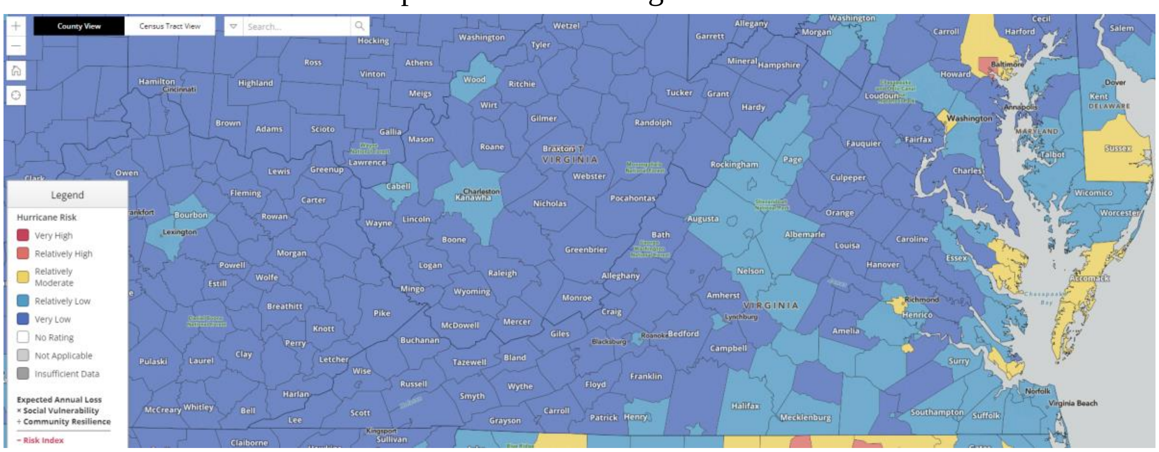


Table 3-69 - NRI Highest Risk Rating for Communities for Hurricane in Virginia

Rank	Community	Rating	Score (100 max)
1	Newport News City	Relatively Moderate	17.19
2	Hampton City	Relatively Moderate	14.84
3	Lancaster County	Relatively Moderate	13.77
4	Richmond City	Relatively Moderate	13.7
5	Petersburg City	Relatively Moderate	13.61
6	Northampton County	Relatively Moderate	12.85
7	Northumberland County	Relatively Moderate	11.58
8	Virginia Beach City	Relatively Low	9.2
9	Norfolk City	Relatively Low	8.77
10	Chesapeake City	Relatively Low	7.57

As discussed above, these measurements are calculated using average past conditions, but they cannot be used to predict future outcomes for a community. The National Risk Index is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies.

Future Conditions

Future climate model projections suggest that topical Atlantic Sea surface temperatures (SSTs) will warm dramatically during the 21st century, and that upper tropospheric temperatures will warm even more than SSTs. The models also project increasing levels of vertical wind shear over parts of the western topical Atlantic. Both the increased warming of the upper tropospheric temperatures relative to the surface and increased vertical wind shear are detrimental factors for hurricane development and intensification[5]. According to the 2022 Hampton Roads Hazard Mitigation Plan, it is likely that the region will be impacted by hurricanes and tropical storms in the future. The effects of smaller hurricanes (Categories 1 and 2 with wind speeds from 74-110 mph) and tropical storms (sustained wind speeds of at least 39 mph and torrential rains) will be frequent, as storms making landfall along the North Carolina and Virginia coastlines could occur in any given year.

Jurisdictional Risk

Probabilistic results represent a range of losses estimated from a simulation of expected hurricane activity. The results are based solely on the total direct losses for the entire study region. This ensures that all the results for a given period come from the same simulated event. Annualized losses are simply the total losses summed over the entire simulation period divided by the return period of the scenario. Annualized losses are very useful for comparing loss estimates from different locations or comparing the risks posed by different hazards at a single location.

The Commonwealth can expect $199,460,000 in total annualized damages estimated in Hazus. The coastal jurisdictions of VDEM Region 5 can expect $18.4 million in annualized damages. Damages range dramatically by jurisdiction. Communities in Southwest Virginia can expect less than $80,000 in annualized damages due to hurricane winds; Northern Virginia can expect $8.5

million in annualized damages. Table 3-70 shows the annualized loss results by VDEM region and jurisdiction.

Table 3-70 - Hazus Hurricane Wind Annualized Loss, by VDEM Region and Jurisdiction

VDEM Region	Jurisdiction	Hurricane Wind Annualized Loss Estimate
VDEM Region 1	Amelia	$11,883
	Brunswick	$15,535
	Charles City	$7,365
	Chesterfield	$401,677
	Colonial Heights	$24,506
	Dinwiddie	$27,895
	Emporia	$7,241
	Essex	$13,529
	Goochland	$31,649
	Greensville	$8,733
	Hanover	$146,298
	Henrico	$408,926
	Hopewell	$24,611
	King and Queen	$6,501
	King William	$18,852
	New Kent	$23,599
	Nottoway	$14,987
	Petersburg	$43,551
	Powhatan	$32,780
	Prince George	$35,137
	Richmond	$270,438
	Sussex	$9,761
VDEM Region 2	Caroline	$32,472
	Clarke	$22,066
	Culpeper	$55,302
	Fauquier	$104,412
	Frederick	$90,546
	Fredericksburg	$36,211
	Greene	$18,831
	King George	$29,955
	Louisa	$41,756
	Madison	$16,206
	Orange	$40,567
	Page	$25,329
	Rappahannock	$11,777
	Shenandoah	$62,131
	Spotsylvania	$153,562
	Warren	$48,056
	Winchester	$38,485
VDEM Region 3	Albemarle	$134,637
	Amherst	$32,294

VDEM Region	Jurisdiction	Hurricane Wind Annualized Loss Estimate
	Appomattox	$15,020
	Augusta	$77,929
	Buckingham	$11,954
	Campbell	$55,277
	Charlotte	$11,451
	Charlottesville	$55,277
	Cumberland	$9,801
	Fluvanna	$29,763
	Halifax	$35,533
	Harrisonburg	$51,506
	Lunenburg	$10,005
	Lynchburg	$91,622
	Mecklenburg	$34,893
	Nelson	$22,694
	Prince Edward	$20,140
	Rockingham	$81,727
	Staunton	$30,691
	Waynesboro	$26,145
VDEM Region 4	Bland	$6,244
	Bristol	$20,997
	Buchanan	$18,027
	Carroll	$28,509
	Dickenson	$11,150
	Galax	$9,266
	Grayson	$15,121
	Lee	$19,871
	Norton	$5,441
	Pulaski	$37,154
	Radford	$16,136
	Russell	$21,306
	Scott	$20,747
	Smyth	$29,485
	Tazewell	$39,622
	Washington	$58,014
	Wise	$32,629
	Wythe	$29,362
VDEM Region 5	Accomack	$42,064
	Chesapeake	$266,902
	Franklin	$9,114
	Gloucester	$44,283
	Hampton	$153,221
	Isle of Wight	$43,804
	James City	$100,341
	Lancaster	$19,286
	Mathews	$11,630

VDEM Region	Jurisdiction	Hurricane Wind Annualized Loss Estimate
	Middlesex	$16,838
	Newport News	$207,121
	Norfolk	$291,729
	Northampton	$15,795
	Northumberland	$21,873
	Poquoson	$16,834
	Portsmouth	$102,661
	Richmond	$9,091
	Southampton	$17,957
	Suffolk	$96,625
	Surry	$7,562
	Virginia Beach	$550,430
	Westmoreland	$26,146
	Williamsburg	$19,283
	York	$92,172
VDEM Region 6	Alleghany	$18,400
	Bath	$8,585
	Bedford	$84,917
	Botetourt	$42,432
	Buena Vista	$7,352
	Covington	$7,004
	Craig	$5,686
	Danville	$52,295
	Floyd	$14,322
	Franklin	$68,227
	Henry	$55,385
	Highland	$3,836
	Lexington	$9,729
	Martinsville	$19,976
	Montgomery	$99,293
	Patrick	$17,904
	Pittsylvania	$57,090
	Roanoke	$235,962
	Rockbridge	$26,044
	Salem	$35,288
VDEM Region 7	Alexandria	$231,504
	Arlington	$319,523
	Fairfax	$1,617,701
	Falls Church	$22,190
	Loudoun	$444,365
	Manassas	$48,240
	Manassas Park	$15,328
	Prince William	$505,334
	Stafford	$167,164

Annualized damages were also calculated based on NCEI crop and property damages. The Commonwealth can expect approximately $25,630,543 in damages per year from hurricane wind events. NCEI annualized damages have been calculated by dividing the total damages statewide by the period of record. Multiple factors account for the differences in the two annualized loss values. While NCEI's data is based on reported estimates, the Hazus results are based on a highly developed model using Census tract data and estimates of hurricane winds to come up with potential damage. Hazus total direct economic loss includes damage to structural, non-structural, building contents, inventory loss, relocation, income loss, rental loss, and wage loss.

Table 3-71 shows the hazard rank for hurricane winds by jurisdiction. Relative to the rest of Virginia, the eastern jurisdictions have the highest risk for hurricane. This ranking, based on NCEI records, does not distinguish winds resulting from tropical and non-tropical weather systems. Some of the impacts in the NCEI records may have been coded as non-tornadic winds (and included in this wind section). However, sorting these damages out would be very difficult given the available information.

Table 3-71 - Hurricane Wind Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	High	High	Medium-Low	Low	Medium
Albemarle	Medium-High	Medium	Low	High	Medium	High	Medium-Low	Medium
Alexandria, City of	Medium-High	High	High	High	Low	Medium-Low	Medium-Low	Medium
Alleghany	Low	Low	Low	Medium-High	Low	Medium	Low	Medium-Low
Amelia	Low	Low	Medium-Low	High	Low	Medium-Low	Low	Medium-Low
Amherst	Medium	Medium	Low	Medium-High	Low	Medium-High	Low	Medium-Low
Appomattox	Low	Low	Low	Medium	Low	Medium-Low	High	Medium-Low
Arlington	High	High	Low	High	Medium	Medium-Low	Medium	Medium
Augusta	Medium-High	Medium	Low	High	Medium-High	Medium-High	Low	Medium
Bath	Low	Low	Low	Medium	Low	Medium-Low	Low	Low
Bedford	Medium-High	Medium	Low	High	Low	High	High	Medium
Bland	Low	Low	Low	Medium-High	Low	Low	Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Accomack	Medium	Medium	Low	High	High	Medium-Low	Low	Medium
Albemarle	Medium-High	Medium	Low	High	Medium	High	Medium-Low	Medium
Alexandria, City of	Medium-High	High	High	High	Low	Medium-Low	Medium-Low	Medium
Alleghany	Low	Low	Low	Medium-High	Low	Medium	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Amelia	Low	Low	Medium-Low	High	Low	Medium-Low	Low	Medium-Low
Amherst	Medium	Medium	Low	Medium-High	Low	Medium-High	Low	Medium-Low
Appomattox	Low	Low	Low	Medium	Low	Medium-Low	High	Medium-Low
Arlington	High	High	Low	High	Medium	Medium-Low	Medium	Medium
Augusta	Medium-High	Medium	Low	High	Medium-High	Medium-High	Low	Medium
Bath	Low	Low	Low	Medium	Low	Medium-Low	Low	Low
Bedford	Medium-High	Medium	Low	High	Low	High	High	Medium
Bland	Low	Low	Low	Medium-High	Low	Low	Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Clarke	Low	Medium	Low	High	Low	Medium-High	Low	Medium-Low
Colonial Heights, City of	Medium	High	High	Medium	Low	Medium-High	Low	Medium
Covington, City of	Low	Medium-High	Medium-Low	High	Low	Low	Low	Medium-Low
Craig	Low	Low	High	Medium	Low	Medium-Low	Low	Medium-Low
Culpeper	Medium	Medium	High	Medium	Medium-Low	Medium-Low	Low	Medium
Cumberland	Low	Low	Low	High	Medium	Medium-High	Low	Medium-Low
Danville, City of	Medium	Medium-High	Low	Medium	Medium-Low	Medium-Low	Low	Medium-Low
Dickenson	Low	Low	Low	High	Medium	Medium-Low	Low	Medium-Low
Dinwiddie	Medium	Low	Low	Medium-Low	Low	Low	Low	Low
Emporia	Low	Medium-High	Low	High	High	Medium-Low	Low	Medium
Essex	Low	Low	Low	Medium	Low	Low	Low	Low
Fairfax	High	High	Low	High	Medium	Medium-Low	Medium	Medium
Fairfax, City of	Medium	High	Low	High	Low	High	High	Medium
Falls Church, Cityof	Low	High	Medium-Low	High	Low	Medium-Low	Low	Medium-Low
Fauquier	Medium-High	Medium	Low	High	Low	Medium-Low	Medium-Low	Medium
Floyd	Low	Low	Low	High	Low	High	Low	Medium-Low
Fluvanna	Medium	Medium	Low	Medium	Low	Medium-Low	Low	Medium-Low
Franklin	Medium	Medium	Medium-Low	Medium	Low	Medium-Low	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Franklin, City of	Low	Medium-High	Medium-Low	High	Low	High	Low	Medium
Frederick	Medium-High	Medium	Low	Low	High	Low	Low	Medium-Low
Fredericksburg, City of	Medium	High	Low	High	High	Medium-High	Low	Medium
Galax, City of	Low	Medium-High	Low	High	Medium	Low	Low	Medium-Low
Giles	Low	Low	High	Medium	Low	Medium-Low	Low	Medium-Low
Gloucester	Medium	Medium	Medium-Low	Medium-High	Low	Medium	Low	Medium-Low
Goochland	Medium	Medium	Low	High	High	Medium-Low	Low	Medium
Grayson	Low	Low	Medium-Low	Low	Low	Medium-Low	Low	Low
Greene	Medium	Medium	Medium-Low	Medium	Low	Medium	Low	Medium-Low
Greensville	Low	Low	High	Medium	Medium-Low	Medium-Low	Low	Medium-Low
Halifax	Medium	Low	Low	Medium-Low	Low	Medium-Low	Low	Low
Hampton, City of	Medium-High	High	Medium-Low	High	Low	High	Medium-Low	Medium
Hanover	Medium-High	Medium	Low	High	Medium	Medium-Low	Medium-Low	Medium
Harrisonburg, Cityof	Medium	High	Medium-Low	Medium-High	Medium-Low	Medium	Low	Medium
Henrico	High	Medium-High	Low	Medium-High	Medium-Low	Low	Medium	Medium
Henry	Medium	Medium	Low	High	Medium-Low	High	Low	Medium
Highland	Low	Low	High	High	Medium-Low	High	Medium	Medium
Hopewell, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Isle of Wight	Medium	Medium	Low	High	High	Low	Low	Medium
James City	Medium-High	Medium-High	Low	High	High	Medium-Low	Medium-Low	Medium
King and Queen	Low	Low	Low	High	Low	Medium-Low	Low	Medium-Low
King George	Medium	Medium	Low	Low	High	Medium-Low	Low	Medium-Low
King William	Low	Low	Medium-Low	High	Low	Medium	Low	Medium-Low
Lancaster	Low	Medium	Medium-Low	Low	Medium-High	Medium-Low	Low	Medium-Low
Lee	Medium	Low	Low	High	Medium	Medium-Low	Low	Medium-Low
Lexington, City of	Low	High	Low	Medium	Medium-Low	Medium	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Loudoun	High	Medium-High	Medium-Low	Medium	Low	Low	Medium	Medium
Louisa	Medium	Medium	Medium-Low	High	Medium-Low	High	Low	Medium
Lunenburg	Low	Low	Low	Medium-High	Low	Medium	Low	Medium-Low
Lynchburg, City of	Low	Medium-High	Low	Medium	Medium-Low	Medium-Low	Low	Medium-Low
Madison	Low	Low	Low	High	Low	Medium-Low	Low	Medium-Low
Manassas, City of	Medium	High	Medium-Low	Medium	Medium	Medium	Low	Medium
Manassas Park, City of	Low	High	High	High	Low	Medium-Low	Low	Medium
Martinsville, Cityof	Low	Medium-High	Low	High	Low	Low	Low	Medium-Low
Mathews	Low	Medium	Low	High	Low	Low	Low	Medium-Low
Mecklenburg	Medium	Low	Low	High	Medium-High	Low	Low	Medium-Low
Middlesex	Low	Medium	Low	High	High	Medium	Low	Medium
Montgomery	Medium-High	Medium	Low	High	High	Medium-Low	Low	Medium
Nelson	Low	Low	Medium-Low	High	Medium-Low	Medium-High	Low	Medium-Low
New Kent	Low	Medium	Medium-Low	Medium-Low	Medium-Low	Medium	Low	Medium-Low
Newport News, City of	High	High	Low	Medium-Low	Low	Medium-Low	Medium-Low	Medium
Norfolk, City of	High	High	Low	High	Medium	Medium-Low	Medium	Medium
Northampton	Low	Medium	Low	High	Low	Medium-Low	Low	Medium-Low
Northumberland	Low	Low	Low	High	High	Medium-Low	Low	Medium-Low
Norton	Low	Medium-High	Low	High	Medium-High	Medium-Low	Low	Medium
Nottoway	Low	Low	Medium-Low	Low	Low	Low	Low	Medium-Low
Orange	Medium	Medium	Medium-Low	Low	Low	Medium	Low	Medium-Low
Page	Medium	Medium	Low	High	Medium-High	Medium-High	Low	Medium
Patrick	Medium	Low	Low	High	High	Medium	Low	Medium
Petersburg, City of	Medium	Medium-High	Low	High	Low	Medium-High	Low	Medium
Pittsylvania	Medium-High	Medium	Low	High	High	Low	Low	Medium
Poquoson	Low	Medium-High	Low	High	Medium-High	High	Low	Medium
Portsmouth, Cityof	Medium-High	High	Low	High	Low	Low	Medium-Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Powhatan	Medium	Medium	Medium-Low	High	Low	Medium-Low	Low	Medium-Low
Prince Edward	Medium	Medium	Low	High	Medium-Low	Medium-Low	Low	Medium-Low
Prince George	Medium	Medium	Low	Medium-Low	Low	Medium	Low	Medium-Low
Prince William	High	Medium-High	Low	High	High	Medium	Medium-High	Medium-High
Pulaski	Medium	Medium	Low	High	Low	High	Low	Medium
Radford, City of	Low	Medium-High	Low	Medium-High	Low	Medium	Low	Medium-Low
Rappahannock	Low	Low	Low	Low	Low	Low	Low	Low
Richmond	Low	Low	Low	Medium-Low	Medium	Medium-Low	Low	Low
Richmond, City of	High	High	Medium-Low	Medium-Low	Medium	Medium-Low	Medium	Medium
Roanoke	Medium-High	Medium-High	High	High	Medium-Low	Medium-Low	Low	Medium
Roanoke, City of	Medium-High	High	Low	High	Low	Medium-High	Medium-Low	Medium
Rockbridge	Medium	Low	Low	High	Low	Medium-Low	Low	Medium-Low
Rockingham	Medium-High	Medium	Low	High	Low	Medium-High	Low	Medium
Russell	Medium	Low	Low	High	Medium	Medium-High	Low	Medium
Salem, City of	Medium	High	Low	Medium-High	Low	Medium	Low	Medium
Scott	Medium	Low	Medium	Medium-High	Low	Medium-Low	Low	Medium-Low
Shenandoah	Medium	Medium	High	Medium-High	Medium-Low	Medium	Low	Medium
Smyth	Medium	Medium	Medium-Low	Medium-High	High	Medium-High	Low	Medium
Southampton	Low	Low	Medium	Medium	Low	Medium	Low	Medium-Low
Spotsylvania	Medium-High	Medium	Low	Medium-Low	High	Medium-Low	Medium-Low	Medium
Stafford	Medium-High	Medium-High	Low	High	Medium	High	Medium-Low	Medium
Staunton, City of	Medium	Medium-High	Medium-Low	High	Low	Medium-High	Low	Medium
Suffolk	Medium-High	Medium	Low	Medium-High	Medium-High	Low	Low	Medium
Surry	Low	Low	Low	High	High	Medium	Low	Medium-Low
Sussex	Low	Low	Medium-Low	High	High	Medium-Low	Low	Medium-Low
Tazewell	Medium	Medium	Medium-Low	Medium-Low	Medium-High	Medium-Low	Low	Medium-Low
Virginia Beach, City of	High	High	Low	High	Low	Medium	Medium-High	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Warren	Medium	Medium	Low	High	High	Medium-High	Low	Medium
Washington	Medium	Medium	Low	Medium	Medium	Medium	Low	Medium-Low
Waynesboro, Cityof	Medium	Medium-High	Low	High	Medium-Low	Medium-High	Low	Medium
Westmoreland	Low	Medium	Low	High	Medium-High	Low	Low	Medium-Low
Williamsburg, Cityof	Low	Medium-High	Low	Medium	Medium	Medium-Low	Low	Medium-Low
Winchester, Cityof	Medium	High	Low	High	Low	Low	Low	Medium-Low
Wise	Medium	Medium	Low	Medium-High	High	Medium-Low	Low	Medium
Wythe	Medium	Medium	Low	Medium-High	Low	Medium	Low	Medium-Low
York	Medium-High	Medium-High	Low	Medium	Low	Medium	Low	Medium-Low

3.8.7.16 Local Plan Risk Assessment

Each of the 20 local hazard mitigation plans were reviewed and summarized based on methodology and results for their hurricane analysis. Each plan varied based on the type of data available and analysis methodology. Techniques for assessing hurricane wind risk in the local plans included one or more of the following methods:

- FEMA Hazus
- NCEI statistics
- FEMA Wind Benefit-Coast Module to determine percent of buildings constructed before and after adoption of local building codes
- ASCE Wind Design Speeds
- Referenced Virginia Hurricane Evacuation Study

Of the 20 local plans, 11 plans used Hazus for hurricane wind analysis in some fashion; nine plans did not calculate annualized loss for hurricane.

Table 3-72 shows the summary of the local plans that provided annualized losses. None of the annualized loss values for the local plan are the same as the values calculated for this revision; this difference may be attributed to the different Hazus scenarios selected for analysis and the precise study area selected for the model run.

Table 3-72 - Local Annualized Loss Estimates

Local Plan	Annualized Loss
Commonwealth RC	$279,714
Central Shenandoah PDC	$274,179
Hampton Roads	$86,748,000
Middle Peninsula	$2,228,660
New River Valley	$563,000
Northern Virginia	$6,898,000
Rappahannock Rapidan*	$491,000
Richmond Crater*	$1,436,741
Southside	$482,000
Thomas Jefferson*	$832,000
West Piedmont*	$29,468,177
*Value updated since 2017	

3.8.7.17 Comparison with Local Ranking

Overall, 14 out of the 20 the local hazard mitigation plans ranked hurricane. Out of the 14 that provided a ranking, 11 ranked hurricanes as a high-risk hazard, 2 ranked hurricane as medium risk, and 1 ranked hurricane as a low hazard risk (Mount Rogers PDC). The average hazard ranking for hurricane is high among the local plans.

3.8.7.18 Changes in Development

As indicated at the beginning of the hurricane section, the 2023 statewide analysis has ranked hurricane as a high hazard. Most 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Some of the coastal communities discussed development of residential structures in high hazard areas and the need to evaluate engineering practices before development or elevation occurs.

Table 3-73 - Emergency Management Accreditation Program 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 minor unless the response personnel live within the impacted area.
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 impacts expected to be moderate, including uprooted trees and widespread debris, which may include hazardous materials.
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.

Community Lifelines Impacted by Hurricanes

Based on the hazard analysis and description of vulnerability and impacts of hurricanes in Virginia, hurricanes impact all the community lifelines which are:

- Food, Water, Shelter
- Energy
- Health and Medical
- Safety and Security
- Communications
- Transportation
- Hazardous Materials

3.8.8 Impoundment Failure

3.8.8.1 Background

Bland County, 1957: Crab Orchard Creek Dam Failure
Crab Orchard Creek Dam Failure
Source: Mount Rogers PDC 2004 Local HMP

Flooding due to impoundment failure refers to a collapse, breach, or other failure that causes an uncontrolled release of water or sludge from an impoundment, resulting in downstream flooding. Dam or levee failures can occur with little warning in either wet or dry conditions. Intense storms may produce a flood in a few hours or even minutes from upstream locations. Flash floods can occur within six hours of the beginning of heavy rainfall, and impoundment failure may occur within minutes to hours of the first signs of breaching. Other failures and breaches can take days to weeks to occur, because of debris jams or the accumulation of melting snow.

Levee/Floodwall Impoundments

FEMA defines a levee as ‘a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water to reduce the risk from temporary flooding.’ FEMA accredits levees and can also de-accredit or provisionally accredit a levee [lxvii]. A levee designed to provide flood protection from at least the 1-percent-annual-chance flood is eligible for accreditation by FEMA. When accredited, the area protected by the levee will be mapped as a moderate risk zone instead of a high-risk zone on the Flood Insurance Rate Map (FIRM)[lxviii].

Before a levee can be accredited, FEMA's levee certification process must be completed, which focuses exclusively on design construction standards certified by a licensed engineer or related federal agency. There are nine accredited levee systems in Virginia: Rivanna in Albemarle County; Bridgewater in Rockingham County; Buena Vista in the City of Buena Vista; Huntington in Fairfax County; Norfolk, in the City of Norfolk; three systems in the City of Richmond; and Scottsville, in Albemarle County. There are 13 other levees in Virginia that are not accredited by FEMA.

Many of the causes and effects of levee failure are similar to dam failure. Failures often occur as a result of overtopping and piping or other failure modes such as intentional damage, seismic events, operational and maintenance errors, foundation scouring, and foundation sliding.

The National Levee Safety Program, authorized by the National Levee Safety Act of 2007, is being implemented by the U.S. Army Corps of Engineers (USACE) and the Federal Emergency Management Agency (FEMA). The purpose of the National Levee Safety Program is to improve the way levees are managed throughout the United States and its territories in order to reduce disaster suffering and improve the resiliency of communities behind levees. There are four major components that are intended to work together to accomplish the goals of the program: National Levee Safety Guidelines; Integrated Levee Management; National Levee Database and Data Collection; and Implementation Support. A potential result may be the establishment of levee safety programs at the state level.

Virginia's levee systems are summarized in Table 3-74. Currently, a total of 22 levee systems, encompassing over 16 miles of levee length and protecting more than 3,400 buildings and a population of more than 20,000, are listed by the USACE. These levees have an average age of 27 years. Levee risk in Table 3-74 is the risk that exists due to the presence of the levee system, and this is the risk used to inform the decision on the risk assignment.

Table 3-74 - Levee Systems in Virginia[5]

Levee Name	Sponsor	Risk	Location	Population	Buildings Protected	Property Value Protected
Alexandria East	City of Alexandria	Low	Alexandria	2,742	223	$323M
Alexandria West	City of Alexandria	Low	Alexandria	56	5	$2.53M
Arlington West	Arlington County	Low	Alexandria	1,351	176	$216M
Arlington East	Arlington County	Low	Arlington County	766	87	$141M
Bridgewater	Town of Bridgewater	Low	Bridgewater, Rockingham County	3,094	1,135	$348M
Buena Vista, Virginia	City of Buena Vista, VA	Low	Buena Vista	1,035	664	$152M
International Paper Levee	Undefined	Not Screened	Camptown, Isle of Wight County	0	0	$0
Danville Flood Reduction System	City of Danville, Virginia (Utilities Division)	Not Screened	Danville	0	0	$0
Danville Sewage Treatment Plant	Danville Sewage Treatment Plant	Low	Danville	0	9	$1.57M
Grundy, VA, LPP	Town of Grundy	Low	Grundy, Buchanan County	112	30	$19.3M

Levee Name	Sponsor	Risk	Location	Population	Buildings Protected	Property Value Protected
Cameron Run Flood Protection Project	Unknown	Not Screened	Huntington, Fairfax County	311	65	$60.4M
Norfolk, Virginia - Central Business District	City of Norfolk, VA	Low	Norfolk	4,502	219	$625M
Richmond Filtration Plant	City of Richmond, VA	Low	Richmond	50	12	$200M
Richmond, Virginia (North)	City of Richmond, VA	Low	Richmond	2,578	296	$501M
Richmond, Virginia (South)	City of Richmond, VDOT	Low	Richmond	1,271	146	$397M
Barn Branch (Quarry) Levee System	Luck Stone Corporation	Not Screened	Rivanna, Albemarle County	0	0	$0
Roanoke FRP	City of Roanoke	Low	Roanoke	871	15	$21.6M
Roanoke Sewage Treatment Plant	Roanoke Sewage Treatment Plant Flood Proofing	Low	Roanoke	42	6	$4.92M
Roanoke STP Ring Levee	City of Roanoke, Virginia	Not Screened	Roanoke	0	0	$0
Scottsville, Virginia	Town of Scottsville, VA	Low	Scottsville, Albemarle County	111	70	$12.8M
Virginia Beach, Virginia	City of Virginia Beach, VA	Low	Virginia Beach	1,991	254	$241M
South River Levee	Unknown	Not Screened	Waynesboro, Augusta County	0	0	$0

Source: https://levees.sec.usace.army.mil/#/

Dam Impoundments

Dams and associated lakes, ponds, and impoundments are part of the Commonwealth's overall water resource landscape. As such, a dam failure or breach can have an extensive impact on the magnitude of downstream flooding and wide scale damages. The Virginia Department of Conservation and Recreation, Division of Dam Safety and Floodplain Management (Virginia DSFPM) administers the Virginia Dam Safety Program under the authority of the Virginia Soil and Water Conservation Board (Virginia SWCB). The Virginia DSFPM, by authority of the Virginia SWCB, is the key regulatory entity for dams in Virginia not otherwise regulated by the Virginia State Corporation Commission, Virginia Department of Energy (DOE), United States Government, or as defined in Section 4VAC50-20-30 of the Virginia Impounding Structure Regulationslxix.

The Virginia SWCB regulates impounding structures in the Commonwealth to ensure that they are 'properly and safely constructed, maintained and operated.'lxx Per section 4VAC50-20-50 of the Virginia Impounding Regulations, "an impounding structure shall be regulated if the impounding structure is 25 feet or greater in height and creates a maximum impounding capacity of 15 acre-feet or greater, or the impounding structures is six feet or greater in height and creates a maximum impounding capacity of 50 acre-feet or greater and is not otherwise exempt from regulation by the Code of Virginialxxi." The regulations promulgated to achieve these ends are recorded in the Virginia Administrative Code also known as the Virginia Impounding Structure Regulations.lxxii Ongoing dam inspections, Virginia's participation in the National Dam Safety

Program, the FEMA High Hazard Potential Dam Program, and the work of the USACE link together in order to identify, assess and mitigate risks of potential dam failures.

Per the current Virginia Impounding Structure Regulations, an “impounding structure” or “dam” can be defined as the following: “a man-made structure, whether a dam across a watercourse or structure outside a watercourse, used or to be used to retain or store waters or other materials[lxxiii].” Dams are classified with a hazard potential depending on the downstream impacts or consequences during a dam failure event. Hazard potential is not related to the structural integrity of a dam, environmental impacts, or to specific social vulnerabilities of the downstream inundation area. Hazard potential, or risk, is strictly related to the potential for adverse downstream effects if the dam were to fail. Regulatory requirements, such as the frequency of dam inspection, the standards for spillway design, and actions within established emergency plans, are dependent upon the dam’s assigned hazard potential classification. Table 3-75 provides additional information on these hazard potential classifications.

Table 3-75 - Dam Hazard Potential Classification System in Virginialxxiv

Hazard Potential	Description	Inspection
High	Failure will cause probable loss of life or serious economic damage (to residences, businesses buildings, facilities, other occupied structures, public utilities, major roadways, railroads etc.)	Annual owner inspection, Professional Engineer inspection every 2 years.
Significant	Failure may cause loss of human life or appreciable economic damage (to residences, businesses, buildings, facilities, other occupied structures, public utilities, secondary roadways, etc.)	Annual owner inspection, Professional Engineer inspection every 3 years.
Low	Failure would result in no expected loss of human life, and cause no more than minimal economic damage	Annual owner inspection, Professional Engineer inspection every 6 years.

The owner(s) of each regulated dam classified as high, significant, or low hazard operating under normal conditions is required to apply to Virginia DSFPM for a Regular Operation and Maintenance Certificate every 6 years. Should a dam have a known deficiency, Virginia DSFPM may issue a Conditional Operation and Maintenance Certificate, during which time the dam owner is required to correct the deficiency. Any application for an Operation and Maintenance Certificate must include an assessment of condition of the dam by a licensed Virginia Professional Engineer and an Emergency Action Plan (EAP) or an Emergency Preparedness Plan.

Dam condition assessment definitions, as accepted by the National Dam Safety Review Board, are as follows:

Satisfactory - No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the minimum applicable state or federal regulatory criteria or tolerable risk guidelines.

- Typical Circumstances:
    - No existing deficiencies or potentially unsafe conditions are recognized, with the exception of minor operational and maintenance items that require attention.
    - Safe performance is expected under all loading conditions including the design earthquake and design flood.

  - Permanent risk reduction measures (reservoir restrictions, spillway modifications, operating procedures, etc.) have been implemented to eliminate identified deficiencies.

Fair - No existing dam safety deficiencies are recognized for normal operating conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action. Note: Rare or extreme event is defined by the regulatory agency based on their minimum applicable state or federal criteria.

- Other Circumstances:
  - Lack of maintenance requires attention to prevent developing safety concerns.
  - Maintenance conditions may exist that require remedial action greater than routine work and/or secondary studies or investigations.
  - Interim or permanent risk reduction measures may be under consideration.

Poor - A dam safety deficiency is recognized for normal operating conditions which may realistically occur. Remedial action is necessary. “Poor” may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Investigations and studies are necessary.

- Other Circumstances:
  - Dam has multiple deficiencies or a significant deficiency that requires remedial work.
  - Lack of maintenance (erosion, sinkholes, settlement, cracking, unwanted vegetation, animal burrows, inoperable outlet gates) has affected the integrity or the operation of the dam under normal operational conditions and requires remedial action to resolve.
  - Critical design information is needed to evaluate the potential performance of the dam. For example, a field observation or a review of the dam’s performance history has identified a question that can only be answered by review of the design and construction history for the dam. Uncertainty arises when there is no design and/or construction documentation available for review and additional analysis is needed to better understand the risk associated with operation under normal operational conditions.
  - Interim or permanent risk reduction measures may be under consideration.

Unsatisfactory - A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

- Typical Circumstances:
  - A critical component of the dam has deteriorated to unacceptable condition or failed.
  - A safety inspection indicates major structural distress (excessive uncontrolled seepage, cracks, slides, sinkholes, severe deterioration, etc.), advanced deterioration, or operational deficiencies which could lead to failure of the dam or its appurtenant structures under normal operating conditions.

- Reservoir restrictions or other interim risk reduction measures are required.
- A partial or complete reservoir drawdown may be mandated by the state or federal regulatory agency.

Not Rated - The dam has not been inspected, is not under state or federal jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Table 3-76 below provides current condition assessments for dams of regulatory size in the Commonwealth. There are 81 dams in Poor or Unsatisfactory condition. In addition, there are a total of 1,876 dams without an assigned condition assessment. These dams are currently being assessed by DSFPM to identify dams with downstream impacts and additional regulatory action(s) needed.

Table 3-76 - Current Condition Assessment for Dams of Regulatory Size

Conditional Assessment	High	High, Special	Significant	Low	Low, Special	Unknown	Grand Total
Unsatisfactory	2		1	2		2	7
Poor	23		12	16	5	18	74
Fair	143	1	53	36	9	39	281
Satisfactory	176	3	65	87	6	22	359
Not Rated	23		43	67	46	1,795	1,974
Grand Total	367	4	174	208	66	1,876	2,695

Downstream flooding following a dam failure may occur due to any one or a combination of the following factors:

- Prolonged periods of rainfall and flooding;
- Inadequate spillway capacity;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees and/or woody vegetation, repair internal seepage problems, replace lost material from the cross section of the dam and abutments, failure to clean and remove debris or obstructions, or maintain gates, valves, or other operational components;
- Improper design, including the use of improper construction materials and incorrect construction practices or methods;
- Improper operation, including failure to remove or open gates or valves during high flow periods;
- Failure of upstream dams on the same waterway (dams in series condition);
- High winds, which can cause significant wave action and result in substantial erosion; or

Intentional terrorism or criminal acts.

3.8.8.2 Location and Spatial Extent

As of May 2022, VA DSFPM is aware of approximately 3,670 dams within the Commonwealth based on information provided through DCR's Dam Safety Inventory System (DSIS) and reported to the USACE National Inventory of Dams. Out of those 3,670 known dams, Virginia DSFPM regulates approximately 2,600 dams (71%). When evaluating the 2,600 dams, it is known that there are 350 high hazards along with four special high hazard dams (14%), 165 significant hazard (6%), 263 low hazard (10%), and more than 1,800 unknown hazard (70%) dams under the regulatory authority of Virginia DSFPM. At this time Virginia DSFPM has decided to utilize the label “unknown hazard potential classification” for dams where an inundation study is required to be performed by the dam owner’s engineer and submitted, reviewed, and approved (confirmed) by Virginia DSFPM prior to assignment of a final hazard potential classification. As an interim measure DCR is conducting simplified dam break inundation zone studies on unknown dams prioritized based on the dam size and impact of failure. These agency studies do not relieve the dam owner of the obligation to undertake detailed dam break inundation studies in accordance with 4VAC50-20-50, Performance standards required for impounding structures. The interim studies do provide Virginia DSFPM, VDEM, and local emergency management officials with best available information to respond to a dam incident. About 1,106 dams are regulated by other entities such as FERC, USACE and Virginia Energy. Five dams are still under evaluation with respect to regulatory status.

Risks and vulnerabilities to and from high hazard potential dams include:

- Potential significant economic, environmental, or social impacts as well as multijurisdictional impacts from a dam incident;
- Loss of services such as flood control, water supply, water quality, wildlife, or recreation when the dam fails;
- Disruptions to the transportation network; and
- Damage to critical infrastructure.

Figure 3-109 shows the locations of the high hazard dams in the state for which coordinates were available; not all dams have coordinate location data in DSIS. Figure 3-110 illustrates the Virginia regulated high hazard dam locations and condition assessment. The majority of high hazard dams in Virginia are in satisfactory or fair condition.

Risk data is compiled in DSIS for each high hazard dam. DCR, VDEM, and local emergency and planning staff are provided copies of approved EAPs. The plans include detailed information on risk to the following:

- Dwellings;
- Schools;
- Hospitals;
- Businesses;
- Railroads;
- Utilities;
- Parks;
- Golf Course;
- Public Trails; and
- Emergency Infrastructure.

Professional Engineers (PEs) analyze the risk at each dam by evaluating growth downstream of the dam in each inspection and in detail every six years during the EAP update. In the case of dams in series, PEs must evaluate the most critical combination. Other factors considered in risk assessment by Virginia DSFPM include the population at risk, land use, inspection condition assessment and any missing studies, such as stability analyses under normal and extreme loading conditions (seismic and hydrologic), and any measures underway that affect the operational status, such as drawdowns or temporary pumps and siphons when dams are compromised. Virginia DSFPM is moving toward the development of more comprehensive evacuation plans in future EAPs that incorporate information about blocked roads and provide the best escape routes.

The owner and PE must regularly monitor development upstream of the dam and update the dam break inundation zone unless the dam was designed for full future upstream development. If upstream changes in development necessitate a new spillway design flood exceeding the existing spillway capacity, an alteration permit and subsequent construction of spillway modifications is required. Currently, Virginia DSFPM requires PEs to map each structure and, for those that are businesses, residences, schools or other occupied structures, compute both the arrival time of the flood wave and time and magnitude of peak flood. Population at Risk (PAR) data for dwellings is calculated using data from the Census Bureau.

The 354 known high hazard dams regulated by the Virginia DSFPM are summarized in Table 3-77. The dam locations are shown in Figure 3-109. Dam condition is shown in Figure 3-110. Figure 3-110 through Figure 3-116 provide a more detailed depiction of the location of the high hazard dams in each VDEM Region. The total number of high hazard dams in each VDEM Region include:

- Region 1 (31 dams)
- Region 2 (53 dams)
- Region 3 (100 dams)
- Region 4 (30 dams)
- Region 5 (23 dams)
- Region 6 (50 dams)
- Region 7 (67 Dams)

Figure 3-109 - High Hazard Dams in Virginia

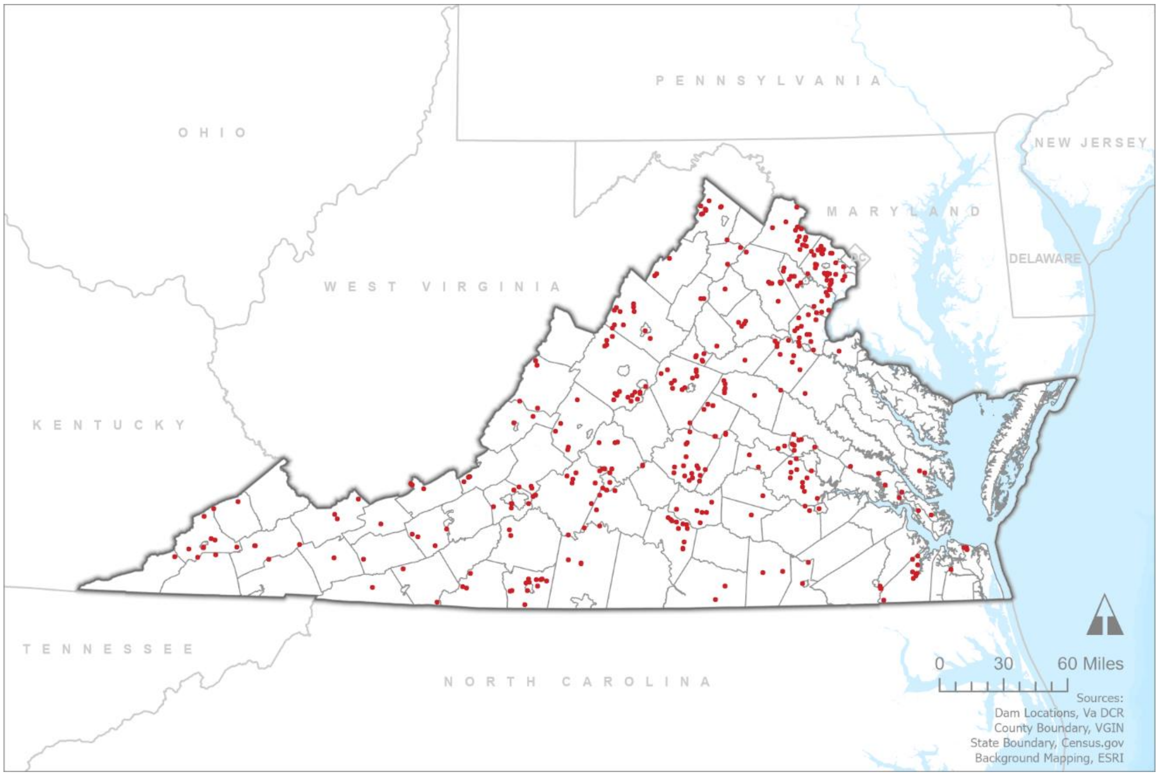


Figure 3-110 - High Hazard Dams in Virginia – Condition Assessment

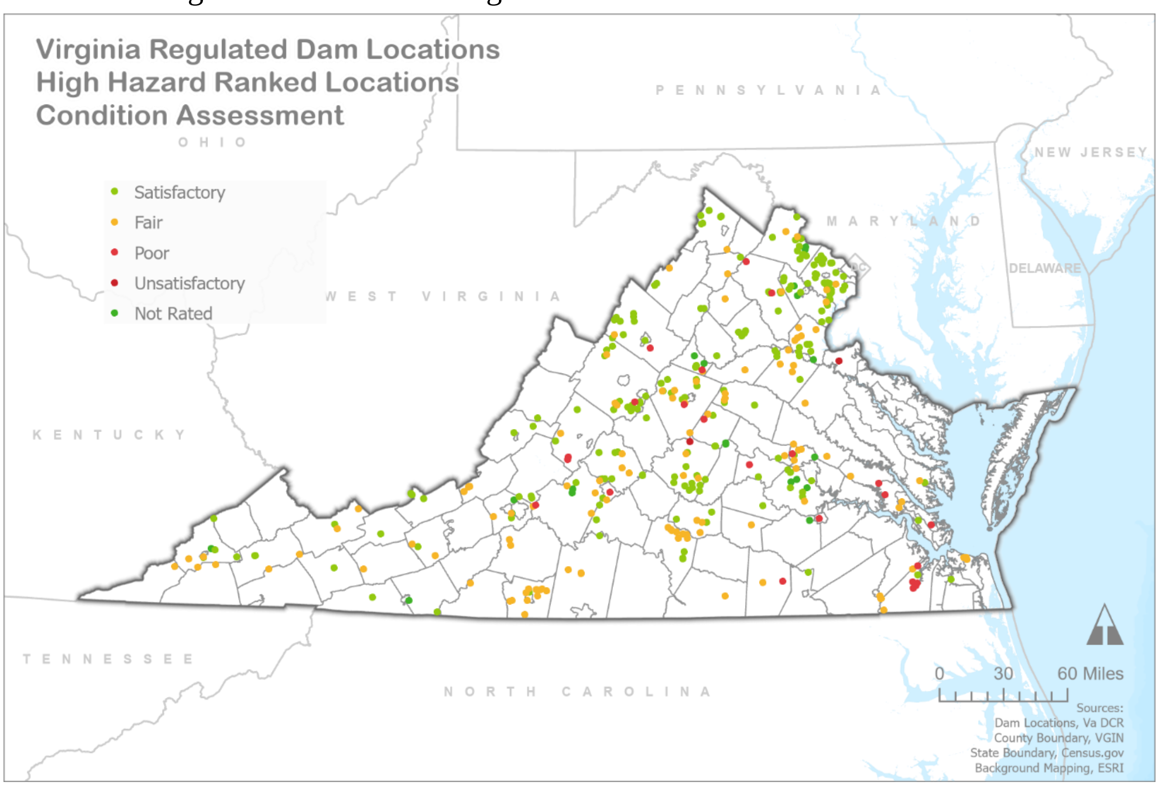


Table 3-77 - Known High Hazard Potential Classification Dams Regulated by VA DSFPM

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Bridgeforth Mill Dam	1	Amelia County	Satisfactory	1	1	6
Brunswick Lake Dam	1	Brunswick County	Poor	1	3	12
Great Creek Dam # 6A	1	Brunswick County	Fair	370	2	968
Swift Creek Dam	1	Chesterfield County	Satisfactory	42	2	274
Cosby Dam	1	Chesterfield County	Not Rated	TBD	TBD	TBD
Swift Creek Reservoir Dam	1	Chesterfield County	Satisfactory	2,400	1	6,243
Margaret Dam	1	Chesterfield County	Fair	11	3	46
Falling Creek Reservoir Dam	1	Chesterfield County	Satisfactory	264	3	698
Woodland Pond	1	Chesterfield County	Satisfactory	10	3	36
Lake Salisbury Dam	1	Chesterfield County	Satisfactory	1,870	6	4,881
Lake Patrick Henry Dam	1	Chesterfield County	Satisfactory	8	1	24
Lake Crystal Dam	1	Chesterfield County	Not Rated	2	3	23
Wake Lake Dam	1	Chesterfield County	Not Rated	22	9	383
Commerce Park Dam	1	Dinwiddie County	Not Rated	53	3	147
Dover Lake Dam	1	Goochland County	Satisfactory	1	1	6
Broad Branch Dam	1	Goochland County	Fair	5	4	26
Jarratt Municipal Raw Water Storage Reservoir Dam	1	Greensville County	Satisfactory	5	2	19
Cherrydale Dam	1	Hanover County	Fair	7	3	27
Tiller Lake Dam	1	Hanover County	Fair	8	TBD	21
Canterbury Dam	1	Henrico County	Fair	205	1	536
Echo Dam	1	Henrico County	Fair	24	2	135
Wellesley Dam	1	Henrico County	Poor	60	3	167
Lake Overton Dam	1	Henrico County	Not Rated	3	1	11
Lake Rooty Dam	1	Henrico County	Fair	8	1	24
Barrington Dam	1	Henrico County	Satisfactory	2	1	31
Woodhaven Dam	1	New Kent County	Fair	11	2	35
Nottoway Lake Dam	1	Nottoway County	Fair	0	7	21
Upper Powhatan Dam	1	Powhatan County	Poor	0	2	6
Mill Quarter Lake Dam	1	Powhatan County	Satisfactory	45	1	120
Wilcox Dam	1	City of Petersburg	Poor	117	10	504
Winston Lake Dam	1	City of Richmond	Fair	2	2	45
Lake Caroline Dam	2	Caroline County	Fair	9	5	39
Mountain Run Dam #11	2	Culpeper County	Satisfactory	25	5	81
Mountain Run Dam #50	2	Culpeper County	Satisfactory	1,241	5	3,243
Mountain Run Dam #13	2	Culpeper County	Satisfactory	11	1	50
Mountain Run Dam #18	2	Culpeper County	Satisfactory	131	9	1,340
Warrenton Dam	2	Fauquier County	Satisfactory	4	4	23
Thompson Dam	2	Fauquier County	Poor	21	4	67
Lake Anne Dam	2	Fauquier County	Satisfactory	7	1	39
Lake Brittle Dam	2	Fauquier County	Fair	1	4	13
Warrenton Lake Dam	2	Fauquier County	Poor	10	4	72
Licking Run Dam	2	Fauquier County	Satisfactory	37	3	106
Cedar Run Dam #3	2	Fauquier County	Satisfactory	19	8	183

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Lake Ashby Dam	2	Fauquier County	Satisfactory	16	1	45
Lake Serene Dam	2	Frederick County	Satisfactory	0	2	6
Cove Lake Dam #1	2	Frederick County	Satisfactory	5	2	19
Cove Dam #2	2	Frederick County	Satisfactory	33	TBD	86
Lake Frederick Dam	2	Frederick County	Fair	31	5	97
Lake Holiday Dam	2	Frederick County	Satisfactory	39	4	470
Lake Isaac Dam	2	Frederick County	Satisfactory	1	2	9
Silver Lake Dam	2	Frederick County	Satisfactory	3	TBD	8
Greene Acres Dam	2	Greene County	Not Rated	4	1	14
Deer Lake Dam	2	Greene County	Fair	11	1	32
Ruckers Lake Dam	2	Greene County	Poor	7	2	25
Twin Lakes Dam # 2	2	Greene County	Satisfactory	10	3	36
Twin Lakes Dam # 1	2	Greene County	Satisfactory	31	2	87
Twin Lakes Dam No. 3	2	Greene County	Satisfactory	5	2	19
Lake Monroe Dam	2	King George County	Unsatisfactory	7	4	31
Gordonsville Dam	2	Louisa County	Satisfactory	330	3	868
South Anna No. 5	2	Louisa County	Fair	3	13	49
South Anna Dam #3	2	Louisa County	Fair	2	10	37
South Anna Dam #4	2	Louisa County	Fair	434	9	1,157
South Anna Dam #6B	2	Louisa County	Satisfactory	315	11	854
South Anna Dam #22	2	Louisa County	Satisfactory	44	3	124
Beautiful Run Dam #2A	2	Madison County	Satisfactory	2	5	23
Lake of the Woods Dam	2	Orange County	Satisfactory	43	1	115
Lake Orange Dam	2	Orange County	Fair	5	3	14
Keaton's Run Dam	2	Orange County	Satisfactory	21	1	58
Dry Run Dam #102	2	Page County	Satisfactory	217	19	625
Dry Run Dam #101	2	Page County	Satisfactory	217	19	625
Whippoorwill Dam	2	Rappahannock County	Fair	2	1	11
Stony Creek Dam #9	2	Shenandoah County	Satisfactory	258	12	2,132
Stony Creek Dam #10	2	Shenandoah County	Satisfactory	211	10	1,594
Woodstock Dam	2	Shenandoah County	Fair	79	6	225
Ni River Dam #1	2	Spotsylvania County	Fair	99	3	267
Motts Run Reservoir Dam	2	Spotsylvania County	Satisfactory	604	26	3,708
Wilderness Dam	2	Spotsylvania County	Satisfactory	9	3	93
Fawn Lake Dam	2	Spotsylvania County	Fair	76	7	220
Indian Acres Dam	2	Spotsylvania County	Satisfactory	6	2	22
Hunting Run Dam	2	Spotsylvania County	Fair	678	29	4,572
The Laurels Dam	2	Spotsylvania County	Fair	4	1	14
Lake of the Clouds Dam	2	Warren County	Satisfactory	2	0	5
Lake Front Royal Dam	2	Warren County	Fair	1	2	43
Montfair West Dam	3	Albemarle County	Satisfactory	4	5	26
Ragged Mountain Dam	3	Albemarle County	Satisfactory	800	47	4,388
Beaver Creek Dam #1	3	Albemarle County	Satisfactory	13	5	50
Sugar Hollow Dam	3	Albemarle County	Satisfactory	30	1	81

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Albemarle Dam	3	Albemarle County	Fair	3	4	21
Chris Greene Dam	3	Albemarle County	Satisfactory	1	3	13
Upper Mint Springs Dam	3	Albemarle County	Satisfactory	21	3	65
Birdwood GC Hole #2 Dam	3	Albemarle County	Satisfactory	TBD	TBD	TBD
Peacock Hill Dam	3	Albemarle County	Fair	0	1	12
Mink Creek Dam	3	Albemarle County	Fair	105	9	504
Hollymead Dam	3	Albemarle County	Satisfactory	8	2	27
Middle Mint Spings Dam	3	Albemarle County	Fair	21	2	67
North Fork Park Pond Dam	3	Albemarle County	Fair	6	2	22
Mountain Valley Dam 1	3	Albemarle County	Fair	0	1	2
Mountain Valley Dam 4	3	Albemarle County	Poor	0	1	2
Pedlar River Dam	3	Amherst County	Satisfactory	41	12	145
Earley Dam	3	Amherst County	Fair	1	1	3
Dan E. French Reservoir Dam	3	Amherst County	Satisfactory	18	3	56
Buffalo River Dam # 3	3	Amherst County	Satisfactory	11	14	73
Buffalo River Dam # 2	3	Amherst County	Satisfactory	6	13	57
Sweet Briar College - Lower Dam	3	Amherst County	Fair	1	1	6
Buffalo River Dam # 4A	3	Amherst County	Fair	15	16	90
Greif Holding Pond Dam	3	Amherst County	Satisfactory	1	1	6
Greif Sludge Pond # 2 Dam	3	Amherst County	Satisfactory	1	1	6
Greif Aeration Pond Dam	3	Amherst County	Satisfactory	1	1	6
South River Dam #26	3	Augusta County	Satisfactory	806	27	10,701
South River Dam #25	3	Augusta County	Satisfactory	983	35	12,543
South River Dam #10A	3	Augusta County	Satisfactory	364	2	953
Upper North River Dam #10	3	Augusta County	Satisfactory	TBD	2	6
Upper North River #76	3	Augusta County	Satisfactory	280	8	754
Upper North River #77	3	Augusta County	Satisfactory	404	9	3,974
South River Dam #23	3	Augusta County	Satisfactory	785	28	10,766
South River Dam #6	3	Augusta County	Fair	15	4	230
South River Dam #4	3	Augusta County	Satisfactory	15	3	239
South River Dam #11	3	Augusta County	Satisfactory	35	3	101
South River Dam #19	3	Augusta County	Poor	9	1	108
Upper Wallace Dam	3	Augusta County	Fair	41	4	119
Staunton Dam	3	Augusta County	Fair	1	1	6
Coles Run Dam	3	Augusta County	Satisfactory	207	3	548
South River Dam #7	3	Augusta County	Satisfactory	8	2	89
Willis River Dam #1A	3	Buckingham County	Satisfactory	10	2	22
Willis River Dam #3	3	Buckingham County	Satisfactory	1	2	9
Willis River Dam #4	3	Buckingham County	Satisfactory	1	1	6
Willis River Dam #5E	3	Buckingham County	Satisfactory	1	1	24
Willis River Dam #5F	3	Buckingham County	Fair	1	1	13
Willis River Dam #6	3	Buckingham County	Satisfactory	2	1	16
Willis River Dam #6A	3	Buckingham County	Satisfactory	2	2	16
Willis River Dam #9	3	Buckingham County	Satisfactory	0	3	3
Muddy Creek Dam #1	3	Buckingham County	Fair	4	8	36

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Muddy Creek Dam #2	3	Buckingham County	Satisfactory	4	2	17
Slate River Dam #2	3	Buckingham County	Satisfactory	9	3	44
Horsepen Creek Dam	3	Buckingham County	Fair	3	1	7
Willis River Dam #2	3	Buckingham County	Satisfactory	0	3	26
Slate River Dam #8	3	Buckingham County	Satisfactory	8	9	50
Slate River Dam #7	3	Buckingham County	Satisfactory	5	2	43
Buckingham County Dam #2	3	Buckingham County	Unsatisfactory	0	1	6
Timberlake Dam	3	Campbell County	Satisfactory	11	7	51
Otter River Raw Water Terminal Reservoir Dam	3	Campbell County	Satisfactory	2	1	8
Roanoke Creek Dam # 72A	3	Charlotte County	Satisfactory	45	6	136
Roanoke Creek Dam # 68	3	Charlotte County	Fair	0	3	10
Roanoke Creek Dam # 5B	3	Charlotte County	Fair	0	2	16
Roanoke Creek Dam # 6A	3	Charlotte County	Fair	0	2	15
Roanoke Creek Dam # 62	3	Charlotte County	Satisfactory	0	1	10
Roanoke Creek Dam # 67	3	Charlotte County	Fair	0	2	6
Roanoke Creek Dam # 4A	3	Charlotte County	Fair	0	1	7
Roanoke Creek Dam # 61A	3	Charlotte County	Satisfactory	0	1	3
Roanoke Creek Dam # 31B	3	Charlotte County	Fair	0	2	12
Roanoke Creek Dam # 54	3	Charlotte County	Fair	0	2	6
Roanoke Creek Dam # 43A	3	Charlotte County	Fair	0	3	10
Cobbs Creek Regional Water Supply Dam (Main Dam A)	3	Cumberland County	Not Rated	2,972	21	7,794
Cobbs Creek Regional Water Supply Reservoir Saddle Dam (Dam B).	3	Cumberland County	Not Rated	2,972	21	7,794
Cobbs Creek Regional Water Supply Reservoir Dam Perimeter Dam (Dam C)	3	Cumberland County	Not Rated	2,972	21	7,794
Lake Monticello Dam	3	Fluvanna County	Satisfactory	5	3	23
Fluvanna Ruritan Dam	3	Fluvanna County	Poor	3	3	20
Lake Monticello Settlement Pond Dam	3	Fluvanna County	Fair	39	4	114
Bremo Power Station East Ash Pond Dam	3	Fluvanna County	Satisfactory	0	1	3
Bremo Power Station Dam	3	Fluvanna County	Satisfactory	1	1	6
Gordons Dam	3	Mecklenburg County	Fair	3	1	11
Lake Monocan Dam	3	Nelson County	Satisfactory	30	1	81
Buffalo Creek Dam # 4	3	Prince Edward County	Satisfactory	34	6	688
Bush River Dam # 2	3	Prince Edward County	Fair	3	4	21
Bush River Dam # 12	3	Prince Edward County	Satisfactory	36	28	756
Bush River Dam # 7	3	Prince Edward County	Fair	1	5	74
Briery Creek Lake Dam	3	Prince Edward County	Fair	41	10	139
Bush River Dam # 4B	3	Prince Edward County	Satisfactory	2	5	80

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Lower North River # 80	3	Rockingham County	Satisfactory	200	4	544
Lower North River # 78	3	Rockingham County	Satisfactory	0	6	19
Lower North River # 83	3	Rockingham County	Fair	300	10	361
Lower North River # 22B	3	Rockingham County	Satisfactory	125	2	729
Lake Shenandoah Dam	3	Rockingham County	Poor	4	7	33
Lower North River # 81C	3	Rockingham County	Satisfactory	TBD	3	10
Lower North River # 82	3	Rockingham County	Satisfactory	753	15	7,212
Shoemaker River # 1A	3	Rockingham County	Satisfactory	54	1	438
Shoemaker River # 4C	3	Rockingham County	Satisfactory	114	10	1,087
Shoemaker River # 3B	3	Rockingham County	Satisfactory	72	6	473
Newman Lake Dam	3	City of Harrisonburg	Satisfactory	49	1	147
College Lake Dam	3	City of Lynchburg	Poor	112	2	331
Lake Summit Dam	3	City of Lynchburg	Satisfactory	24	4	142
Lakeland Dam	3	City of Lynchburg	Fair	12	1	40
South River Dam #8A	3	City of Waynesboro	Satisfactory	310	2	846
Crab Orchard Creek Dam	4	Bland County	Satisfactory	115	9	328
Stewarts Creek - Lovills Creek Dam #9	4	Carroll County	Satisfactory	9	2	15
Isom Dam	4	Carroll County	Not Rated	TBD	TBD	TBD
White Oak Creek Dam	4	Dickenson County	Satisfactory	8	2	27
Glen Lyn Fly Ash Dam	4	Giles County	Satisfactory	0	1	3
Celanese Acetate Pond A	4	Giles County	Satisfactory	1	TBD	3
West Pond Dam	4	Giles County	Satisfactory	0	1	3
Hidden Valley Estates Dam	4	Grayson County	Satisfactory	16	8	67
Keokee Dam	4	Lee County	Fair	162	8	159
Hogan Dam	4	Pulaski County	Satisfactory	81	2	217
Lake Powhatan Dam	4	Pulaski County	Fair	17	2	51
Gatewood Dam	4	Pulaski County	Fair	710	12	1,884
Laurel Bed Dam	4	Russell County	Fair	118	7	329
Clinch River Flyash Dam #2	4	Russell County	Satisfactory	TBD	TBD	TBD
Clinch River Flyash Dam #1	4	Russell County	Satisfactory	TBD	2	6
Bark Camp Dam	4	Scott County	Fair	111	3	416
Hungry Mother Dam	4	Smyth County	Satisfactory	189	18	2,539
Upper Clinch River Dam #8	4	Tazewell County	Fair	284	23	1,198
Falls Mill Dam	4	Tazewell County	Fair	58	3	60
Upper Clinch Valley Dam #1B	4	Tazewell County	Satisfactory	323	7	861
Hidden Valley Lake Dam	4	Washington County	Fair	21	2	61
Bens Branch Dam	4	Wise County	Fair	172	5	547
Bear Creek Dam	4	Wise County	Satisfactory	826	11	2,368
Big Cherry RCC Dam	4	Wise County	Fair	1,764	14	4,628
UVA Wise #1 Dam	4	Wise County	Not Rated	18	2	508
UVA Wise #2 Dam	4	Wise County	Not Rated	18	2	508
Dominion Virginia City Dam #2	4	Wise County	Satisfactory	24	3	122
Rural Retreat Dam	4	Wythe County	Fair	39	4	185
Lower Norton Reservoir Dam	4	City of Norton	Fair	17	15	344

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Upper Norton Reservoir Dam	4	City of Norton	Satisfactory	17	15	344
Cow Creek Dam	5	Gloucester County	Satisfactory	2	3	33
Beaverdam Lake Dam	5	Gloucester County	Fair	248	2	651
B - 1 Pond Dam	5	Isle of Wight County	Fair	54	6	160
B - 2 Pond Dam	5	Isle of Wight County	Fair	54	6	160
ASB Pond Dam	5	Isle of Wight County	Fair	54	4	231
Little Creek Dam	5	James City County	Poor	2	2	12
Diascund Creek Dam	5	New Kent County	Poor	208	25	621
Harwood's Mill Dam	5	York County	Poor	172	21	867
Waller Mill Dam	5	York County	Fair	4	3	70
Chesapeake Energy Center Bottom Ash and Sediment Pond Dam	5	City of Chesapeake	Satisfactory	0	0	1
Lee Hall Reservoir Dam	5	City of Newport News	Satisfactory	312	4	1,270
Lake Whitehurst Dam	5	City of Norfolk	Fair	15	1	44
Lake Cohoon Dam	5	City of Suffolk	Poor	163	10	1,176
Lake Kilby Dam	5	City of Suffolk	Poor	127	8	883
Lake Burnt Mills Dam	5	City of Suffolk	Fair	23	4	321
Speights Run Dam	5	City of Suffolk	Poor	53	10	271
Western Branch Dam	5	City of Suffolk	Satisfactory	267	14	1,445
Lake Meade Dam	5	City of Suffolk	Poor	122	17	657
Godwins Millpond Dam	5	City of Suffolk	Poor	4	1	30
C - Pond Dam	5	City of Suffolk	Fair	165	5	1,095
Lake Smith Dam	5	City of Virginia Beach	Fair	669	1	1,745
Little Creek Reservoir Dam	5	City of Virginia Beach	Fair	23	1	65
Lake Matoaka Dam	5	City of Williamsburg	Fair	13	1	54
Clifton Forge Dam	6	Alleghany County	Satisfactory	611	15	1,987
Landfill No. 2 Dam	6	Alleghany County	Satisfactory	1	1	6
Douthat Lake Dam	6	Bath County	Satisfactory	44	2	159
Beaverdam Creek Dam	6	Bedford County	Poor	7	2	58
Stoney Creek Reservoir Dam (Bedford)	6	Bedford County	Fair	24	7	244
Bedford Lake Dam	6	Bedford County	Satisfactory	1	3	81
Springhill Lake Dam	6	Bedford County	Not Rated	1	3	12
Falling Creek Reservoir Dam	6	Bedford County	Fair	18	5	198
Ivy Hill Dam	6	Bedford County	Fair	125	18	1,163
Woods Landing Dam	6	Bedford County	Satisfactory	0	1	1
Abert Water Plant - Sludge Lagoon Dam	6	Bedford County	Satisfactory	0	1	1
Elk Garden Lake Dam	6	Bedford County	Not Rated	1	3	12
Eagle Eyrie Lake Dam	6	Bedford County	Fair	1	4	23
Stroobants Dam	6	Bedford County	Fair	1	2	8
Carvin Cove Dam	6	Botetourt County	Satisfactory	3,656	84	32,468
Rainbow Forest Dam	6	Botetourt County	Satisfactory	140	6	383
Blue Ridge Estates Dam	6	Botetourt County	Satisfactory	100	5	276

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Johns Creek Dam #2	6	Craig County	Fair	24	1	265
Johns Creek Dam #1	6	Craig County	Fair	58	1	559
Johns Creek Dam #3	6	Craig County	Fair	17	1	191
Johns Creek Dam #4	6	Craig County	Fair	25	1	260
Upper Blackwater River Dam #6	6	Franklin County	Fair	14	6	55
Upper Blackwater River Dam #4	6	Franklin County	Fair	6	3	39
Leatherwood Creek Dam #5	6	Henry County	Fair	28	8	357
Beaver Creek Dam	6	Henry County	Fair	113	4	307
Leatherwood Creek Dam #3	6	Henry County	Fair	29	7	98
Leatherwood Creek Dam #2A	6	Henry County	Fair	26	9	328
Leatherwood Creek Dam #4	6	Henry County	Fair	2	3	48
Leatherwood Creek Dam #6	6	Henry County	Fair	4	7	77
Marrowbone Creek Dam #1	6	Henry County	Fair	63	8	426
Horse Pasture Creek Dam #2	6	Henry County	Fair	2	4	26
Horse Pasture Creek Dam #1C	6	Henry County	Fair	1	1	51
Smith River Dam	6	Henry County	Fair	110	3	590
Patriot Centre SW Pond #2	6	Henry County	Satisfactory	27	2	77
Hunt Country Farms Dam	6	Henry County	Fair	7	1	94
Braswell's Dam	6	Patrick County	Fair	7	9	47
Cherrystone Creek Dam # 1	6	Pittsylvania County	Fair	5	4	26
Cherrystone Creek Dam # 2A	6	Pittsylvania County	Fair	27	5	86
Burton Dam	6	Pittsylvania County	Fair	2	4	18
Pittsylvania Power Station Raw Water Storage Basin Dam	6	Pittsylvania County	Satisfactory	9	2	30
Loch Haven Lake Dam	6	Roanoke County	Not Rated	3	3	12
Clifford D. Craig Memorial Dam	6	Roanoke County	Fair	1,023	51	18,688
Woods End Dam	6	Roanoke County	Satisfactory	2	3	15
Goshen Dam	6	Rockbridge County	Satisfactory	763	24	5,171
Robertson Dam	6	Rockbridge County	Fair	69	10	211
Moores Creek Dam	6	Rockbridge County	Satisfactory	46	4	319
Turner Pond Dam	6	Rockbridge County	Poor	5	2	51
Natural Bridge Dam # 5	6	Rockbridge County	Poor	10	3	30
Windsor Lake Dam	6	City of Roanoke	Fair	11	1	420
Spring Valley Lake Dam	6	City of Roanoke	Not Rated	24	1	67
Barcroft Dam	7	Fairfax County	Satisfactory	4,047	57	26,681
Burke Lake Dam	7	Fairfax County	Fair	487	7	1,289
Pohick Creek Dam #7	7	Fairfax County	Satisfactory	89	1	701
Lake Accotink Dam	7	Fairfax County	Fair	108	12	2,589
Pohick Creek Dam #8	7	Fairfax County	Satisfactory	141	1	780
Lake Anne Dam	7	Fairfax County	Satisfactory	21	11	203
Lake Fairfax Dam	7	Fairfax County	Satisfactory	12	3	41
Lake Thoreau Dam	7	Fairfax County	Satisfactory	183	18	1,228
Crosspointe Lake Dam	7	Fairfax County	Satisfactory	2	1	9
Lake Audubon Dam	7	Fairfax County	Satisfactory	85	12	465
Pohick Creek Dam #4	7	Fairfax County	Satisfactory	144	1	1,085

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Pohick Creek Dam #2	7	Fairfax County	Satisfactory	106	1	1,323
Upper Occoquan Sewage Authority Dam	7	Fairfax County	Satisfactory	86	5	337
Pohick Creek Dam #3	7	Fairfax County	Satisfactory	69	1	1,001
Pohick Creek Dam #1	7	Fairfax County	Satisfactory	24	2	142
Lake Newport Dam	7	Fairfax County	Satisfactory	52	16	635
Fairview Lake Dam	7	Fairfax County	Satisfactory	165	4	1,362
Kingstowne Lake Dam	7	Fairfax County	Satisfactory	73	3	199
West Ox Road BMP Dam	7	Fairfax County	Satisfactory	9	1	46
Burke Centre Section 11B Dam	7	Fairfax County	Satisfactory	13	1	34
Reston Town Center Western BMP Dam	7	Fairfax County	Satisfactory	5	3	84
Reston Northern Sector Pond 1 Dam	7	Fairfax County	Satisfactory	9	1	6
Fair Lakes Dam #1	7	Fairfax County	Satisfactory	0	1	4
Pulte McLean SWM Pond Dam	7	Fairfax County	Satisfactory	5	1	27
Hampton Forest Section 4 SWM Dam	7	Fairfax County	Satisfactory	6	3	28
Carrington Regional Dam	7	Fairfax County	Satisfactory	6	1	18
Kingstowne SWM DP #4 Regional	7	Fairfax County	Satisfactory	2	1	124
Fair Lakes Land Bay 2 SWM BMP Pond Dam	7	Fairfax County	Satisfactory	6	TBD	16
Beaverdam Creek Dam	7	Loudoun County	Satisfactory	165	19	1,563
Goose Creek Dam	7	Loudoun County	Satisfactory	146	9	993
Horsepen Dam	7	Loudoun County	Satisfactory	732	5	1,924
Sleeter Lake Dam	7	Loudoun County	Satisfactory	15	6	58
Kalnasy Dam	7	Loudoun County	Fair	17	2	51
Gore Dam	7	Loudoun County	Satisfactory	0	1	6
Ashburn Village Lake #1	7	Loudoun County	Not Rated	TBD	TBD	TBD
Ashburn Village Lake #2	7	Loudoun County	Not Rated	TBD	TBD	TBD
Hope Parkway Dam	7	Loudoun County	Satisfactory	0	1	6
Brambleton Land Bay 3 Pond 6 Dam	7	Loudoun County	Satisfactory	TBD	TBD	TBD
Moorefield Station East SWM Pond Dam	7	Loudoun County	Satisfactory	44	2	123
Moorefield Station West SWM Pond Dam	7	Loudoun County	Satisfactory	1	1	9
The Lakes at Red Rock Dam	7	Loudoun County	Satisfactory	0	1	6
Richmond Square Dam	7	Loudoun County	Fair	31	4	154
T. Nelson Elliott Dam	7	Prince William County	Satisfactory	2,824	73	20,040
Lake Montclair Dam	7	Prince William County	Satisfactory	310	4	1,455
Upper Occoquan Dam	7	Prince William County	Satisfactory	153	10	1,869
Occoquan Lower Storage Dam	7	Prince William County	Satisfactory	35	1	428
Omisol Dam	7	Prince William County	Fair	0	1	3
Silver Lake Dam	7	Prince William County	Satisfactory	155	4	416

Dam Name	VDEM Region	City/County	Condition Assessment	Structure Impacts	Primary Road Impacts	Est. PAR
Possum Point Ash Dam #D	7	Prince William County	Satisfactory	0	1	3
Prince William Parkway Regional SWM	7	Prince William County	Satisfactory	12	5	184
Rocky Branch Regional SWM Dam	7	Prince William County	Satisfactory	11	3	82
New Bristow Village Regional SWM Facility Dam	7	Prince William County	Not Rated	1	1	7
North Fork Wetlands Bank Dam	7	Prince William County	Satisfactory	43	4	125
Innovation at Prince William - Pond 3	7	Prince William County	Satisfactory	3	1	11
Locust Shade Park Dam	7	Prince William County	Satisfactory	0	4	13
Potomac Creek Dam #1	7	Stafford County	Satisfactory	315	7	841
Lake Arrowhead Dam	7	Stafford County	Fair	8	1	25
Kennedy Dam	7	Stafford County	Not Rated	604	26	3,708
Aquia Creek Dam	7	Stafford County	Fair	924	2	2,442
Lake Curtis Dam	7	Stafford County	Fair	3	7	95
Potomac Creek Dam #2	7	Stafford County	Satisfactory	314	5	916
Rocky Pen Run Regional Pond 2A Dam	7	Stafford County	Satisfactory	8	2	51
Walden Ten No. 1 Dam	7	Stafford County	Fair	13	1	6
Seven Lakes Dam	7	Stafford County	Fair	TBD	1	20
Lake Mooney Dam	7	Stafford County	Satisfactory	343	16	2,239
Leeland Lake Dam	7	Stafford County	Satisfactory	7	1	20
Greene County Reservoir Dam		Greene County	Not Rated	0	2	6
ARC Redevelopment SWM Pond Dam		Prince William County	Not Rated	14	3	61

Figure 3-111 - High Hazard Dams in VDEM Region 1[25]

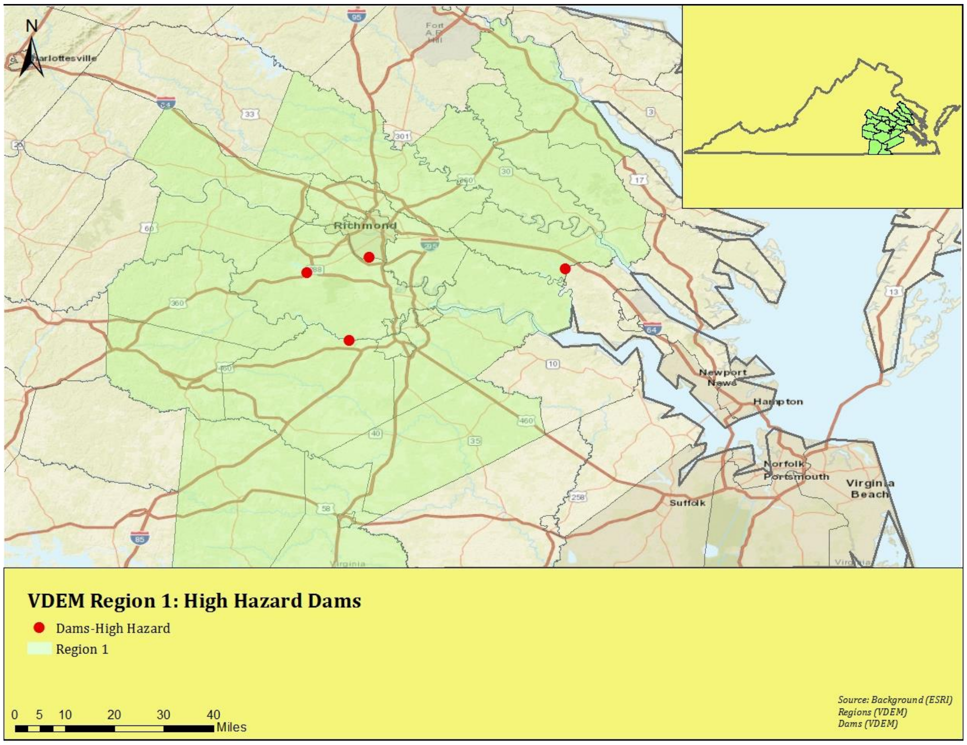


Figure 3-112 - High Hazard Dams in VDEM Region 2[26]

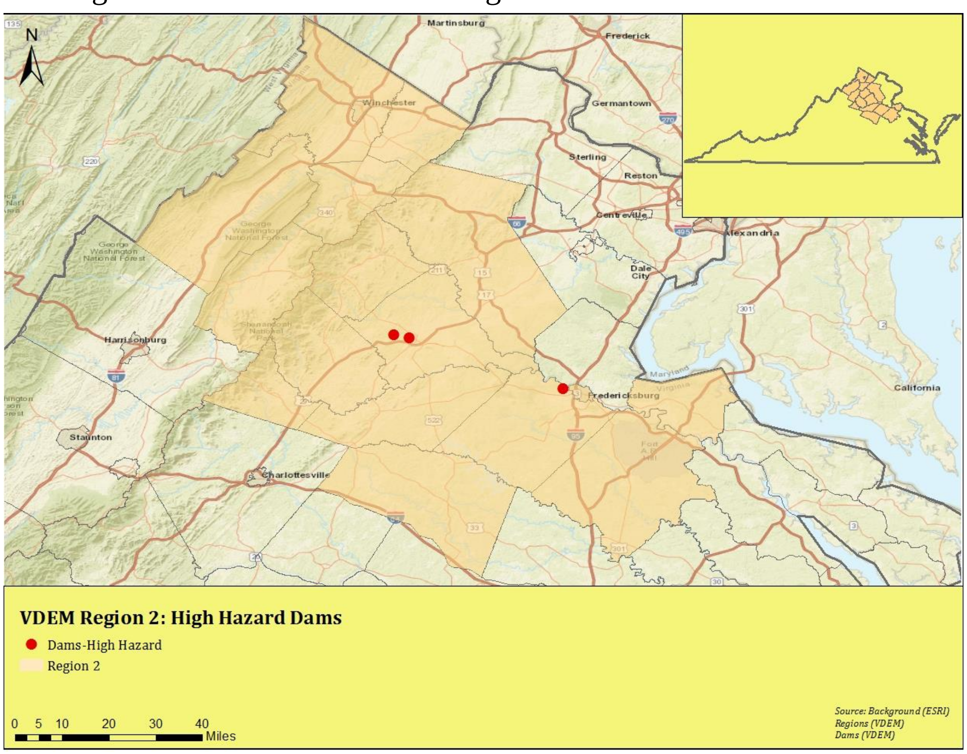


Figure 3-113 - High Hazard Dams in VDEM Region 3[27]

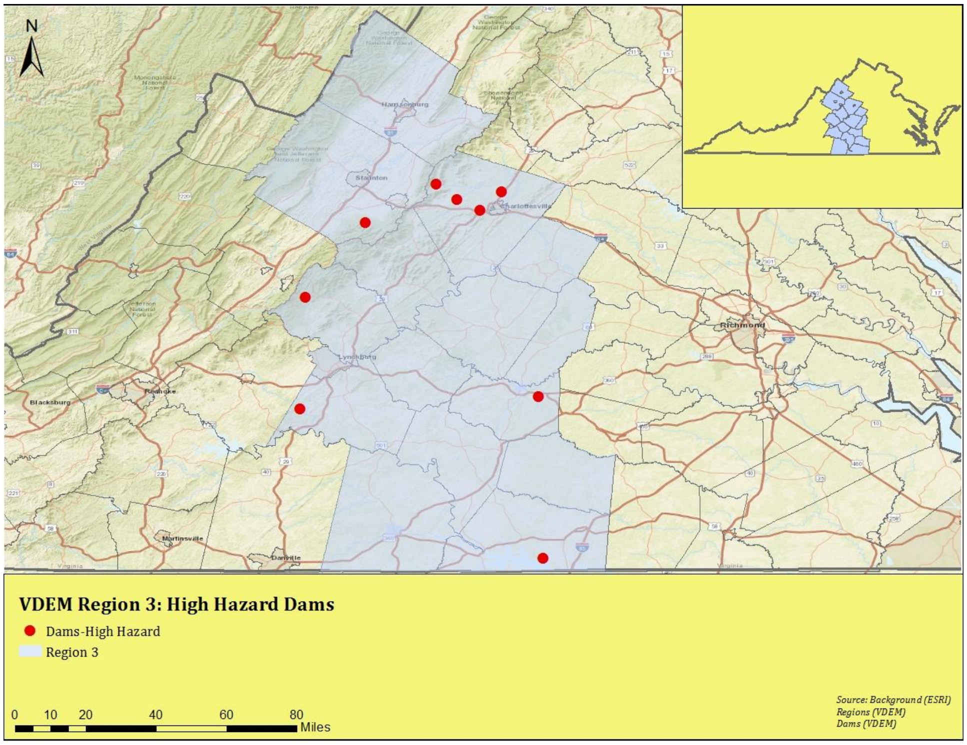


Figure 3-114 - High Hazard Dams in VDEM Region 4[28]

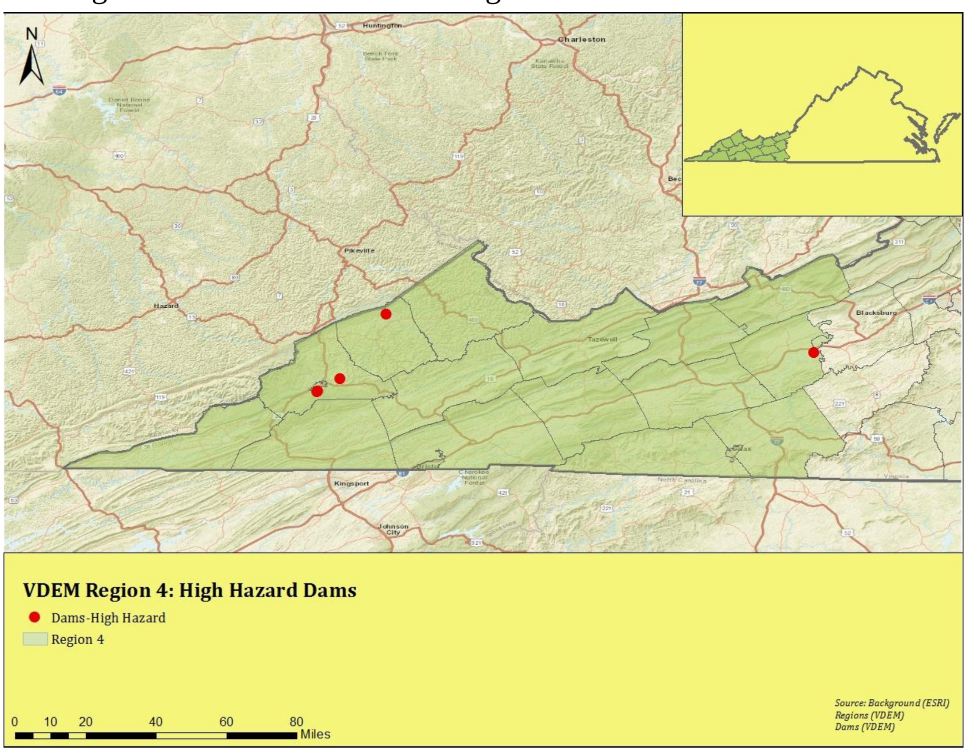


Figure 3-115 - High Hazard Dams in VDEM Region 5[29]

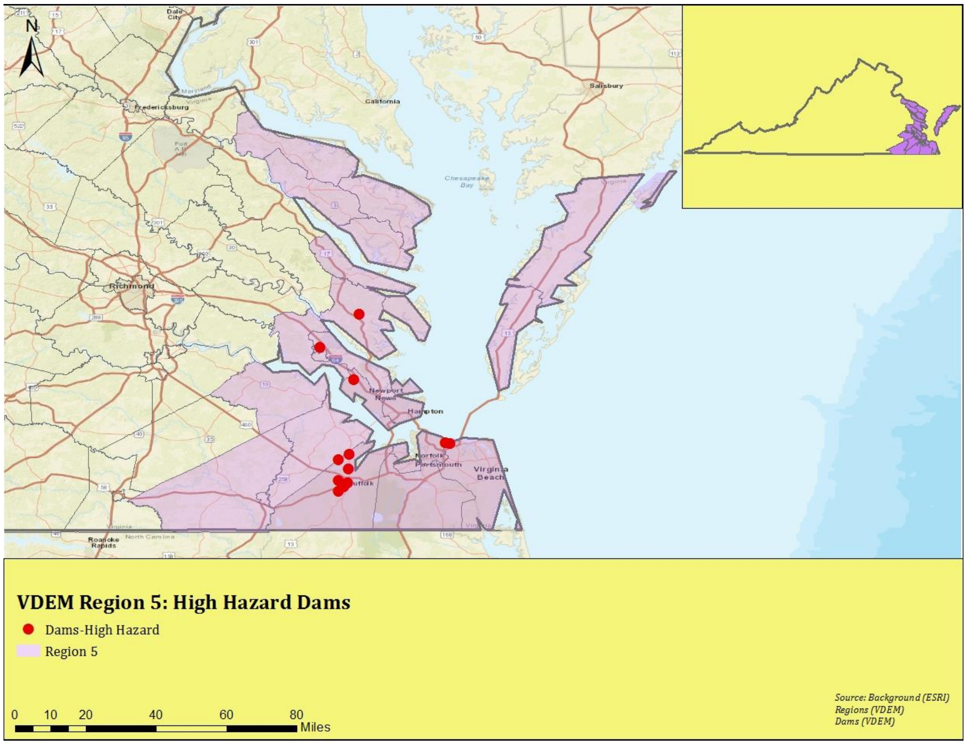


Figure 3-116 - High Hazard Dams in VDEM Region 6[30]

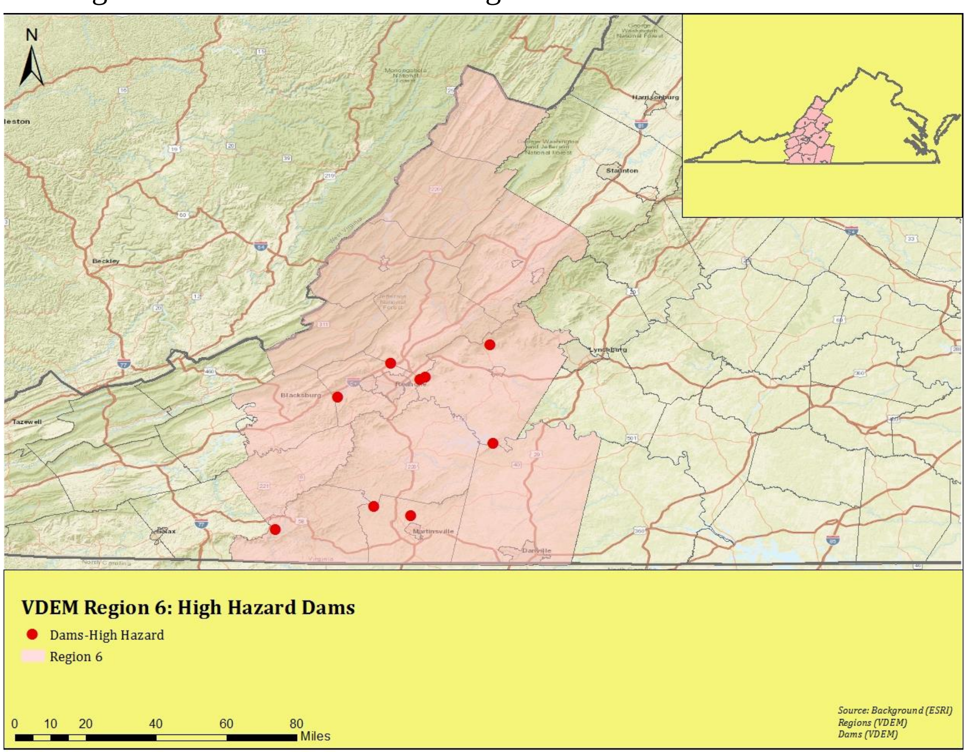
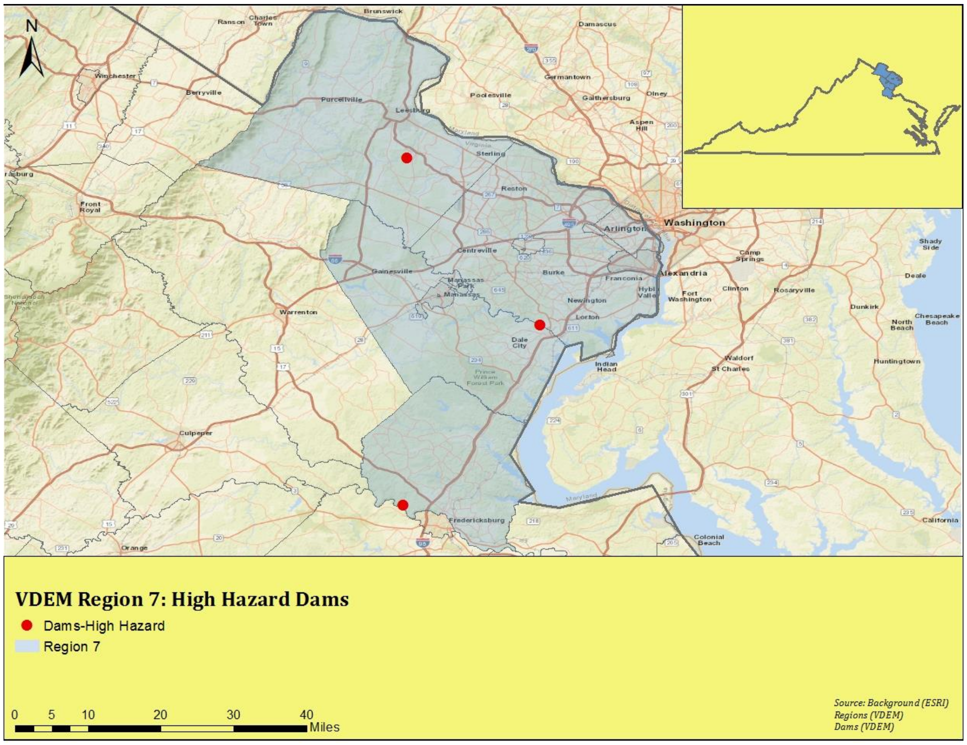


Figure 3-117 - High Hazard Dams in VDEM Region 7[31]



There are 27 known high hazard dams within the Commonwealth that are not regulated by or under the jurisdiction of Virginia DSFPM. A list of these dams is shown in Table 3-78 below and includes the regulatory agency with oversight of the dams.

Table 3-78 - Known High Hazard Potential Classification Dams Not Regulated by Virginia DSFPM

Dam Name	Hazard Class	VDEM Region	City/County	Regulatory Agency
Brasfield Dam	High	1	Chesterfield County	Federal Energy Regulatory Commission - Federal Exempt
Emporia Dam	High	1	Greensville County	Federal Energy Regulatory Commission - Federal Exempt
Lakeview Dam	High	1	City of Colonial Heights	Federal Energy Regulatory Commission - Federal Exempt
Unimin Fresh Water Dam	High	2	Frederick County	Department of Mines Minerals and Energy - State Exempt
Unimin Tailings Dam	High	2	Frederick County	Department of Mines Minerals and Energy - State Exempt
Cove Ridge Tailing Pond	High	2	Frederick County	Department of Mines Minerals and Energy - State Exempt
North Anna Dam	High	2	Spotsylvania County	Federal Energy Regulatory Commission - Federal Exempt
South Rivanna Dam	High	3	Albemarle County	Federal Energy Regulatory Commission - Federal Exempt
Reusens Dam	High	3	Amherst County	Federal Energy Regulatory Commission - Federal Exempt
John H. Kerr Dam	High	3	Mecklenburg County	US Army Corp of Engineers - Federal Exempt
Byllesby Dam	High	4	Carroll County	Federal Energy Regulatory Commission - Federal Exempt
Buck Dam	High	4	Carroll County	Federal Energy Regulatory Commission - Federal Exempt
John W. Flannagan Dam	High	4	Dickenson County	US Army Corp of Engineers - Federal Exempt
Claytor Dam	High	4	Pulaski County	Federal Energy Regulatory Commission - Federal Exempt
North Fork of Pound Dam	High	4	Wise County	US Army Corp of Engineers - Federal Exempt
Gathright Dam	High	6	Alleghany County	US Army Corp of Engineers - Federal Exempt
Bath Co. Pumped Storage - Upper Dam	High	6	Bath County	Federal Energy Regulatory Commission - Federal Exempt
Bath Co. Pumped Storage - Lower Dam	High	6	Bath County	Federal Energy Regulatory Commission - Federal Exempt
Smith Mountain Dam	High	6	Bedford County	Federal Energy Regulatory Commission - Federal Exempt
Little River Hydro Dam	High	6	Montgomery County	Federal Energy Regulatory Commission - Federal Exempt
Talbott Dam	High	6	Patrick County	Federal Energy Regulatory Commission - Federal Exempt
Townes Dam	High	6	Patrick County	Federal Energy Regulatory Commission - Federal Exempt
Leesville Dam	High	6	Pittsylvania County	Federal Energy Regulatory Commission - Federal Exempt
Niagara Dam	High	6	Roanoke County	Federal Energy Regulatory Commission - Federal Exempt
Camp 5 Dam	High	7	Prince William County	US Army Corp of Engineers - Federal Exempt
Lunga Dam	High	7	Stafford County	US Army Corp of Engineers - Federal Exempt
Breckinridge Dam	High	7	Stafford County	US Army Corp of Engineers - Federal Exempt

Appendix E provides a comprehensive list of all dams of regulatory size regardless of agency oversight.

Virginia DSFPM recommends that the dam-related information presented in this section be reviewed annually and updated as necessary to ensure accurate information is provided for planning, public safety, and emergency management purposes. As the agency works to incorporate geographical information, dam characteristics, and EAP information for additional dams in the DSIS, the information summarized in this plan will change.

3.8.8.3 Significant Historical Events

An Association of State Dam Officials summary of 1924-2018 dam failures in Virginia significant enough to cause damage to homes, a variety of fish and wildlife habitats, recreational areas, or to have caused fatalities include:

- The muck dam at Saltville broke and flooded the community of Palmertown, killing 19 people and dislodging several homes from their foundations on Christmas Eve in 1924[11].

- In 1957 the Crab Orchard Creek Dam failed due to heavy rains; no one was hurt, but the estimated damage came to half a million dollars[12].
- In 1969, the Lake Louisa Dam failed because of Hurricane Camille[13].
- Rainfall from Tropical Storm Agnes caused the failure of the Barcroft Dam in Fairfax County on June 21, 1972[14].
- Hurricane Floyd in 1999 caused twelve unregulated dams to break in eastern Virginia, including the Cow Creek Dam in Gloucester County[15].
- Timberlake Dam, which killed two in 1995 and cost nearly one million dollars to rebuild.
- Powhatan Lakes Dam, which failed due to a heavy storm during the summer of 2004 and caused over one million dollars in damage.[16]
- Falling Creek Dam in Chesterfield County, which was overtopped during Tropical Storm Gaston flooding in late summer 2004.
- Several dams failed or were overtopped following Tropical Depression Ernesto in 2006.
- The Kingstowne Park Dam in Fairfax County failed in 2010, resulting in the almost complete drainage of two lakes and the destruction of a variety of fish and wildlife habitats, as well as the loss of recreational areas[17].
- Several dams including Beaver Creek Dam and Reedy Millpond Dam were overtopped in May 2018, following a period of heavy rains that caused water levels to breach the dams and damage some structural components including the wingwalls and spillways.

While there is no comprehensive database of historical dam failures, Virginia DSFPM has compiled a list of known dam incidents and failures. Table 3-79 provides the current list of known incidents and failures in Virginia. Most failures occur due to lack of maintenance of dams in combination with major precipitation events.

Table 3-79 - Known Historic Dam Incidents and Failures

Count	Year	Date of Failure	No.	Dam Name	Damage	Deaths	County	Hazard Class
1	1924	12/24/1924	n/a	Saltville Muck Dam	Full Breach	19	Smyth	High
2	Unknown	00/00/1930	095012	Lake Powell Dam	Overtopped with Damage		James City	Significant
3	Unknown	1/29/1957	021002	Crab Orchard Creek dam	full breach		Bland	High
4	1969	8/19/1969	145049	Lake Louise Dam	full breach		Louisa	Significant
5	1972	6/21/1972	059001	Barcroft Dam	Full Breach		Fairfax	High
6	1986	00/00/1986	n/a	Lake Cherokee Dam	Overtopped with Damage		Richmond	Significant
7	1991	11/30/1991	095012	Lake Powell Dam	Spillway failure		James City	Significant
8	1993	09/00/1993	193011	Chandler's Mill Dam	Full Breach		Westmoreland	High
9	1994	3/5/1994	095012	Lake Powell Dam	piping failure		James City	Significant
10	1995	6/22/1995	031002	Timberlake Dam	Full Breach	2	Cambell	Significant
11	1999	9/17/1999	095013	Cranston Mill Pond Dam	full breach		James City	Significant
12	1999	9/17/1999	003201	Advanced Mills Dam	Slope Failure		Albemarle	Significant
13	1999	9/17/1999	073005	Cow Creek Dam	Full Breach		Gloucester	Significant
14	1999	9/17/1999	073006	Burke Dam	Slope Failure		Gloucester	Unknown
15	1999	9/17/1999	073008	Haines Pond Dam	Full Breach		Gloucester	Low
16	1999	9/17/1999	085036	Hanover Learning Center Dam	Full Breach		Hanover	Low
17	1999	9/17/1999	087006	Miles Dam	Full Breach		Henrico	Low
18	1999	9/17/1999	095011	Lake Pasbehegh Dam	Overtopped with Damage		James City	Unknown
19	1999	9/17/1999	095012	Lake Powell Dam	Overtopped with Damage		James City	Significant
20	1999	9/17/1999	095015	Kingsmill Dam	Overtopped with Damage		James City	Unknown
21	1999	9/17/1999	095023	Old Mill Pond Dam	full breach		James City	Low
22	1999	9/17/1999	097004	Allen's Mill Dam	Full Breach		King & Queen	Low
23	1999	9/17/1999	097005	Corbin Mill Dam	Slope Failure		King & Queen	Unknown
24	1999	9/17/1999	101013	Herring Creek Millpond Dam	Slope Failure		King William	Significant
25	1999	9/17/1999	101016	Gravatts Millpond Dam	Full Breach		King & Queen	Low
26	1999	9/17/1999	101017	Fogg Dam	Full Breach		King William	Low
27	1999	9/17/1999	101019	Townsends Dam #2	Full Breach		King William	Low
28	2004	7/25/2004	095012	Lake Powell Dam	Full Breach		James City	Significant
29	2004	7/26/2004	057007	Essex Mill Dam	Full Breach		Hanover	Low
30	2004	8/31/2004	041015	Falling Creek Reservoir Dam	Overtopped with Damage		Chesterfield	High
31	2004	8/31/2004	085020	Lake Idylwild Dam	full breach		Hanover	Significant
32	2004	8/31/2004	085032	Pebble Creek Dam	Full Breach		Hanover	Low
33	2004	8/31/2004	085041	Carter's Pond Dam	Full Breach		Hanover	Significant
34	2004	8/31/2004	085044	Walden's Pond Dam	Slope Failure	1	Hanover	Significant
35	2004	8/31/2004	085062	Cady Lake Dam	Full Breach	1	Hanover	Significant
36	2004	8/31/2004	145001	Upper Powhatan Dam	Full Breach		Powhatan	Significant
37	2004	8/31/2004	145002	Lower Powhatan Dam	Slope Failure		Powhatan	Low
38	2004	9/7/2004	057001	Hunters Mill Dam	Full Breach		Essex	Low
39	2004	9/7/2004	057005	Cheatwoods Mill Dam	Full Breach		Essex	Low
40	2004	9/7/2004	075053	Columbia Junction Dam	Full Breach		Goochland	Low
41	2004	9/7/2004	085007	Parsleys Mill/Beaties Dam	Full Breach		Hanover	Low
42	2004	9/7/2004	085008	Flanagan's Mill Pond Dam	Full Breach		Hanover	Low-Special
43	2004	9/7/2004	085038	Rainer Dam	Full Breach		Hanover	Low
44	2004	9/7/2004	087015	Staples Mill Dam	Overtopped with Damage		Hanover	Unknown
45	2004	9/7/2004	095021	Toano Dam	Full Breach		James City	Low
46	2004	9/7/2004	097002	King & Queen Courthouse Dam	Full Breach		King & Queen	Low
47	2004	9/7/2004	099007	Madison Mill Dam (Mason)	Full Breach		King George	Low
48	2004	9/15/2004	n/a	Cedar Lake Dam	Full Breach		Gloucester	Unknown
49	2004	10/7/2004	073008	Haines Pond Dam	Full Breach		Gloucester	Low
50	2005	7/22/2005	085019	Mechumps Dam	Full Breach		Hanover	Low

Count	Year	Date of Failure	No.	Dam Name	Damage	Deaths	County	Hazard Class
51	2005	9/15/2005	087014	Lake Overton Dam	Spillway failure		Henrico	Significant
52	2005	12/20/2005	041011	Gordon Dam	Full Breach		Chesterfield	Low
53	2006	7/28/2006	033112	Upper Tanyard Run Dam	Full Breach		Caroline	Low
54	2006	9/1/2006	073005	Cow Creek Dam	Full Breach		Gloucester	Significant
55	2006	9/1/2006	036002	Lake Charles VCU-Rice Ctr Dam	Full Breach		Charles City	Low
56	2006	9/1/2006	095012	Lake Powell Dam	full breach		James City	Significant
57	2006	9/1/2006	n/a	Hunters Ridge Equest. Ctr. Dam	Pipe Collapse		Powhatan	Significant
58	2006	9/1/2006	095013	Cranston Mill Pond Dam	full breach		James City	Significant
59	2006	10/6/2006	095009	Jolly Pond Dam	Sloughing		James City	Significant
60	2006	12/1/2006	085018	Forest Lake Dam	Pipe Collapse		Hanover	Low
61	2007	4/23/2007	127015	Walker's Dam	Partial Breach		New Kent	Low
62	2008	3/17/2008	119001	Healys Dam	Partial Breach		Middlesex	Significant
63	2008	5/21/2008	041079	Geara Woods Dam	piping failure		Chesterfield	Significant
64	2008	7/7/2008	033040	Coburn Dam	Full Breach		Caroline	Low-Special
65	2008	9/5/2008	075037	Hollands Hills Dam	Sloughing		Goochland	Low
66	2008	12/3/2008	033025	Coleman Pond Dam	Full Breach		Caroline	Low
67	2009	1/23/2009	119008	Hilliards Mill Pond Dam	full breach		Middlesex	Low
68	2009	3/20/2009	095008	Barlows Pond Dam	Cavitation		James City	Significant
69	2009	8/7/2009	101013	Herring Creek Millpond Dam	Slope Failure		King William	Significant
70	2009	8/7/2009	101012	Mitchells Millpond Dam	Full Breach		King William	Significant
71	2009	12/27/2009	101026	Central Crossing Dam	Spillway failure		King William	Low
72	2010	3/1/2010	n/a	Pruden Blvd Dam	Overtopped with Damage		City of Suffolk	Unknown
73	2010	10/1/2010	059050	Kingstowne SWM DP #4 Regional Dam	full breach		Fairfax	High
74	2010	10/1/2010	103007	Blackmore Millpond Dam	full breach		Lancaster	Unknown
75	2010	00/00/2010	095054	Kings Pointe Dam	Slope Failure		James City	Low-Special
76	2011	00/00/2011	193011	Chandler's Mill Dam	full breach		Westmoreland	High
77	2011	3/31/2011	103004	Golden Eagle Dam	Spillway failure		Lancaster	Low
78	2011	7/19/2011	109014	Lake Sherman Dam	Piping failure		Louisa	Low
79	2011	8/19/2011	095008	Barlows Pond Dam	Slope Failure		James City	Significant
80	2011	9/1/2011	109008	Yanceville Dam	Center Slump - Earthquake		Louisa	Unknown
81	2011	9/4/2011	033019	Byrds Mill Dam	Overtopped with Damage		Caroline	Significant
82	2011	9/4/2011	095007	Richardson Millpond Dam	Cavitation		James City	Significant
83	2011	9/4/2011	n/a	Plantation Forest	Overtopped with Damage		Spotsylvania	Unknown
84	2011	9/9/2011	033003	Smoots Dam	Slope Failure		Caroline	Unknown
85	2011	9/9/2011	033019	Byrds Mill Dam	Full Breach		Caroline	Significant
86	2011	9/9/2011	n/a	Niceviewfarm Lake Dam	Pipe Collapse		Charles City	Low
87	2011	9/9/2011	n/a	Parr Drive	Overtopped with Damage		Essex	Unknown
88	2011	9/9/2011	057007	Essex Mill Dam	full breach		Essex	Low
89	2011	9/9/2011	n/a	Horn Quarter Farm Dam	Full Breach		Hanover	Low
90	2011	9/9/2011	n/a	Longest Farm Dam	Full Breach		Hanover	Low
91	2011	9/9/2011	127008	Old Forge Pond Dam	Spillway Activation		New Kent	Low
92	2011	9/9/2011	127010	Goodins Dam	Slope Failure		New Kent	Significant
93	2011	9/9/2011	159009	Connellee Dam	Full Breach		Richmond	Significant
94	2011	9/9/2011	193001	Morris Dam	Full Breach		Westmoreland	Low
95	2011	9/9/2011	810024	Placid Lake Dam 1	Full Breach		Westmoreland	Unknown
96	2011	9/9/2011	810025	Placid Lake Dam 2	Full Breach		Westmoreland	Unknown
97	2011	9/9/2011	193006	Placid Lake Dam 3	Full Breach		Westmoreland	Low
98	2011	12/14/2011	075004	Killarney Dam	Spillway failure		Goochland	Significant
99	2012	7/25/2012	087028	Cox Road Dam/Waterfront Lake	Sloughing		Henrico	Significant
100	2012	7/27/2012	033030	Terrell Brothers Dam	Partial Failure		Caroline	Low

Count	Year	Date of Failure	No.	Dam Name	Damage	Deaths	County	Hazard Class
101	2013	2/6/2013	079011	Twin Lakes Dam No.2	Pipe Collapse		Greene	High
102	2013	6/1/2013	n/a	Waterford Dam	Pipe Collapse		Spotsylvania	Unknown
103	2013	7/1/2013	n/a	Five Lakes Pond Dam	Pipe Collapse		New Kent	Unknown
104	2013	10/2/2013	075033	Royal Virginia Golf Club Dam	Pipe Collapse		Goochland	Unknown
105	2014	4/27/2014	003200	PVCC Dam	Lake Drained		Albemarle	Low
106	2014	5/14/2014	107068	Corti-Jencen Dam	Piping failure		Loudon	High
107	2014	6/11/2014	041073	Lower Madowdale Dam	Piping Failure		Chesterfield	Unknown
108	2014	7/3/2014	041023	Rieves Dam	Partial Breach		Chesterfield	Low
109	2014	8/6/2014	041077	Baeufont Springs Dam	Slope Failure		Chesterfield	Significant
110	2014	12/9/2014	095019	Rennicks Pond Dam	Pipe Collapse		James City	Significant
111	2015	5/20/2015	193011	Chandler's Mill Dam	Partial Breach		Westmoreland	High
112	2016	10/1/2016	025005	Flatrock Pond Dam	Partial Failure		Brunswick County	Unknown
113	2016	10/5/2016	085039	Mattawan Dam	Riser Failure		Hanover County	Significant
114	2016	10/14/2016	n/a	Yahley Mill Road Dam	Overtopping/Erosion		Henrico County	Unknown
115	2016	10/25/2016	095008	Barlows Millpond Dam	Berm Erosion		James City County	Significant
116	2018	8/3/2018	680002	College Lake Dam	Overtopped with Damage		City of Lynchburg	High
117	2018	10/12/2018	147005	Goodwin Dam	Downstream Slope Failure		Prince Edward County	Low
118	2018	10/15/2018	159002	Garland Mill Pond	Downstream Slope Failure		Richmond County	Low
119	2018	10/23/2018	083039	Edmunds Lake Dam	Downstream Slope Failure		Halifax County	Low-Special
120	2018	12/12/2018	087002	Canterbury Dam/Pump Road	Partial Failure		Henrico County	High
121	2019	1/15/2019	035017	Webb/Stricken Deer Reserve Dam	Partial Failure		Carroll County	High
122	2019	2/23/2019	015506	Lake Powhatan Dam	Pipe Collapse		Pulaski County	High
123	2019	3/14/2019	077004	Laurel Creek Dam/Lost Lake Dam	Overtopped with Damage		Grayson County	Unknown
124	2019	3/19/2019	067000	Rakes Tavern LP Dam	Pipe Collapse		Franklin County	Unknown
125	2019	5/9/2019	131004	Kellam Dam	Pipe Collapse		Northampton County	Unknown
126	2019	9/16/2019	095054	Kingspoint Dam	Partial Failure		City of Williamsburg	Unknown
127	2019	12/7/2019	177036	Spotsylvania County Dam #9	Pipe Collapse		Spotsylvania County	Unknown
128	2020	5/20/2020	770002	Spring Valley Lake Dam	Overtopped No Damage		City of Roanoke	High
129	2020	6/5/2020	700004	Maury Dam/Lions Bridge Dam	Downstream Slope Failure		City of Newport News	High
130	2020	6/22/2020	085006	Gaines Mill Dam	Downstream Slope Failure		Hanover County	Unknown
131	2020	8/15/2020	041039	Izaak Walton Park Dam	Overtopped No Damage		Chesterfield County	Unknown
132	2020	8/15/2020	041015	Falling Creek Reservoir Dam	Overtopped with Damage		Chesterfield County	High
133	2020	8/15/2020	041012	Swift Creek Reservoir Dam	Overtopped with Damage		Chesterfield County	High
134	2020	8/15/2020	570001	Lakeview Dam	Overtopped with Damage		Colonial Heights City	High
135	2020	9/1/2020	101026	Central Crossing Dam	Spillway Collapse		King William County	Low
136	2020	10/30/2020	029037	Doug Branch Pond	Partial Failure		Buckingham County	Low
137	2020	11/12/2020	193011	Chandler's Mill Dam	Overtopped with Damage		Westmoreland County	Significant
138	2020	11/12/2020	137015	Spotswood Drive Dam	Partial Failure		Orange County	Low
139	2020	11/30/2020	177036	Spotsylvania County Dam #9	Pipe Collapse		Spotsylvania County	Unknown
140	2021	8/19/2021	149027	Chappell Creek Dam	Partial Failure		Prince George County	Unknown
141	2022	1/5/2022	099006	Lake Monroe Dam	Pipe Collapse		King George County	High
142	2022	1/17/2022	193011	Chandler's Mill Dam	Partial Failure		Westmoreland County	Significant
143	2022	3/21/2022	065006	McIver Dam	Pipe Collapse		Fluvanna County	Unknown

Source: DCR

3.8.8.4 Probability of Future Occurrence

Risk exposure from dam or levee failure includes exposure to all the types of dam-related risks, including risk to the dam or population, infrastructure, or other assets and resources downstream. Risk can relate to damage that occurs indirectly as a result of a dam failure or to residual risk. Virginia DSFPM adopts the following definition of risk:

Incremental Risk: The risk (likelihood and consequences) to the pool area and downstream floodplain occupants that can be attributed to the presence of the dam should the dam breach prior or subsequent to overtopping, or undergo component malfunction or mis-operation, where the consequences considered are over and above those that would occur without dam breach. The consequences typically are due to downstream inundation, but loss of the pool can result in significant consequences in the pool area upstream of the dam.

Non-Breach Risk: The risk in the reservoir pool area and affected downstream floodplain due to 'normal' dam operation (e.g., large spillway flows within the design capacity that exceed channel capacity) or 'overtopping of the dam without breaching' scenarios.

Residual Risk: The risk that remains after all mitigation actions and risk reduction actions have been completed. With respect to dams, FEMA defines residual risk as "risk remaining at any time" (FEMA, 2015, p A-2). It is the risk that remains after decisions related to a specific dam safety issue are made and prudent actions have been taken to address the risk. It is the remote risk associated with a condition that was judged to not be a credible dam safety issue.[lxxv]

Virginia DSFPM uses predictive modeling related to dam failure risk under specified conditions to produce dam break inundation zone maps. These analyses provide information related to site-specific potential failure modes and offers predictions of the downstream consequences if the dam were to fail during a storm event or on a "sunny day." The inundation maps aid emergency personnel in warnings and evacuations of downstream homes, schools, or businesses.

Within Virginia's regulatory hazard classification system, higher hazard classifications trigger more stringent requirements, such as increased spillway capacity and/or reservoir storage volume, more frequent inspections. These imbedded incremental risk assessments and processes allow for the identification of human and infrastructure consequences should the dam fail.

Virginia DSFPM site visits, dam owner, and dam owner PE inspections provide vital information and often identify non-breach and residual risks at a dam. Examples may include hazard creep, flawed design and construction, overdue maintenance and repair, debris obstructing trash racks, inlet/outlet works and spillways, damage to earthen embankments caused by plants or animals, and upstream dam events. Risks associated with operational decisions can be mitigated through education and training and the required annual drills and tabletop exercises.

Where risk factors are increased or dam failures are probable or imminent, the Department can unilaterally take action under authority granted in §10.1 -608 and §10.1 – 609 for unsafe dams presenting imminent or non-imminent failure. Actions that can be taken include forced drawdown of the reservoir pool, notching the dam to increase spill capacity, or complete removal of the dam.

Virginia DSFPM's current inventory of regulatory size includes approximately 1,800 dams without a regulatory hazard classification. The hazard classification is a critical step in determining risk to life and property downstream. The absence of a hazard classification for any dam of regulatory size poses an unacceptable risk to the public. Virginia DSFPM has begun developing modified dam break inundation studies and EAPs for these dams using readily available information to assess the provisional hazard rating pending the owner's more detailed study. These modified studies use simplified engineering assumptions and methods similar to work done by North Carolina Department of Environmental Quality's Dam Safety Program and the NWS. The modified studies and EAPs provide Virginia DSFPM, localities and emergency managers with critical information in the absence of full plans and studies should the dam fail. Additionally, Virginia DSFPM is developing a dam inspection application for use by engineers and owners to inspect dams to establish a baseline condition assessment.

Impact and Vulnerability

Although dam break inundation maps are a requirement of the current Impounding Structure Regulations[18], Virginia DSFPM does not currently have this information available in a digital form for all dams. Predicting the probability of flooding due to dam failure requires a detailed, site-specific engineering analysis for each dam in question. Failure may result from hydrologic and hydraulic design limitations, geotechnical, or operational factors. The data and time necessary to perform a probabilistic failure analysis for each dam in Virginia is beyond the scope of this plan. The probability of dam failure due to hydrologic and hydraulic design limitations is related to the regulatory standards for dam spillway design in Virginia. Dams are required to pass a spillway design flood (SDF) without failure, as indicated in Table 3-80.

Table 3-80 - Performance Standards for Dams[19]

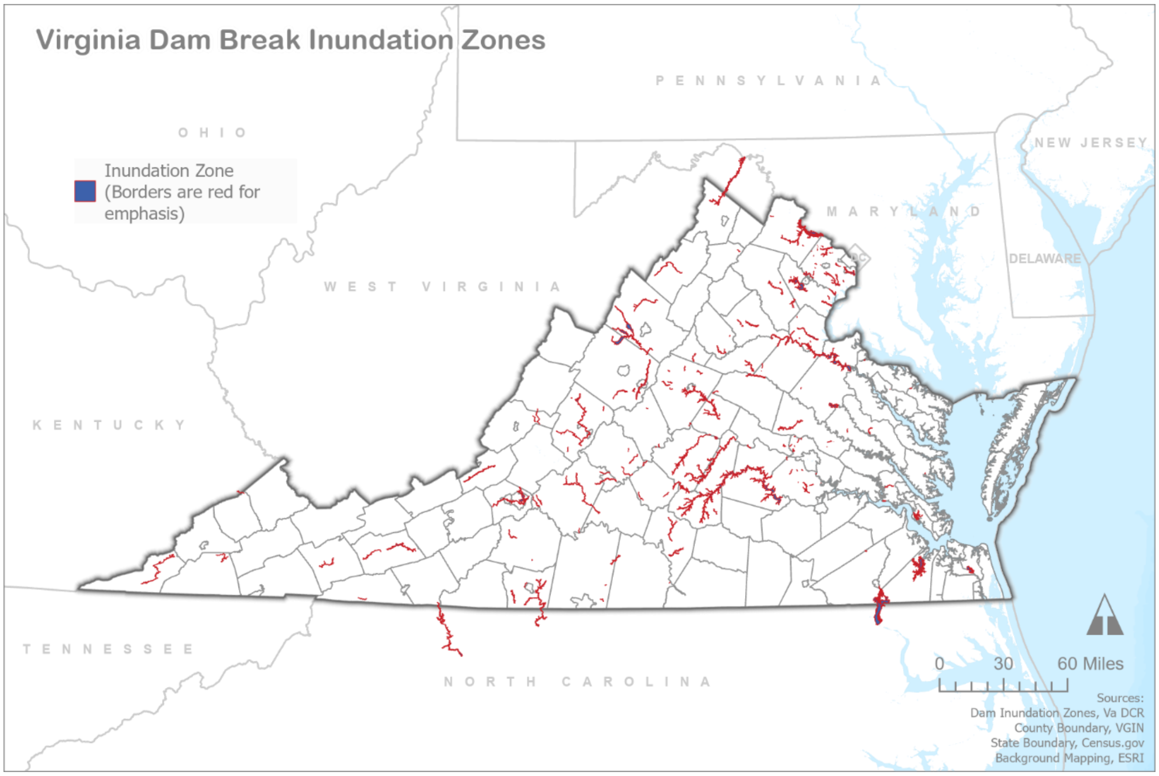
Hazard Potential	Spillway Design Flood (SDF) B for New Construction F	Spillway Design Flood (SDF) B for Existing Impounding Structures F, G	Minimum Threshold for Incremental Damage Analysis
High	PMFC	0.9 PMPH	100-YRD
Significant	.50 PMF	.50 PMF	100-YRD
Low	100-YRD	100-YRD	50-YRE

Note that a dam may be designed to a slightly lower standard than the spillway design flood based on a detailed incremental damage analysis showing that using the higher design flood does not significantly worsen downstream flooding. Low hazard dams expected to result in no loss of human life and no economic damage to any property, except the dam owner's, may be exempted from the spillway design standards as well as many of the otherwise applicable regulations.

Failure of dams may result in catastrophic localized damages. Vulnerability to dam failure is dependent on dam operations planning and the nature of downstream development. Depending on the elevation and storage volume of the impoundment, the impact of flooding due to dam failure may include loss of human life, economic losses such as property damage and infrastructure disruption, and environmental impacts such as destruction of habitat. Evaluation of vulnerability and impact is highly dependent on site-specific conditions; no broad-brush approach can be applied at a statewide level.

Dam infrastructure continues to age across the country; an estimated seven in 10 dams will have reached the end of its useful life by 2025. Dams regulated by Virginia DSFPM with known deficiencies continue to create a growing public safety concern for downstream residents, communities, and overall infrastructure. Modified plans and studies are underway for more than 1,800 dams of regulatory size without a hazard classification. These dams will be prioritized by size and potential downstream impact to determine those that may pose the greatest risk to life and property. Figure 3-118 below from Virginia DSFPM shows a summary of dam break inundation zones within the Commonwealth.

Figure 3-118 - Virginia dam break inundation zones.



Risk

Based on data from the USACE National Inventory of Dams (NID), there are approximately 2,919 dams in the Commonwealth, both regulated and unregulated. Most dams in Virginia are classified as Low hazard (44%). Significant hazard structures make up 18%, and 20% do not have a hazard classification determined. The remaining 16% are classified as High hazard by the USACE's NID. Of the 2,919 dams inventoried, 2,512 (86%) are privately owned.

Within the DSIS database of known dams, there are 16 dams with condition determined to be unsatisfactory, and 79 dams in poor condition. These dams with known impoundment deficiencies pose more risk to downstream people and infrastructure than other regulated and inspected dams. Of those poor condition dams, only 3 have mapped inundation zones. Downstream assets in inundation zones identified in the EAP include:

- South River Dam in Augusta County (High Hazard Dam) – 5 dwellings, 2 businesses, 2 railroads and 3 roads
- Goodwin Dam in Prince Edward County (Low Hazard Dam) – 4 roads
- Hidden Lake Dam in Stafford County (Significant Hazard Dam) – 2 roads

Additional dams exist that are not regulated and their (largely unknown) condition poses a risk associated with that uncertainty.

3.8.8.5 State Facility Risk

Damage to state facilities in downstream impoundment failure inundation zones may include flood-related damage to structures, including damage from hydrostatic pressure against foundations, as well as water and debris damage. Recreational facilities such as state parks, trails and wildlife management areas could experience damage to natural areas, including debris damage, water damage, and damage to trees, undergrowth and habitats, as well as damage to park structures such as cabins, garages and sheds. Roads and bridges are subject to being washed out or severely damaged by rushing water or may have less visible structural damage to bridge components. Infrastructure that runs along or across streams, such as railways and pipelines, are also subject to damage by rushing water associated with dam failure.

The potential consequence of impoundment failure specifically to state assets and critical facilities were analyzed using FEMA HAZUS critical features data and VAPS state-owned asset data. Critical facilities include emergency resources, fire stations, police stations, hospitals and schools, while examples of state-owned assets include colleges and universities, the Department of Motor Vehicles, and the Department of Health. These data were used to identify which features are in areas that could be subject to flooding following impoundment failure for the state-regulated dams that have mapped inundation zones. Analysis of these data indicated that there are at least 57 critical facilities and 115 state-owned assets located in dam inundation zones throughout the Commonwealth.

Critical facilities in mapped impoundment failure inundation zones are shown in Table 3-81. The at-risk state-owned assets are estimated at $267 million as shown in Table 3-82. Caution should be used with these results because not all state-regulated dams have digitally mapped inundation areas, and not all state assets have geographic coordinates or valuations. According to the data provided by state agencies, there are no geolocated state assets within FEMA certified levee-protected areas in Virginia.

Table 3-81 - Critical facilities in mapped impoundment failure inundation zones

Location	Count*
Albemarle County	1
Alleghany County	3
Augusta County	6
Botetourt County	14
Chesterfield County	3
Culpeper County	1
Fairfax County	8
Fauquier County	1
Prince Edward County	1
Prince William County	3
Roanoke County	4
Rockbridge County	2
Rockingham County	1
Spotsylvania County	4
City of Suffolk	3
TOTAL	57

*Analysis based only on state-regulated dams with digitally mapped inundation zones.

Table 3-82 - State-owned assets in impoundment failure inundation zones

Location	Count*	Building Value*	Contents*	Total*
Albemarle County	1	$2,831	$620,304	$623,135
Alleghany County	2		$273,328	$273,328
Augusta County	3		$410,398	$410,398
Bath County	63	$13,550,969	$1,346,360	$14,897,329
Bedford County	1		$328,090	$328,090
Botetourt County	18	$47,956,655	$8,987,800	$56,944,456
Culpeper County	1		$28,591	$28,591
Fairfax County	4	$1,168,247	$611,984	$1,780,231
King and Queen County	8	$521,705	$262,428	$784,133
Prince Edward County	1	$98,000	$62,250	$160,250
Roanoke County	9	$180,370,894	$10,244,866	$190,615,760
Rockbridge County	1		$13,540	$13,540
Spotsylvania County	3		$627,149	$627,149
TOTAL	115	$243,669,301	$23,817,000	$267,486,390

*Analysis based only on state-regulated dams with digitally mapped inundation zones, and state assets with coordinate locations and dollar valuations.

3.8.8.6 National Risk Index

The NRI does not include an assessment for impoundment failure. The NRI's social vulnerability information for flooding, a related hazard, is included herein. While social vulnerability factors for flooding may be similar to many of the factors affecting social vulnerability to impoundment failure, the geographic areas of potential impoundment failure do not necessarily align with the areas vulnerable to 100-year flooding. Despite these shortcomings, an assessment of areas with concurrent higher NRI Risk Index for inland flooding and *currently available* information on structures at risk of dam failure inundation was conducted. Only Shenandoah County meets both criteria, with 469 structures in mapped downstream inundation zones of Stony Creek Dams #9 and #10, indicating additional study is necessary. The county has a Relatively Moderate NRI Risk Rating for Inland Flooding.

A far more useful assessment of social vulnerability to both dam and levee inundation failure would be a full analysis of structures in downstream inundation zones for the approximately 1,800 unclassified dams in the Commonwealth, particularly those in poor or unsatisfactory condition, as well as full condition assessments and risk ratings for the many unknown dams throughout Virginia. Virginia DSFPM continues to gather the data points necessary to work toward such an analysis, but the missing data preclude further assessment at this time. Virginia DSFPM officials estimate that more than 50% of all dams in the Commonwealth are privately owned, and most private dam owners don’t have the resources and capabilities necessary to manage and mitigate risk from their dam.

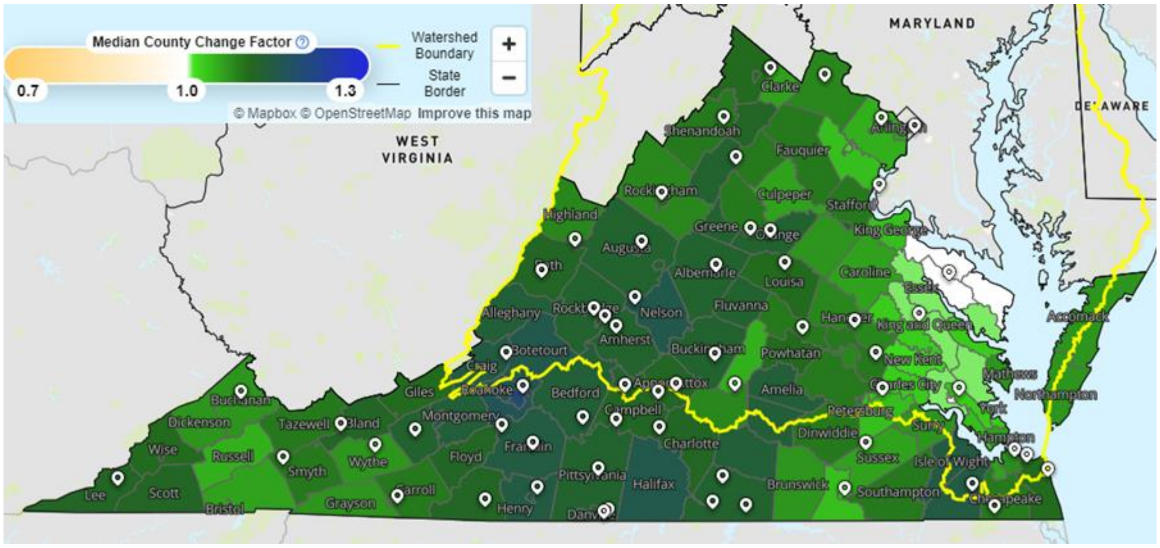
Future Conditions

New projections of increased rainfall, duration, and frequency (IDF) curves that have been developed for the Commonwealth of Virginia[1] are now available through a web tool that provides 2-year through 100-year change factors to precipitation based on the current NOAA Atlas 14 IDF curves for both low and high emissions scenarios (RCP 4.5 and RCP 8.5) through 2100 (https://midatlantic-idf.rcc-acis.org/).

These projections as shown in Figure 3-119 for a 50-year return period and a low emissions scenario between 2020 and 2070, indicate an overall environment of increased precipitation with the exception of the City of Williamsburg, and Westmoreland, Richmond and Northumberland counties. Areas in the central part of the state, including especially City of Roanoke, Roanoke County, Cities of Salem and Radford, Nelson County, Halifax County, Botetourt County have the highest projected departure from current intensity-duration-frequency curves. The City of Roanoke has the highest projected departure, with an expected 19% increase in precipitation by 2070. Increased intensity, duration and frequency of precipitation leads to increased flooding, which in turn, increases the potential for overtopping which is the most common mode of dam failure[2]. Precipitation and flooding can also lead to erosion and decreased impoundment stability which can contribute to failure. As precipitation amounts fluctuate and extreme weather events become more common, the flood control and impoundment infrastructure in Virginia becomes more of a concern. Like most of the country, the infrastructure in Virginia is overwhelmingly privately-owned and maintained, and it is aging – in many cases, to the end of its design life. The occurrence of more frequent high intensity rainfall events may create conditions that exceed the original design criteria of these aging facilities and increase the probability of impoundment failure.

[1] Miro, M.E., DeGaetano, A.T., López-Cantú, T., Samaras, C., Webber, M., and Grocholski, K.R. 2021. Developing Future Projected Intensity-Duration-Frequency (IDF) Curves. RAND, 62 pp. DOI https://doi.org/10.7249/TLA1365-1. Retrieved 7 September 2022 from https://www.rand.org/pubs/tools/TLA1365-1.html.

Figure 3-119 - Projected Intensity-Duration-Frequency Curve Data for Virginia, 2020-2070



Jurisdictional Risk

3.8.8.7 Local Plan Risk Assessment

Local plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

Of the 20 local plans, one (Rappahannock-Rapidan Regional Commission) estimated losses for dam failure as negligible. The other 19 local plans did not provide loss estimates for flooding due to dam failure. Of the plans that provided a general description of the hazard, many of them provided USACE National Inventory of Dams statistics for dams in their region. Middle Peninsula PDC and Southside PDC each provided a dam inundation zone map for dams in their region, along with the information about the number of structures in the inundation zone. The Southside PDC plan identified the hazard potential for dams in the region, with hazard potential for 96 dams in the region as unknown and requiring further study, review, and approval before hazard potential classification could be assigned.

DCR's DSIS provides an inventory of dam related data and regulatory documents for every state-regulated dam in the state and the agency is constantly updating the inventory of regulatory documents and inundation mapping to support the use of this tool for local planning. Updated and comprehensive DSIS data can support improved local planning in the future.

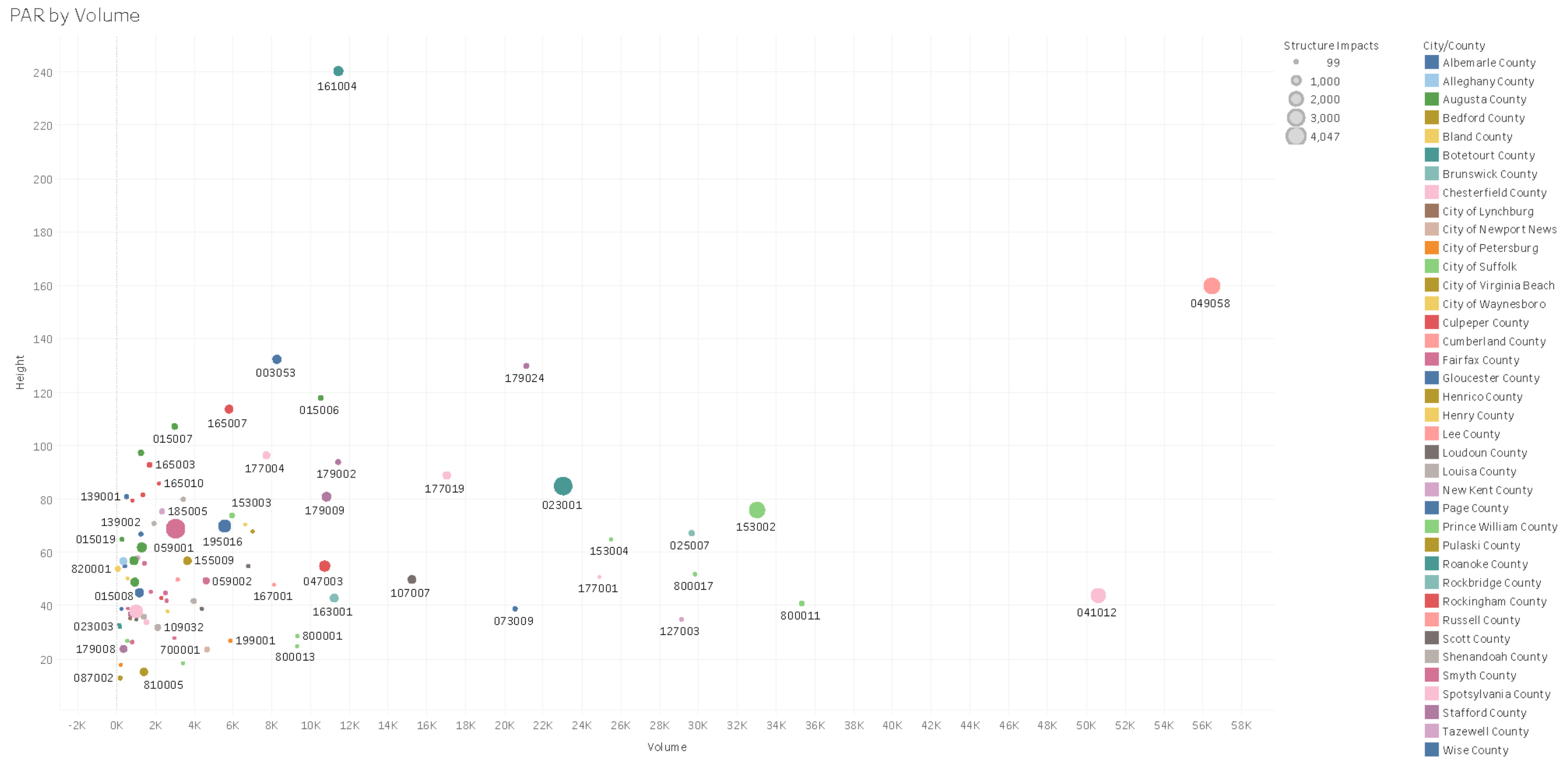
Both the Hampton Roads plan and the Richmond-Crater plan include tables with the number of facilities at risk of inundation in the event of impoundment failure from State-regulated high hazard dams, including risks to homes, businesses, roadways, downstream dams, railroads, and parks. The data are from DSIS. Three dams in Hampton Roads are in "Poor" conditions and summary impacts include:

- Harwood's Mill Dam in York County - 172 homes, 21 roadways;
- Little Creek Dam in James City County – 2 homes, 2 roadways;
- Godwin's Millpond Dam in Suffolk – 1 home, 3 businesses and 1 road.

Dam condition is not noted in the Richmond Crater plan, but the status of the EAP is provided, and 12 dams are noted as having expired EAPs. Downstream impacts are not included for 7 high hazard dams, likely indicating that the inundation areas have not been mapped for these dams: Cosby Da, Lake Crystal Dam, Falling Creek Reservoir Dam, Brasfield Dam, Lake Overton Dam, Lakeview Dam, and Emporia Dam.

Figure 3-120 provides a graphical analysis of available data to assess potential impacts to structures downstream of high hazard dams on a jurisdictional basis. The graphic also shows dam characteristics of height and volume to provide an idea of the relative consequences of failure; each dam is indicated by its ID number from the DSIS platform. While the greatest risk in the Commonwealth is believed to be from uncertified and unregulated dams with unknown characteristics, the data in Figure 3-120 provide a level of analysis regarding jurisdictional risk that will undoubtedly improve as data inputs on dams are acquired in a digital format.

Figure 3-120 - Jurisdictional Risk to Structures from Impoundment Failure



Volume vs. Height. Color shows details about City/County. Size shows sum of Structure Impacts. The marks are labeled by Id Number. Details are shown for Id Number, Dam Name and City/County. The data is filtered on Exclusions (Est. PAR,Height), which keeps 344 members. The view is filtered on Id Number, which keeps 85 of 345 members.

3.8.8.8 Comparison with Local Ranking

Of the 20 local plans, 15 provided a hazard ranking for impoundment failure (dam or levee). Nine jurisdictions ranked the hazard as low and 5 ranked impoundment failure as medium hazard; only Central Shenandoah PDC ranked the hazard as high. The Central Shenandoah HMP coupled flooding and dam failure as a hazard. The local plan average for dam failure is low. For comparison, the 2023 statewide analysis ranked dam failure as low.

3.8.8.9 Changes in Development

Most 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 terms. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Localities and VDEM should work with DCR for future updates to this section. Since dam inundation zone maps are required, this information could be used to determine high risk areas for future development. Such data would greatly improve ability to identify impact, vulnerability, and loss estimates due to dam inundation.

Table 3-83 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts expected to be extensive for inundation area and moderate to light for other affected areas.
Health and Safety of Response Personnel	Unless response personnel are within the inundation area, impacts will be limited.
Continuity of Operations	Damage to facilities/personnel in the area of the event may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impacts to facilities, property, and infrastructure in the inundation area could be extensive depending on capacity of dam and types of development in inundation areas.
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 impacts expected to be extensive for inundation areas and moderate to light for areas outside the inundation zone.
Economic and Financial Condition	Economic and financial conditions will be impacted, potentially for long periods of time.
Public Confidence in the Jurisdiction's Governance	Localized impact expected to affect dam owners and local government entities responsible for land use planning.

Community Lifelines Impacted by Impoundment Failure

Based on the hazard analysis and description of vulnerability and impacts of impoundment failure in Virginia, impoundment failure impacts the following community lifelines:

- Food, Water, Shelter
- Health and Medical
- Safety and Security
- Transportation

3.8.9 Karst (Sinkholes)

3.8.9.1 Background

Karst terrain is formed from the dissolution of soluble rocks resulting in distinctive surficial and subterranean features. Karst areas are characterized by sinking streams, cavern openings, closed depressions, and sinkholes. The term karst also encompasses many surface and subsurface conditions that give rise to economic and environmental impacts.

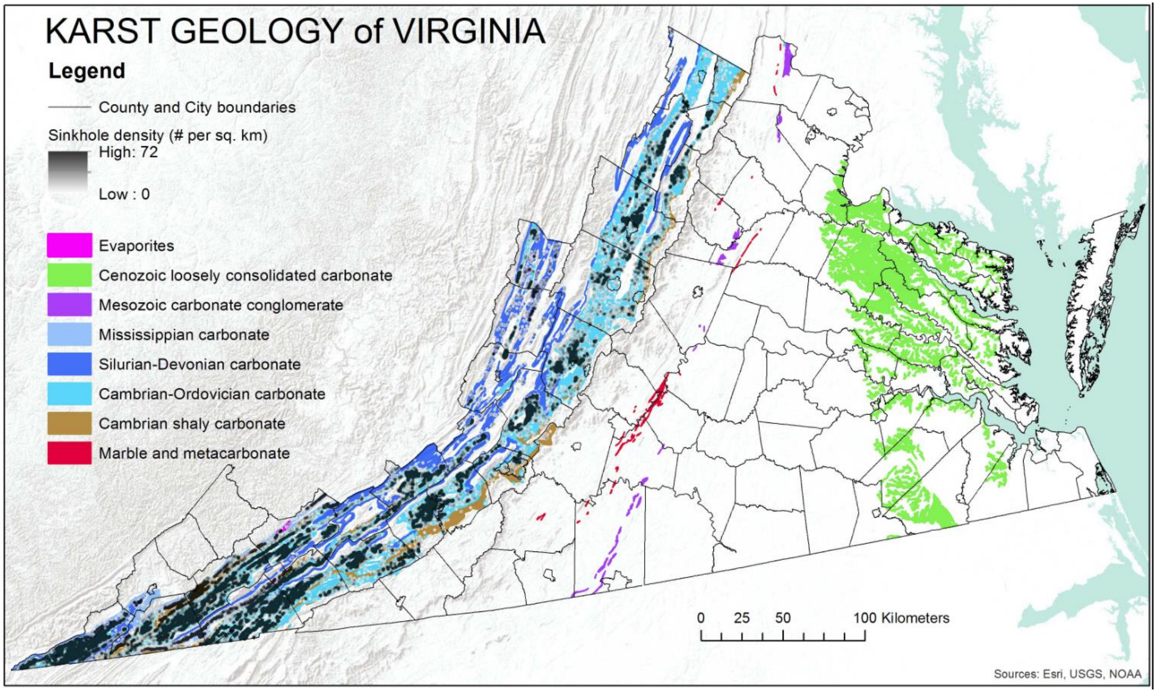
In Virginia, most karst lands are underlain by soluble limestone and dolomite, collectively referred to as carbonate rock. Carbonate rocks are common in valleys west of the Blue Ridge Mountains, but karst terrain is also associated with marble in the Piedmont province and the shell-rich formations in the eastern Coastal Plain. A karst sinkhole is formed by the collapse or subsidence of rock or sediment overlying pre-existing subsurface voids. These are sometimes referred to as "cover collapse" or "roof-collapse" sinkholes but most sinkholes in karst develop gradually. These sinkholes are formed and enlarged by weakly and naturally acidic surface water that, as it moves downward through small openings in the bedrock, slowly enlarges and dissolves soluble bedrock such as limestone.

Virginia also has known active and abandoned underground mines. These are present primarily in the southwestern part of the state, including the counties of Lee, Scott, Wise, Dickenson, Russell, Buchanan, Tazewell, and the City of Norton[1]. The Richmond area (coal mines), the Piedmont area (gold mines), and the Blue Ridge and Valley and Ridge (iron mines) are also dotted with old mines. Like karst terrain, underground mines may pose a hazard to certain types of land use.

3.8.9.2 Location and Spatial Extent

An estimated 18-percent of the land area of Virginia is karst terrain (USGS, Open File Report 2014-1156, Weary and Doctor). Major regions and approximated sinkhole densities are identified in Figure 3-121. The counties on the western side of the state are dominated by karst and the principal area affected by sinkholes is the Valley and Ridge Physiographic Province which is underlain with limestone and dolomite.

Figure 3-121 - Sinkhole density and location of karst geology in Virginia (USGS, Open-File Report 2014-1156).

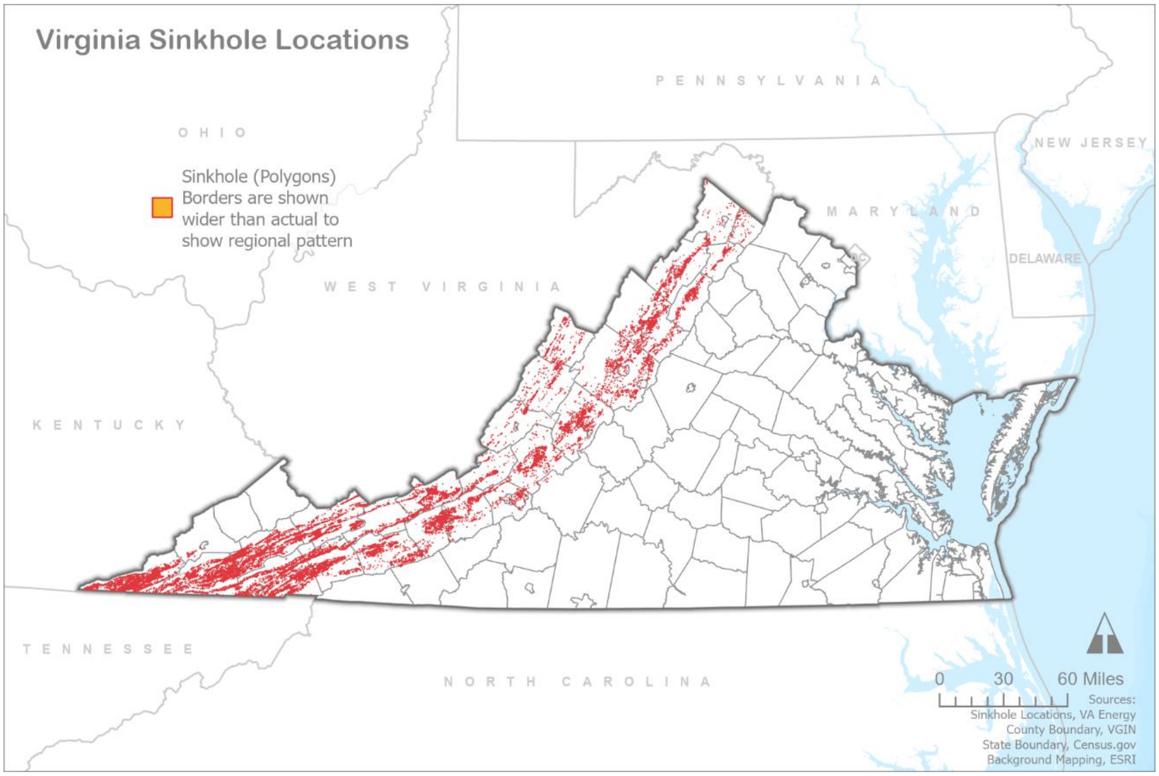


3.8.9.3 Significant Historical Events

To date, there have been no federal disaster declarations or NCEI recorded events for karst-related sinkhole events. Figure 3-122 shows the sinkhole locations from VA Energy between 2000 and 2021. Most incidences occur along the western border of the Commonwealth. Additional historical events gathered from news articles are documented in

Table **3-84**.

Figure 3-122 - Location of Sinkholes in the Commonwealth of Virginia, 2000-2021.



Source: VA Energy

Table 3-84 - Historical Sinkhole Events in Virginia

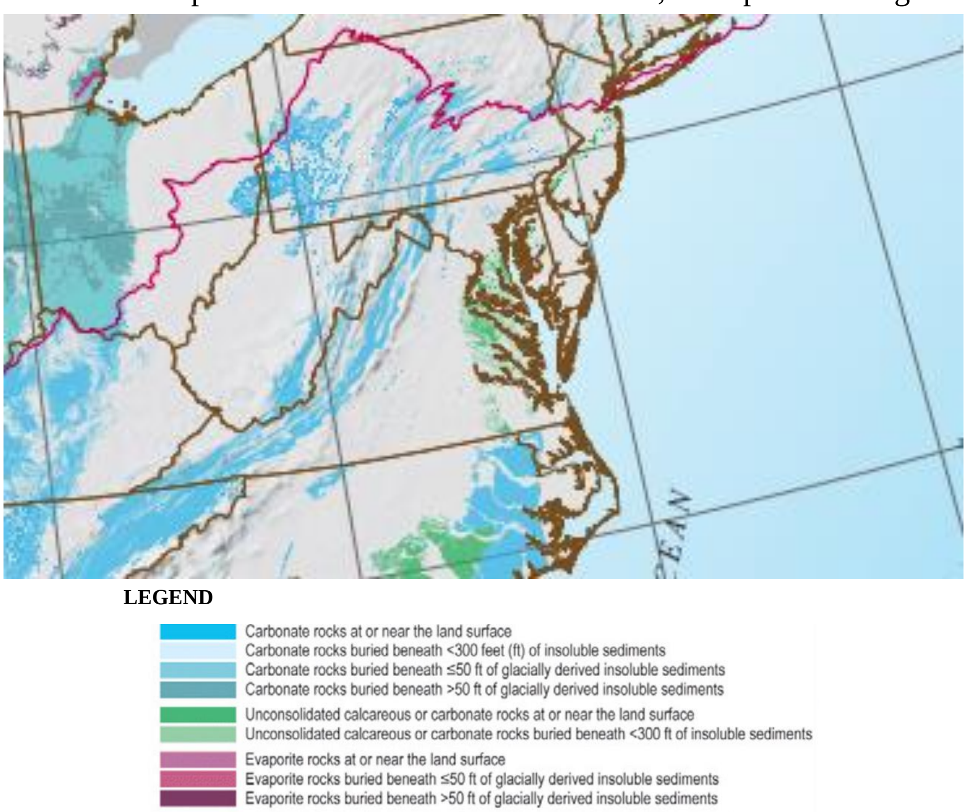
Year	Location of Sinkhole	Description
1910	City of Staunton	Three sinkholes opened up on Lewis and Baldwin Street and Central Avenue in Staunton. One of the sinkholes was so large that it swallowed a 35-foot maple tree and a house. One worker was killed when he fell into one of the chasms caused by the sinkhole as it was being repaired.
1977	Smyth County	A sinkhole 50 feet in diameter caused a section of State Route 91 to collapse in Smyth County. The incident took place in front of US Gypsum Company offices.
1992	Clarke County	A house collapsed inside of a sinkhole after the drilling of a new well on the property in Clarke County.
2000	City of Staunton	Thirty-two sinkholes were reported after 7" of rain fell in April after a long dry spell in the City of Staunton.
2001	Augusta County	Interstate 81 was closed for a nine-mile stretch in Augusta County because of the sudden appearance of three sinkholes. The largest of the three sinkholes was measured at 20 feet long, 11 feet wide and 22 feet deep and cost over $100,000 to repair.
2005	Botetourt County	A sinkhole 40 feet deep and 25 feet wide was discovered on Trinity Road (Virginia 670) in Botetourt County[2].
2006	City of Staunton	A sinkhole 18 feet deep on Interstate 64 closed one lane and shoulder in the City of Staunton.
2010	City of Richmond	The ramp from I-95 North to Broad Street in downtown Richmond was closed because of a sinkhole. Reports say that what started as a pothole quickly became a gaping hole in which the ground collapsed, with about 5 feet of earth underneath it washed away. (Source: WWBT-TV NBC 12 Richmond, VA; http://www.nbc12.com/story/11763653/update-sinkhole-closes-i-95-downtownexit?redirected=true)
2010	Chesterfield County	Sinkholes in the Scottingham neighborhood were reported around storm drain infrastructure. (Source: WWBT-TV NBC 12 Richmond, VA)

Year	Location of Sinkhole	Description
2011	Town of Strasburg	A sinkhole 50 feet deep and 75 feet wide shut down Oranda road in both directions in the Town of Strasburg. The Virginia Department of Transportation believed this to be one of the larger sinkholes they had seen. The road was closed for several days for repairs[3].
2011	Rockbridge County	Near mile marker 170, the northbound lanes of Interstate 81 had to be closed because of a sinkhole[4].
2011	City of Richmond	A sinkhole closed the intersection of Grove and Stafford Avenues in Richmond. (Source: Richmond Times-Dispatch)
2013	Giles County	A mudslide and several sinkholes were reported along Route 100 and Meadows Road near Staffordsville.
2015	Woodstock	A 20-foot sinkhole closed both lanes of northbound Interstate 81, resulting in significant travel delays during repairs. VDOT believed the sinkhole was formed by a cracked box culvert used to carry water from one side of the roadway to the other[5].
2018	Fairfax County	A water main break in the 4500 block of Twinbrook Road near Pickett Road resulted in a sinkhole. The sinkhole repairs caused minor traffic delays.
2019	Prince William County	A sinkhole on the shoulder of Princedale Drive resulted in the loss of one vehicle and road closure.
2020	Manassas Park	Flash flooding resulted in a 50 by 100 ft sinkhole along Moseby Court and Moseby Drive. The sinkhole compromised access to a condo and townhouse community with around 400 residents, prohibiting them from entering or leaving the community.

3.8.9.4 Probability of Future Occurrence

Karst in the US; A Digital Map Compilation and Database was produced by the USGS in 2014. This report, and the mapping information it contains, describes new digital maps delineating areas of the US that have karst or the potential for the development of karst. Figure 3-123 shows the sinkhole locations in Virginia.

Figure 3-123 - Karst and potential karst areas in soluble rocks, excerpted for Virginia region.



Karst formations are influenced by unique local conditions. Sinkholes can be induced through natural or human causes. Sinkholes that occur naturally usually form by the slow downward dissolution of carbonate rock though bedrock collapse in areas that overlie caverns[9]. Human-induced sinkholes can be triggered by a simple alteration in the local hydrology. Inadequate drainage along highways and increased runoff from pavement can also be sources of sinkhole development. Failure or collapse of underground infrastructure can also cause sinkholes that may or may not be associated with karst geology.

The probability of karst cannot be expressed in terms of specific return periods or recurrence intervals as easily as it can be for other hazards. As a result, the probability analysis consists of delineating those regions that experience relatively more karst-related events.

Impact and Vulnerability

The most important environmental issue with respect to karst is the sensitivity of karst aquifers to groundwater contamination. Karst covers an estimated 10 to 20-percent of the earth’s surface and provides 40 to 50-percent of the world’s drinking water, which means care must be taken to mitigate negative human impacts and allow sustainable development. Karst systems are highly vulnerable to pollution, water withdrawals, and changes in land use. The dissolution of limestone creates voids in the earth that can lead to collapse and directly impact people and the built environment in the immediate area of the collapse. These collapses can lead to property damage, infrastructure damage, and injuries or loss of life[10].

According to the Virginia Cave Board Report (DNR, 2017) there are six main areas of potential concern from a Virginia landowner or Virginia residents’ perspective:

- Legal Issues - There are many federal and state laws, and local ordinances that apply to sinkholes; some of these carry serious consequences for non-compliance.
- Groundwater Contamination - Many sinkholes provide a rapid pathway from the surface to groundwater, so they can be a common source of groundwater contamination that may affect your water supply or the water supply of entire communities; this is a major reason that the use of sinkholes as a convenient place in which to dump trash of all types is of major concern in all karst terrains.
- Stormwater Management - For the same reasons as the groundwater contamination section above, there are laws and regulations specific to stormwater management and sinkholes.
- Structural Damage - Voids are often present below sinkholes, and if nearby buildings or structures are not properly engineered and built, structural damage may occur.
- Human Safety - The hazard that a rapidly collapsing sinkhole may cause injury or severe damage, for instance, some sinkholes have large openings at the bottom where water enters the subsurface, and some of these openings may be large enough for small children or animals to enter.
- Biological and Ecological - Beneath a sinkhole there may be caves or karst resources with specialized habitat that might be supporting a wide array of diverse and specially adapted species; some of these species are legally protected.

Risk

Risk, strictly defined as probability multiplied by impact, cannot be fully estimated for karst due to the lack of historical data and detailed mapping. To assess risk, mapping of karst regions in Virginia by the USGS was used as the probability of future occurrence.

"The principal area affected by sinkholes is the Valley and Ridge province, an extensive karst terrain underlain by limestone and dolomite. The narrow marble belts in the Piedmont and some shelly beds in the Coastal Plain are also pocked with sinkholes[11]". This assessment focuses on areas vulnerable to collapse resulting from geologic formations prone to dissolution. The analysis does not include assessment of areas underlain by materials which can be subject to abandoned mine collapse (such as old coal, gold, or iron mines), or urban areas where failed underground infrastructure can lead to sinkholes.

3.8.9.5 State Facility Risk

To determine which facilities are at risk to sinkholes, state facilities were intersected with the USGS karst geology layer. The results of this analysis indicate 2,433 buildings are located within identified karst formation areas. Annualized loss estimates were not calculated for state facilities due to the scale of available karst mapping, the lack of available valuation data, and the unknown probability of future occurrence.

The 2,433 buildings located in karst formation areas can be divided between 31 different agencies as listed in Table 3-85 by agency and number of buildings. The agencies listed represent approximately 18-percent of the buildings owned by the Commonwealth. The value of assets at risk is provided in the table as well.

Table 3-85 - Agencies with State-Owned Assets in Karst Formation Areas

Agency	Number of Buildings in Karst Zone	Value of Assets
Academy for Staff Development In Marion	4	$7,609,931
Appalachian Detention Center	14	$3,494,627
Augusta Correctional Center	1	$231,391
Bland Correctional Center	96	$41,093,962
Blue Ridge Community College	27	$152,976,503
Caroline Correctional Unit #2	28	$14,667,883
Catawba Hospital	67	$166,336,728
Cold Springs Correctional Unit #10	40	$7,502,895
Commonwealth Center for Children & Adolescents	1	$15,622,659
Deerfield Correctional Center	27	$116,890,765
Department of Agriculture and Consumer Services	3	$13,157,191
Department of Alcoholic Beverage Control	6	$2,353,464
Department of Conservation & Recreation	123	$32,585,000
Department of Environmental Quality	2	$11,463
Department of Forensic Science	1	$23,548,916
Department of Forestry	38	$4,287,877
Department of Game and Inland Fisheries	56	$6,782,960

Agency	Number of Buildings in Karst Zone	Value of Assets
Department of General Services	15	$577,715,211
Department of Historic Resources	11	$2,636,550
Department of Military Affairs	43	$103,602,859
Department of Motor Vehicles	3	$1,765,899
Department of State Police	11	$7,640,478
VDOT	505	$151,059,841
Department of Veterans Services	4	$27,585,805
Environmental Service Unit	29	$19,022,358
Frontier Culture Museum of Virginia	22	$13,718,856
Germanna Community College	4	$76,799,110
Harrisonburg Men Detention and Diversion Center	28	$7,110,244
James Madison University	188	$2,454,202,118
Lord Fairfax Community College	7	$67,099,693
Marion Correctional Treatment Center	14	$12,821,438
Mountain Empire Community College	12	$88,704,803
New River Community College	8	$123,676,228
Northern Region Correctional Field Units	2	$7,022,831
Radford University	71	$1,063,067,540
Roanoke Higher Education Center	2	$47,956,655
Southampton Correctional Center	4	$20,035
Southwest Virginia Higher Education Center	1	$22,192,646
Southwest Virginia Community College	10	$86,878,747
Southwestern Virginia Mental Health Institute	42	$108,670,949
Stafford Diversion Center	16	$8,222,192
State Corporation Commission	1	$90,390,100
UVA	58	$25,189,563
Virginia School for the Deaf & the Blind - Staunton	20	$113,333,370
Virginia Commonwealth University	35	$982,080,009
Virginia Community College System	1	Not Provided
Virginia Highlands Community College	16	$94,184,298
Virginia Military Institute	118	$823,548,056
Virginia Outdoors Foundation	2	$325,305
Virginia Tech	517	$4,069,130,435
Virginia Retirement System	1	$14,169,719
Virginia Western Community College	19	$165,987,686
Wallens Ridge State Prison	1	$302,273
Western State Hospital	1	$153,478,160
White Post Diversion - Detention Center	34	$2,489,224
Wytheville Community College	8	$59,152,141

3.8.9.6 Critical Facility Risk

Risk for critical facilities was calculated in the same fashion described above for state facilities. Approximately 3-percent of state-owned assets are critical facilities in regions with some karst geology. Table 3-86 shows the number of critical facilities identified in karst formation areas, by use. Utilities, fuel service/storage, and emergency response represent many of the critical facilities in known karst areas. Annualized loss estimates were not calculated for critical facilities due to the scale of available karst mapping, limited information on mapped critical facilities (including valuation data), and the unknown probability of future occurrence.

Table 3-86 - Critical Facilities in Karst Formation Areas

Critical Facility Use	Number in Karst Zone
Animal Health	2
Armory	11
Childcare	1
Communications	18
Emergency Operations Center	1
Fire Service/Support/Suppression	9
Food Service/Storage	14
Fuel Storage/Delivery	110
Hazardous Materials Storage	87
Medical Services/Support/EMS	40
Public Safety	32
Research	24
Special Populations Housing	3
Utilities	113
Total	**465**

3.8.9.7 Karst Risk to Energy Pipelines

Pipeline infrastructure, underlain by karst terrain, can be damaged by a collapse in the supporting soil. Such collapse could lead to leaks or breaks in the pipeline.

Future Conditions

Because of the role precipitation plays in sinkhole formation, it is possible that climate change may affect the frequency with which they occur. However, there is not a large body of literature establishing how climate change projections can be used to project frequency or severity changes in sinkhole formation, including which precipitation return periods are of most value to determining sinkhole risk. The studies that exist have been conducted outside of Virginia. For example, systematic reviews have been conducted to consider how changes in precipitation and drought frequency may alter sinkhole flooding cases in arid to dry sub-humid regions[3], which do

[3] Delle Rose, M. Sinkhole Flooding and Aquifer Recharge in Arid to Dry Sub-Humid Regions: A Systematic Review in the Perspective of Climate Change. Hydrology. 2022; 9(2):25. https://doi.org/10.3390/hydrology9020025

not include the eastern United States. Research from Spain establishes that periods of drought correlate with higher frequencies of sinkhole occurrence.[4]

New projections of increased rainfall, duration, and frequency (IDF) curves that have been developed for the Commonwealth of Virginia[5] are now available through a web tool that provides 2-year through 100-year change factors to precipitation based on the current NOAA Atlas 14 IDF curves for both low and high emissions scenarios (RCP 4.5 and RCP 8.5) through 2100 (https://midatlantic-idf.rcc-acis.org/). Many areas of the largest projected changes in rainfall are overall increases in precipitation that occur in northern portions of VDEM regions 4 and 6, which also align with locations of known sinkhole borders in Figure 3-122. However, the tool focuses on overall changes to IDF curves over decades of time and does not provide guidance on drought frequency and severity during those time periods under climate projections. Even in an overall environment of increased precipitation averages over decades, droughts will still occur and occasionally be severe. To project changes under climate change, significant scientific research is required to determine the precipitation impact of both increased rainfall events and changes in drought frequency and severity on future sinkhole formation in these regions.

Jurisdictional Risk

Inputs for historical karst events were very limited because of the lack of recorded NCEI events. However, NCEI was supplemented with the Virginia Energy sinkhole data. To be able to include karst in the risk assessment some assumptions were made. Geographical extent, using USGS Karst Topography maps, was the primary basis for establishing risk and was calculated as a percentage of the jurisdictional area. In lieu of probability of future occurrence, areas with more karst terrain were assumed to be at greater risk.

These parameters in the karst risk assessment are provided in Table 3-87, along with the total ranking, including the complete ranking of all the local plans. There are currently no karst related records in NCEI; thus, the lowest ranking score (1) was assigned to the annualized data for events, damages, fatalities, and injuries to be able to compare karst to the other hazards, as described in Section 3.7. Population vulnerability and density were not altered for this calculation.

Jurisdictions ranked as having highest risk for Virginia include Harrisonburg, Winchester, Roanoke and Roanoke County. Communities in the Valley and Ridge Province have a large percentage of karst geology and, therefore, have a higher risk of karst event occurrence. Many of these areas also have an extensive history of sinkhole development. The jurisdictions identified at higher risk are generally urbanized areas in the western, more mountainous parts of the state.

[4] Linares,R., Roqué, C., Gutiérrez, F., Zarroca, M., Carbonel, D., Bach, J., and Fabregat, I. The impact of droughts and climate change on sinkhole occurrence. A case study from the evaporite karst of the Fluvia Valley, NE Spain. Science of The Total Environment. 2017, 579: 345-358. https://doi.org/10.1016/j.scitotenv.2016.11.091.

[5] Miro, M.E., DeGaetano, A.T., López-Cantú, T., Samaras, C., Webber, M., and Grocholski, K.R. 2021. Developing Future Projected Intensity-Duration-Frequency (IDF) Curves. RAND, 62 pp. DOI https://doi.org/10.7249/TLA1365-1. Retrieved 7 September 2022 from https://www.rand.org/pubs/tools/TLA1365-1.html.

3.8.9.8 Comparison with Local Ranking

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information informs the text and figures of each of the sections in this revision. The 12 local plans that specifically included karst as a hazard did not provide loss estimates for the hazard. Of the plans that provided a general description of karst, some of them intersected US Census data with the USGS karst zones to estimate the population located within a karst zone; most of these assessments were general in nature. The consensus of the local plans is that there is no way to estimate potential damage. Some local plans estimated the exposure of buildings and infrastructure, but this was done in a general way, based on proximity to identified sinkholes.

Overall, 12 local plans ranked karst as a hazard in their HMPs. Only one of the local plans (Hampton Roads PDC) ranked karst as a high hazard. Lenowisco PDC and Central Shenandoah Valley PDC, both ranked karst as a medium hazard for their regions; however, the hazard was often combined or discussed with other geologic hazards, such as landslides and sinkholes. A review of the text made clear that while karst was described as a hazard, it was sinkholes and/or landslides that were the actual concern for the jurisdictions. Nine plans ranked karst as low. The 2023 statewide analysis ranks karst as low and is consistent in that regard with the local plans.

3.8.9.9 Changes in Development

Most local hazard mitigation 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 terms. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. A few plans exclusively noted that they have zoning ordinances related to sinkhole development or they have mitigation actions to address these in the future.

Table 3-87 - Karst (Sinkholes) Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Low	Low	Low	Low	Low
Albemarle	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Alexandria, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Alleghany	Low	Low	Low	Low	Low	Low	Low	Low
Amelia	Low	Low	Low	Low	Low	Low	Low	Low
Amherst	Medium	Medium	Low	Low	Low	Low	Low	Low
Appomattox	Low	Low	Low	Low	Low	Low	Low	Low
Arlington	High	High	Low	Low	Low	Low	Low	Medium-Low
Augusta	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Bath	Low	Low	Low	Low	Low	Low	Low	Low
Bedford	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Bland	Low	Low	Low	Low	Low	Low	Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Low	Low	Medium-Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Brunswick	Medium	Low	Low	Low	Low	Low	Low	Low
Buchanan	Medium	Low	Low	Low	Low	Low	Low	Low
Buckingham	Low	Low	Low	Low	Low	Low	Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Campbell	Medium	Medium	Low	Low	Low	Low	Low	Low
Caroline	Medium	Low	Low	Low	Low	Low	Low	Low
Carroll	Medium	Medium	Low	Low	Low	Low	Low	Low
Charles City	Low	Low	Low	Low	Low	Low	Low	Low
Charlotte	Low	Low	Low	Low	Low	Low	Low	Low
Charlottesville, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Chesapeake, City of	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Chesterfield	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Clarke	Low	Medium	Low	Low	Low	Low	Low	Low
Colonial Heights, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Covington, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Craig	Low	Low	Low	Low	Low	Low	Low	Low
Culpeper	Medium	Medium	Low	Low	Low	Low	Low	Low
Cumberland	Low	Low	Low	Low	Low	Low	Low	Low
Danville, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Dickenson	Low	Low	Low	Low	Low	Low	Low	Low
Dinwiddie	Medium	Low	Low	Low	Low	Low	Low	Low
Emporia	Low	Medium-High	Low	Low	Low	Low	Low	Low
Essex	Low	Low	Low	Low	Low	Low	Low	Low
Fairfax	High	High	Low	Low	Low	Low	Low	Medium-Low
Fairfax, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Falls Church, City of	Low	High	Low	Low	Low	Low	Low	Low
Fauquier	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Floyd	Low	Low	Low	Low	Low	Low	Low	Low
Fluvanna	Medium	Medium	Low	Low	Low	Low	Low	Low
Franklin	Medium	Medium	Low	Low	Low	Low	Low	Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Frederick	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Fredericksburg, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Galax, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Giles	Low	Low	Low	Low	Low	Low	Low	Low
Gloucester	Medium	Medium	Low	Low	Low	Low	Low	Low
Goochland	Medium	Medium	Low	Low	Low	Low	Low	Low
Grayson	Low	Low	Low	Low	Low	Low	Low	Low
Greene	Medium	Medium	Low	Low	Low	Low	Low	Low
Greensville	Low	Low	Low	Low	Low	Low	Low	Low
Halifax	Medium	Low	Low	Low	Low	Low	Low	Low
Hampton, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Hanover	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Harrisonburg, City of	Medium	High	Low	Low	Low	Low	Medium	Medium-Low
Henrico	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Henry	Medium	Medium	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Highland	Low	Low	Low	Low	Low	Low	Low	Low
Hopewell, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Isle of Wight	Medium	Medium	Low	Low	Low	Low	Low	Medium-Low
James City	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
King and Queen	Low	Low	Low	Low	Low	Low	Low	Low
King George	Medium	Medium	Low	Low	Low	Low	Low	Low
King William	Low	Low	Low	Low	Low	Low	Low	Low
Lancaster	Low	Medium	Low	Low	Low	Low	Low	Low
Lee	Medium	Low	Low	Low	Low	Low	Low	Low
Lexington, City of	Low	High	Low	Low	Low	Low	Low	Low
Loudoun	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Louisa	Medium	Medium	Low	Low	Low	Low	Low	Low
Lunenburg	Low	Low	Low	Low	Low	Low	Low	Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Madison	Low	Low	Low	Low	Low	Low	Low	Low
Manassas, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Manassas Park, City of	Low	High	Low	Low	Low	Low	Low	Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Mathews	Low	Medium	Low	Low	Low	Low	Low	Low
Mecklenburg	Medium	Low	Low	Low	Low	Low	Low	Low
Middlesex	Low	Medium	Low	Low	Low	Low	Low	Low
Montgomery	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Nelson	Low	Low	Low	Low	Low	Low	Low	Low
New Kent	Low	Medium	Low	Low	Low	Low	Low	Low
Newport News, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Norfolk, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Northampton	Low	Medium	Low	Low	Low	Low	Low	Low
Northumberland	Low	Low	Low	Low	Low	Low	Low	Low
Norton	Low	Medium-High	Low	Low	Low	Low	Low	Low
Nottoway	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Orange	Medium	Medium	Low	Low	Low	Low	Low	Low
Page	Medium	Medium	Low	Low	Low	Low	Low	Low
Patrick	Medium	Low	Low	Low	Low	Low	Low	Low
Petersburg, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Pittsylvania	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Poquoson	Low	Medium-High	Low	Low	Low	Low	Low	Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Powhatan	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince Edward	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince George	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince William	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Pulaski	Medium	Medium	Low	Low	Low	Low	Low	Low
Radford, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Rappahannock	Low	Low	Low	Low	Low	Low	Low	Low
Richmond	Low	Low	Low	Low	Low	Low	Low	Low
Richmond, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Roanoke	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Roanoke, City of	Medium-High	High	Low	Low	Low	Low	Medium	Medium-Low
Rockbridge	Medium	Low	Low	Low	Low	Low	Medium	Low
Rockingham	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Russell	Medium	Low	Low	Low	Low	Low	Low	Low
Salem, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Scott	Medium	Low	Low	Low	Low	Low	Low	Low
Shenandoah	Medium	Medium	Low	Low	Low	Low	Low	Low
Smyth	Medium	Medium	Low	Low	Low	Low	Low	Low
Southampton	Low	Low	Low	Low	Low	Low	Low	Low
Spotsylvania	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Stafford	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Staunton, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Suffolk	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Surry	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Sussex	Low	Low	Low	Low	Low	Low	Low	Low
Tazewell	Medium	Medium	Low	Low	Low	Low	Low	Low
Virginia Beach, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Warren	Medium	Medium	Low	Low	Low	Low	Low	Low
Washington	Medium	Medium	Low	Low	Low	Low	Low	Low
Waynesboro, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Westmoreland	Low	Medium	Low	Low	Low	Low	Low	Low
Williamsburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Winchester, City of	Medium	High	Low	Low	Low	Low	Medium	Medium-Low
Wise	Medium	Medium	Low	Low	Low	Low	Low	Low
Wythe	Medium	Medium	Low	Low	Low	Low	Low	Low
York	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low

For the 2023 plan, the overall hazard ranking for karst (sinkholes) is low. Potential detrimental impacts associated with the hazard are included in Table 3-88.

Table 3-88 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts are expected to be moderate to severe in the impact area.
Health and Safety of Response Personnel	Limited unless sinkhole involves broken utility lines.
Continuity of Operations	Limited, unless a facility is impacted
Property, Facilities, and Infrastructure	Depending on the magnitude of the event, localized impact to facilities, residential properties, and infrastructure around the event could be severe.
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 impacts expected to be moderate for the impacted areas. Risk of pollution to ground water and drinking water. Always a potential for utility line breaks.
Economic and Financial Condition	Limited. Depending on the magnitude of the event, local economy and finances may be impacted.
Public Confidence in the Jurisdiction's Governance	Localized impacts expected to cause property owners confidence in state and local land use/development policies to waiver.

Community Lifelines Impacted by Karst (Sinkholes)

Based on the hazard analysis and description of vulnerability and impacts of karst (sinkholes) in Virginia, karst (sinkholes) impacts the following community lifelines:

- Safety and Security
- Transportation

3.8.10 Landslides

3.8.10.1 Background

A landslide is the downslope transport of a mass of soil and rock material and refers to several different varieties of ground movement landforms and processes. The primary driving force for a landslide is gravity, but other factors may contribute to the failure of a slope. Landslides are usually triggered by heavy rainfall, rapid snow melt, over steepening of slopes by stream incision, or earthquakes, while certain man-made changes to the land, such as slope modification or drainage alteration, can greatly increase the likelihood of landslides. Landslides can destroy buildings, rupturing gas, water, and sewer mains, and knocking out power and telephone lines while blocking transportation routes. Sometimes a landslide may move slowly down a slope, but often the movement can occur without warning and be extremely fast. Soil creep and slumping cause property damage gradually, whereas rockslides and debris flows can sweep away people and property instantaneously.

Landslides occur in many manifestations and are usually classified according to the type of material involved and the mode of downslope movement. The material can range from loose earth to blocks of solid rock. These materials may then move downslope by falling, sliding or flowing. The following are some of the more important types of mass movement:

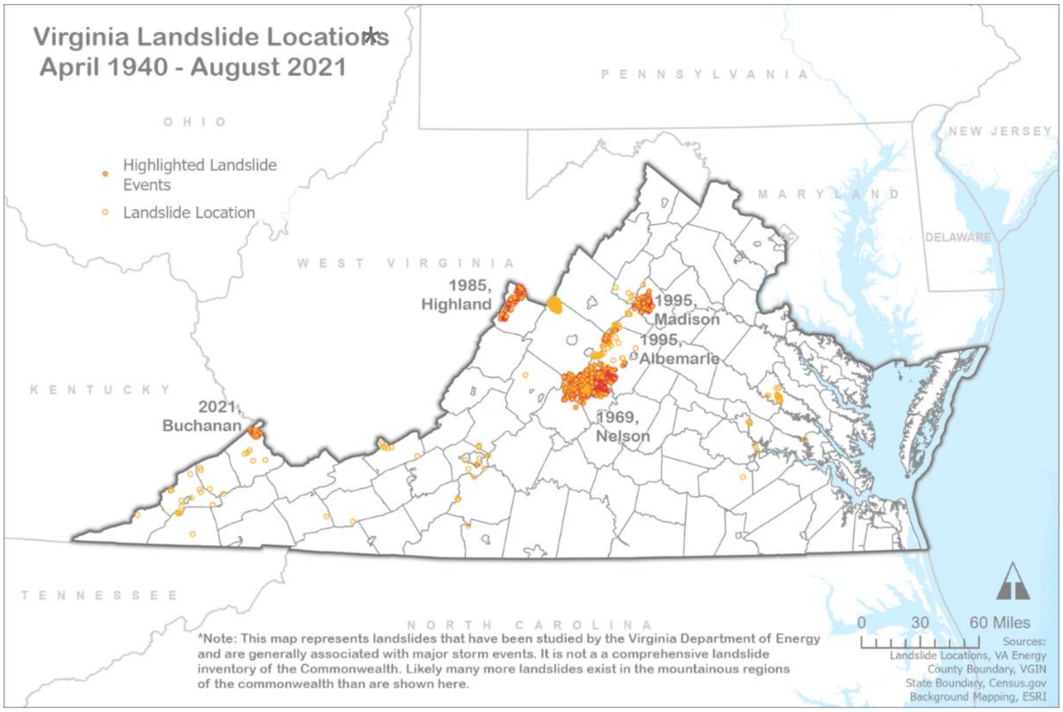
- Rockfalls entail large blocks of bedrock breaking off a cliff face and tumbling downslope.
- Rockslides occur when a detached section of bedrock slides down an inclined surface, frequently along a bedding plane.
- Earthslides involve masses of soil moving down a slip face, usually on top of the bedrock.
- Creep is the slow, continuous, imperceptible downslope movement of soil and rock particles.
- Rotational Slides or Slumps result from the rotation of a cohesive unit of soil or rock down a slip surface, leaving a curved scarp.
- Debris flows develop on steep slopes because of heavy rainfall that saturates the soil, which under the extra weight and lubrication breaks loose and becomes slurry that takes everything with it, including large trees and houses. Channeled debris flows can reach speeds approaching a hundred miles an hour and strike without warning.

3.8.10.2 Location and Spatial Extent

Landslides are most common in the mountainous terrain of Virginia because of the presence of steep slopes and highly fractured bedrock over shallow soils. The lower-relief areas of the Piedmont and Coastal Plain also have landslides, but they are often smaller and generated by human disturbance, such as making an over-steepened road cut. The most disastrous landslide events have been associated with heavy rainfall along the steep slopes of the Blue Ridge Mountains and the Appalachians. Areas that are prone to mass movement include: areas where landslides have occurred in the past; steep slopes with an angle greater than 30 degrees; and, over-steepened cuts and fills, particularly due to home and road building. According to the North Carolina Geological Survey, about 56% of recent landslides happened on slopes that had been altered in some way by development.

Figure 3-124 shows the location of known landslides in the Commonwealth of Virginia that Virginia Energy has studied. State geologists emphasize that this figure is not intended, nor does it actually, represent all landslide locations; they know that every mountainous county in Virginia has likely experienced landslides. Instead, the figure provides geographic information on landslides that geologists have studied during the cited time period.

Figure 3-124 - Location of Studied Landslides within the Commonwealth of Virginia.



Landslides are a major geologic hazard because they are widespread, occurring in all 50 states and US territories, causing up to $2 billion in damages, and leading to more than 25 fatalities on average each year[2]. Casualties in the US are primarily caused by rockfalls, rockslides, and debris flows. Expansion of urban and recreational developments into hillside areas exposes more people to landslide-prone conditions each year.

3.8.10.3 Significant Historical Events

The greatest landslide hazards are present in western and southwestern Virginia. One federal disaster declaration has been recorded for Buchanan County (1995); recently in 2021, disaster relief was provided to Hurley in the Appalachian Regional Commission (ARC) to the United Way of Southwest Virginia, Inc. for the Hurley Disaster Recover Project following the August 30, 2021, flooding in Hurley, Virginia. Two other declared disasters in Nelson (1969) and Madison (1995) Counties were a result of landslides due to flooding or hurricane-related events. The USGS has an informative publication titled ‘Debris-Flow Hazards in the Blue Ridge of Virginia’ that highlights past events, specifically the June 27, 1995, event in Madison County.

For the 2011 *Commonwealth of Virginia Hazard Mitigation Plan*, scientists from the USGS determined that most of the debris-flow events between 1844 and 1985 occurred in the Blue Ridge. Studies of stream channels found evidence of prehistoric debris flows in Madison County. Radiocarbon dating from these debris-flow deposits indicates that landslide events have repeatedly occurred there over the last 34,000 years[3]. One of the most destructive events occurred during Hurricane Camille in August 1969 in Nelson County. In an eight- hour span, between 27 to 31 inches of rainwater triggered approximately 3,700 landslides, which killed more than 150 people[4].

NCEI *Storm Events Database* has landslide/debris flow records for King George County (1998), Tazewell County (2006), Staffordsville (2013), and Carsonville (2015)[5]. Additional sources, including local plans, were used to collect information on historical occurrences included in Table 3-89.

Table 3-89 - Historical Landslide Occurrences

Year	Location of Landslide	Description
1969	Nelson County	Hurricane Camille stalled over the Blue Ridge Mountains, dropping more than 30 inches of rain in less than eight hours. Flooding and numerous landslides and debris flows led to the deaths of more than 150 people, 100 injuries, destruction of more than 100 bridges, and more than $150 million in property damage. This event resulted in the most recorded deaths by a natural hazard in the Commonwealth.
1985	Potomac and Cheat River Watersheds	Affecting both Virginia and West Virginia, 72 hours of storms produced record floods and extensive landslide and debris flow activity, causing 70 deaths and a total of $1.3 billion in damage to homes, businesses, roads, and farmlands.
1987	Alleghany County	Heavy rains caused landslides along Smith Creek in the Town of Clifton Forge.
1994	Pulaski County	Landslides were observed in June when six inches of rain fell in a three hour period. The landslides knocked one home from its foundation and blocked five miles of roads.
1995	Buchanan County	Previous rains and a saturated ground caused an abandoned/sealed underground mine to burst. Water, rocks, and dirt cascaded into a home along Laurel Creek, about three miles south of Whitewood. A 26-year- old woman was buried in the basement by debris and property damage was estimated at $15,000.
1995	Madison County	For 16 hours, approximately 30 inches of rain fell in small area of Madison County. Eight people were killed in June when hundreds of landslides combined with widespread flooding. As many as 2,000 homes were affected and 35,000 acres of crops were damaged. Total property damages were estimated at $112 million.
1995	Albemarle County	Numerous landslides occurred along the North Fork of the Moormans River. This reduced the holding capacity of the Sugar Hollow Reservoir.
1998	King George County	A rockslide caused a portion of local route 627 to slide down a cliff. At least 1/2 the width of the road was removed. The rockslide was partly due to repeated heavy rains, very moist soil, and minor flooding along the river during the winter of 1997/98. Major river and flash flood events in 1996 likely set the stage, over the long term, for the slide. Property damage was estimated at $150,000.
2000	City of Staunton	16 landslides were experienced along Staunton district roads.
2004	City of Richmond	The remnants of Tropical Depression Gaston caused severe landslides throughout the Church Hill and Riverside Drive sections of Richmond in August following 14” of rain in eight hours.
2006	Tazewell County	A severe storm with very intense rain. Intense enough to help produce a landslide near a pipeline construction project near the town of Tannersville, VA. The landslide blocked sections of Freestone Valley Road with mud up to 3 inches deep.
2008	Giles County	Showers and thunderstorms produced enough rain to cause a mudslide that blocked Highway 42. Property damage was estimated at $10,000
2008	Alleghany County	Due to a series of thunderstorms and rainfall, a rockslide occurred on Route 220 just north of the City of Covington. No property damage estimates were reported.
2013	Giles County	Storms along the southwest Virginia mountains created a mudslide along Rouge 100 and Meadows Road near Staffordsville.

Year	Location of Landslide	Description
2015	Grayson County	Slow moving storms across central and southern Grayson County produced rainfall of one to three inches with isolated amounts up to five inches. Mudslides were reported in the area around Peach Bottom Road.
2018	Bedford County	A cluster of thunderstorms developed along a stationary front and produced torrential rains across parts of Patrick, Henry and Franklin counties. Rainfall was estimated at 2 to 3 inches in a few hours. Heavy rain triggered a mudslide on the eastbound lane of US Highway 460 near the route 122 intersection.
2018	Tazewell County	Evening thunderstorms affected parts of Tazewell County with 1 to 3 inches falling in several hours. A mudslide was reported in the Falls Mills area.
2018	Galax County	Hurricane Michael resulted in heavy rainfall and severe flooding and all the animals and staff were evacuated from the Galax Veterinary Clinic on Stockyard Road after a mudslide along the road above the clinic brought down a power pole and caused its lines to fall onto the clinic. Hurricane Michael resulted in heavy rainfall and severe flooding which resulted in a large mudslide along East Stuart Drive that closed the road for several hours.
2020	Tazewell County	A strong cold front extending from a complex surface low pressure system, brought intense thunderstorms which produced damaging winds and very heavy rain on April 12-13. A massive landslide along Highway 16 between Thompson Valley and Tannersville washed out part of the roadway and closed the southbound lane.
2020	Henry County	Late afternoon thunderstorms developed along the southwest Virginia Blue Ridge and drifted southward into the foothills and piedmont producing intense rainfall and flooding. A debris flow damaged the powerhouse at Philpott Dam knocking out power to the dam and causing some damage. Late afternoon thunderstorms developed along the southwest Virginia Blue Ridge and drifted southward into the foothills and piedmont producing intense rainfall and flooding. A mudslide was reported on Fairystone Park Highway near Trent Hill Drive. Late afternoon thunderstorms developed along the southwest Virginia Blue Ridge and drifted southward into the foothills and piedmont producing intense rainfall and flooding. Carson Drive in Bassett was blocked by a mudslide.
2020	Tazewell County	A very moisture rich atmosphere led to the formation of heavy rain producing showers and storms. This resulted in a mudslide along Dry Fork Road.
2020	Tazewell County	A very moisture rich atmosphere led to the formation of heavy rain producing showers and storms. This resulted in a mudslide along Lick Branch Road.
2020	Wythe County	Deep moisture returned to the lower mid-Atlantic region during the period August 12th - 15th, with precipitable water values ranging from 1.6 to 1.9 inches each day. The Wythe County 911 Operations Center reported multiple debris flows taking place along VA Highway 94 in and around the community of Ivanhoe.
2020	Smyth County	Deep moisture returned to the lower mid-Atlantic region during the period August 12th - 15th, with precipitable water values ranging from 1.6 to 1.9 inches each day. A debris flow was observed along River Road near Interstate 81 in Chilhowie. A tree and other debris slid into the road off the side of a roadside hill, blocking the road.
2020	Henry County	Radar rainfall estimates and nearby personal mesonet station indicated that 2 to 3 inches of rain fell across the Collinsville community in a 2-to-3-hour period of time. This heavy rain caused a debris flow to occur along Figsboro Road near the intersection of Kings Mountain Road, causing the road to be blocked and impassible until maintenance crews could clear the debris.
2021	Albemarle County	Rockslide occurred in Afton, May 2021 in Albemarle County. Closed US 250 for 2 months.
2021	Roanoke County	A low-pressure system passed across the lower mid-Atlantic during the early morning hours of January 26th, which produced 1 to 2 inches of rain across portions of the mountains of Virginia. A car wash sustained severe structural damage when the hillside immediately behind the building gave way and smashed through the rear wall of the building.
2021	Bedford County	Widely scattered thunderstorms developed during the afternoon of June 11th resulting in 2 to 4 inches of rain. This resulted in a mudslide along Highway 501. The road was passable after the debris was cleared.

Year	Location of Landslide	Description
2021	Amherst County	Deep tropical moisture associated with the remnants of Tropical Storm Nicholas was lifted northward ahead of a strong cold front. Precipitable water values ranging from 1.9 to 2.2 inches were carried into southern Virginia during the evening of the 21st. This resulted in a small debris flow to occur along the Blue Ridge Parkway near the James River. The parkway was reopened after the debris was removed. Flooding and landslides in Hurley on August 2021, approximately 40 landslides were mapped for that storm.

The 2023 statewide analysis has ranked landslide as low risk.

3.8.10.4 Probability of Future Occurrence

Landslide probability is highly site-specific and can only be generalized on a statewide basis. Relative risk ranking is intended only for general comparison to the other hazards that impact Virginia.

The landslide hazard is dependent on the amount of water present to mobilize the slide, the total size of the slide, and damages are related to the amount of development in the area that could potentially be impacted. Landslides are more common in areas with steeper slopes (generally greater than 22 degrees) and in poorly drained soils. Some areas that are generally prone to landslides include old landslide sites, the base of slopes, the base of minor drainage hollows, the base or top of old fill slope, the base or top of a steep cut slope, and developed hillsides where leach field septic systems are used [6].

A hazard map was developed by the USGS based on the 1995 Madison County event. Generally, the mountains of the Blue Ridge can expect to see a series of damaging debris flows every 10 to 15 years. These intervals will decrease when considering larger geographic areas. Recurrence for a debris-flow event, in a small area, can be one event every 3,000 to 4,000 years (0.03 – 0.025 percent annual chance). The drainage needs to be charged with soil material that could potentially fail.

Impact and Vulnerability

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

The USGS recognizes six major impacts or characteristics of landslides:

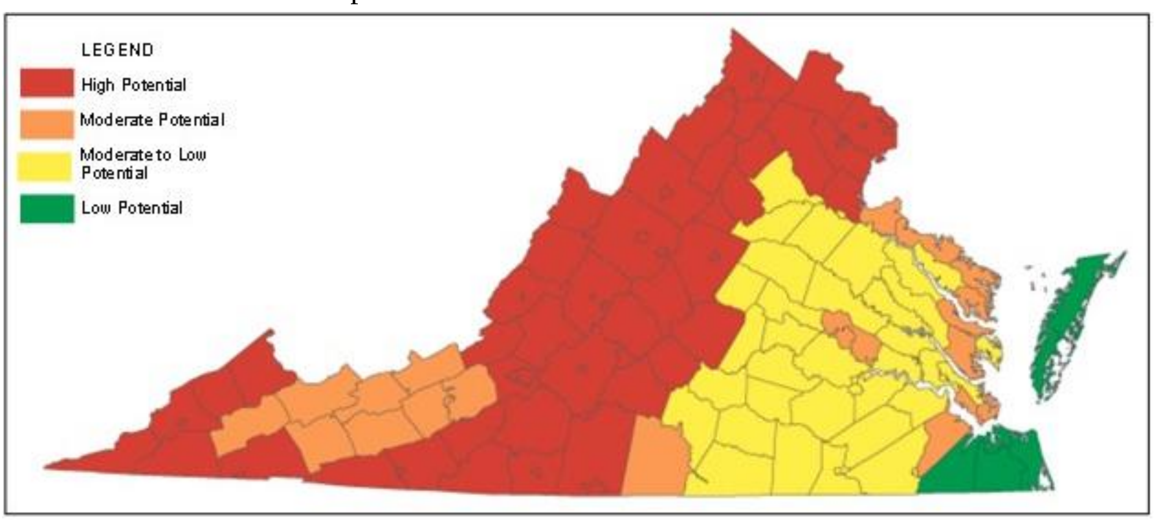
- Cause damage in all 50 states, Puerto Rico, and the US Virgin Islands;
- Cost $3.5 billion per year, in 2005 dollars, in damage repair;
- Cause between 25 and 50 deaths in the US annually;
- Reduce real estate values and tourist revenue;
- Lead to lost human, industrial, agricultural, and forest productivity; and
- Cause damage to the natural environment[8].

Risk

Because the data are highly generalized, owing to the small scale and the scarcity of precise landslide information for much of the country, it is unsuitable for local planning or actual site selection. Without well-established occurrence probabilities and damage values, true risk and annualized dollar losses cannot be estimated. However, a rough estimate of financial impact can be developed based on the NCEI *Storm Events Database*, although such an estimate is subject to the biases and inconsistencies present in that data. For the 24-year data period from 1998 through 2022, NCEI reports an annualized average cost of damage of $31,833 per year[9].

The best available landslide data are data provided by Virginia Energy; however, this data is currently being updated for a specific location in Nelson/Albemarle that is schedule to be delivered in September 2023. Therefore, the USGS *Landslide Overview Map of the Coterminous US,* was mainly used and was considered the best available data for this HIRA update. This dataset shows areas in the US where large numbers of landslides have occurred and areas which are susceptible to landslides. This dataset is a digital representation of USGS Open-File Report 97-289, which is a PDF version of the 1997 USGS Digital Representation of Landslide Overview Map (scale 1:4,000,000). The map classifies the major political subdivisions of the US and assesses the vulnerability based on subdivision characteristics. Figure 3-125 is a map of the counties of Virginia and their susceptibility to landslides adapted from the USGS Landslide Overview Map.

Figure 3-125 - Counties Susceptible to Landslides.

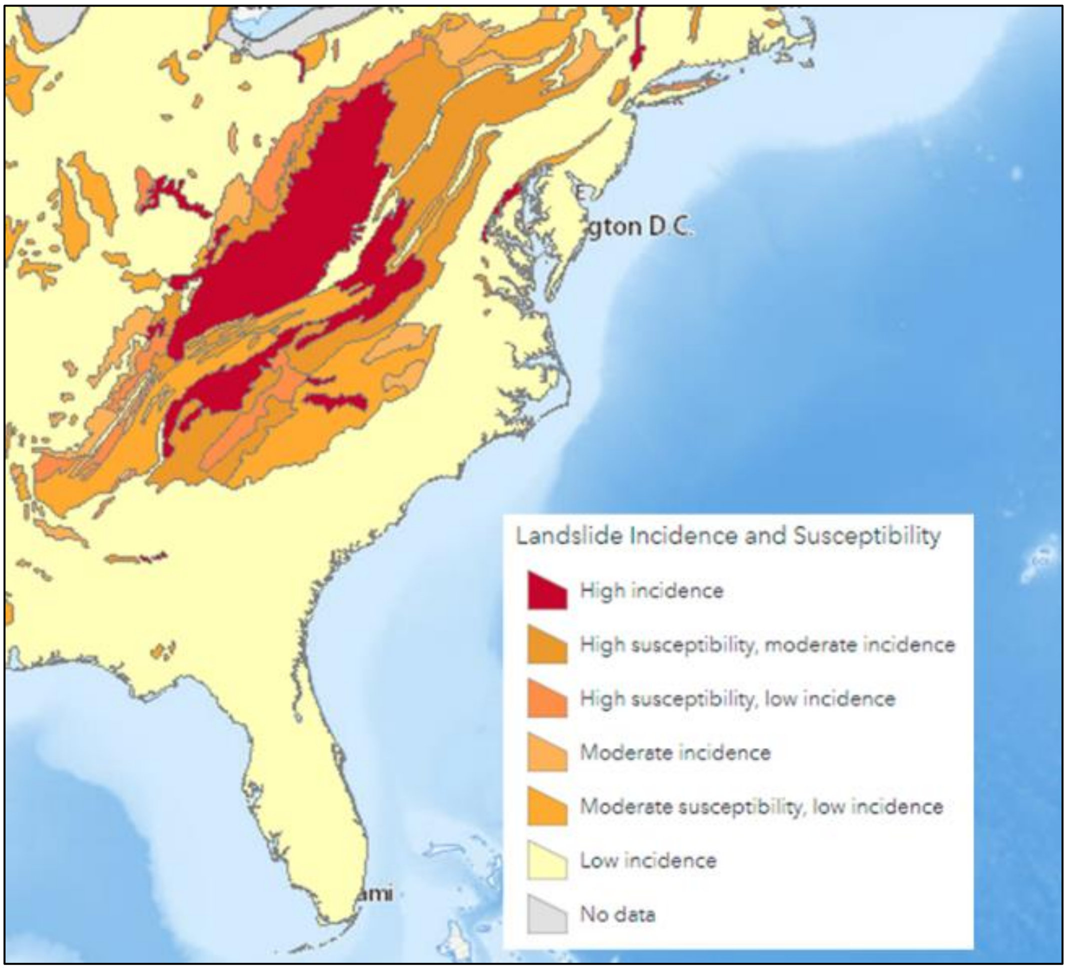


This assessment focuses on areas that may be susceptible to landslides and are likely to occur based on past incidence. "The assigning of any area to the lowest incidence or susceptibility category should not be construed to mean that no landslides exist or that no areas are susceptible to landslides. Even areas in the lowest category may contain landslides unknown to the compilers or have an incidence of less than 1.5 percent. In general, the possibility is great that a lot more landslides than indicated exist in any given map area (except for the highest category), owing to the overall scarcity of landslide data. Moreover, many published special-purpose geologic maps do not show landslides, even where they are known to exist[11]."

The USGS divides landslide risk into six categories. These six categories were grouped into three, broader categories to be used for the risk analysis and ranking. Geographic extent is based on these groupings (Figure 3-126). These categories include:

- High susceptibility to landslide and moderate incidence.
- High susceptibility to landslide and low incidence.
- High landslide incidence (more than 15 percent of the area is involved in landslide).
- Moderate Risk
- Moderate susceptibility to landslide and low incidence.
- Moderate landslide incidence (1.5 - 15 percent of the area is involved in landslide).
- Low Risk
- Low landslide incidence (less than 1.5 percent of the area is involved in landslide)[1]

Figure 3-126 - Landslide Incidence and Susceptibility



3.8.10.5 State Facility Risk

To determine which facilities were at risk for landslide, the state facilities were intersected with NRI expected annual loss data for each county. The results of indicate 11 counties in the southwest region of the state have relatively high landslide risk based on the expected annual loss rating. Table 3-90 shows the distribution of building risk for state facilities and the value of assets at risk. Annualized loss estimates were not calculated for state facilities due to the scale of available landslide mapping, the lack of building detail data available (including valuation, ground elevation, foundation design, and site characteristics), and the unknown probability of future occurrence.

Table 3-90 - Number of State Facilities Located in Relatively High Landslide Risk Zone per NRI

Locality	Agency and Facility	Number of State Assets at Risk	Total Value of at Risk Assets
Alleghany County	DEQ Kim Stan	2	$6,690
	State Police Area 38 office	3	$762,563
	VDOT Covington HQ and Triangle Area HQ	19	$1,288,342
	Mountain Gateway Community College	11	$57,195,303
Bedford County	DCR Smith Mountain Lake	63	$13,673,401
	VDOF shed	1	$20,358
	Department of Military Affairs	3	$7,255,009
	Game & Inland Fisheries	1	$5,336
	State Police	1	$8,790
	VDOT Smith Mountain Lake HQ, New London Area HQ, Bedford Residency Complex, Irving Area HQ, Big Island HQ	46	$2,571,159
	Virginia Tech Bedford Office	1	Not provided
Buchanan County	VDOF Vansant	3	$292,529
	Keen Mountain Correctional Center	16	$83,654,474
Franklin County	Game & Inland Fisheries Penhook Boat Shed	1	$59,026
	Department of Military Affairs	2	$6,907,738
	VDOT Syndorsville HQ, Glade Hill HQ, Rocky Mount Residency Complex, Calloway HQ, Burnt Chimney HQ	44	$3,854,196
Giles County	Va Tech Giles Office	1	Not provided
	UVA	33	$11,902,484
	VDOT Pearisburg HQ	5	$518,597
	Game & Inland Fisheries	3	$24,512
Roanoke County	Catawba Hospital	67	$439,909,063
	DEQ Air Monitoring	2	$3,913
	Forensic Science Western Lab	1	$23,548,916
	State Police Salem Facilities	2	$5,005,329
	VDOT Hanging Rock HQ, Airport Area HQ, Rte 220 Storage, Salem Traffic Management	27	$7,787,088
Rockbridge County	Department of Military Affairs	2	$7,058,973
	VDOT Fancy Hill HQ, Kerrs Creek racks, Fairfield HQ, Eskimo HQ	30	$2,662,304
	Virginia Military Institute	8	$8,745,664
Russell County	Appalachian Detention Center	14	$3,494,627
	Department of Military Affairs	4	$2,769,632
	Va Tech Russell Extension	1	Not provided
Scott County	Va Tech Scott Office	1	Not provided

Locality	Agency and Facility	Number of State Assets at Risk	Total Value of at Risk Assets
	DCR Natural Tunnel State Park	47	$16,764,463
	VDOT Ft Blackmore & inactive fire tower	5	$100,171
	Department of Military Affairs	6	$16,700,629
Tazewell County	VDOT Claypool Hill, Tazewell Residency Complex, Springville HQ	25	$4,899,888
	Pocahontas State Correctional Center	10	$39,527,602
	Southwest Virginia Community College	10	$86,878,747
Wise County	Virginia ABC	1	$225,832
	VDOF Equipment storage	1	$104,826
	Game & Inland Fisheries	1	$32,683
	VDOT Coeburn HQ, Glamorgan HQ, East Stone Gap HQ, Wise Residency Complex	28	$3,324,261
	Mountain Empire Community College	12	$88,704,803
	Red Onion State Prison	15	$71,276,939
	UVA at Wise	52	$306,768,490
	Wallens Ridge State Prison	15	$141,343,034
	Wise Correctional Unit #18	20	$6,469,314

3.8.10.6 Critical Facility Risk

Risk for critical facilities was calculated in the same fashion described above for state facilities. Approximately eight percent of state-owned assets are critical facilities in regions with a moderate or high risk of landslide. Table 3-91 shows the number of critical facilities identified in moderate or high-risk landslide areas, by risk level and use. Utilities, fuel service/storage, and hazardous materials represent many critical facilities in potential risk areas. Annualized loss estimates were not calculated for critical facilities due to the scale of available landslide mapping, limited information on mapped critical facilities (including valuation data), and the unknown probability of future occurrence.

Table 3-91 - Critical Facilities in Landslide Risk Areas

Critical Facility Use	Number in High-Risk Areas	Number in Moderate Risk Areas
Airfield	4	5
Animal Health	4	12
Armory	11	10
Childcare	5	0
Communications	18	12
Emergency Operations Center	0	1
Fire Service/Support/Suppression	8	9
Food Service/Storage	12	10
Fuel Storage/Delivery	179	96
Hazardous Materials Storage	127	78
Medical Services/Support/EMS	43	18
Public Safety/Security	51	27
Research	37	70
Special Populations Housing	9	3
Utilities	178	127
Total:	686	467

3.8.10.7 Landslide Risk to Energy Pipelines

Soil movement associated with landslides can destabilize the structural supports of pipelines, possibly leading to pipeline ruptures. In Virginia, landslides can be expected to occur in conjunction with other hazard events such as flooding, which also pose independent risks to pipelines.

Future Conditions

In general, different phenomena influence the stability of slopes and cause landslides, including precipitation, snow melt, temperature changes, wildfires, earthquakes, and volcanic activity. Climate and its variations, chiefly precipitation, and temperature influence some of these phenomena. It is, therefore, expected that climate (influences slope stability at different temporal and geographical scales[14].

That climate changes affect the stability of natural and engineered slopes, and have consequences on landslides, is clear. Less clear are the details of those consequences - the type, extent, magnitude, and direction of the changes in the stability conditions, and on the location, abundance, activity, and frequency of landslides in response to the projected climate changes[14].

Climate and landslides act at only partially overlapping spatial and temporal scales, complicating the evaluation of the climate impacts on landslides[15]. How changes in the climate of Virginia will impact landslides cannot currently be determined. Additional detailed land risk study is necessary to determine the specific potential impacts to Virginia.

Jurisdictional Risk

The hazard ranking for landslide is based on events reported in the NCEI *Storm Events Database* and a generalized geographic extent rating developed from the USGS landslide susceptibility and incidence. To be able to include landslide in the risk assessment, several general assumptions were made. Geographical extent was the primary basis for establishing risk and was calculated as a percent of the jurisdictional area in high risk. In lieu of probability of future occurrence, areas with higher landslide risk were assumed to be at greater risk. These parameters are illustrated in Table 3-92, along with the total ranking. Most of the Commonwealth is in the lower risk categories.

The NCEI database has limited data available for geological hazards. The limitations are evident in the ranking and when compared to the known historical events; Hurricane Camille in 1969 resulted in landslides that killed 150 people, but this event is not within the period of record of the NCEI database. Table 3-92 shows the relative ranking results for the landslide hazard from the NRI. The table includes all communities that have Very High or Relatively High risk index rating for landslide.

Table 3-92 - Communities With High Risk Index Rating for Landslide

Locality	NRI Risk Index Rating
City of Danville	Relatively High
Giles County	Relatively High
City of Norton	Relatively High
Bath County	Very High

Source: NRI

Zoning and grading ordinances to avoid building in areas of potential hazard or to regulate construction to minimize potential for landslide are non-structural methods to reduce the likely consequences of debris flows. Loudoun County adopted a zoning ordinance preventing the development of building sites with steep slopes along the Blue Ridge (defined in the ordinance as exceeding a 15-percent grade, equivalent to an 8-degree slope) which substantially reduces the hazards of landslides and debris flows within that area.

3.8.10.8 Local Plan Comparison

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

None of the 20 local plans provided loss estimates for this hazard. Of the plans that provided a general description of landslides, some of them referred to the USGS landslide susceptibility and incidence mapping. The consensus in the local plans is that there is no definitive way to estimate potential damages due to landslides at the local level with available local resources and data.

Lenowisco PDC, Cumberland Plateau PDC, Central Virginia, and Roanoke Valley-Allegheny PDC all ranked landslide as a medium hazard. In total, 10 plans ranked landslide as a low hazard, the remaining six plans did not provide a rank for this hazard, resulting in a local plan average of low for landslide.

3.8.10.9 Changes in Development

As stated above, the 2023 statewide analysis has ranked landslide as low risk. Most 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use. Lenowisco PDC and Cumberland Plateau PDC mentioned that the densely populated areas in the PDC are in areas with a more gradual slope and therefore the widespread damages due to landslides would be expected to be limited in those developed areas. Changes in development would most likely have an impact on loss estimates if there was an established method for calculating loss.

Table 3-93 - Landslide Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Low	Low	Low	Low	Medium-Low
Albemarle	Medium-High	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Alexandria, City of	Medium-High	High	Low	Low	Low	Low	Medium-High	Medium
Alleghany	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Amelia	Low	Low	Low	Low	Low	Low	Low	Low
Amherst	Medium	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Appomattox	Low	Low	Low	Low	Low	Low	Low	Low
Arlington	High	High	Low	Low	Low	Low	Low	Medium-Low
Augusta	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Bath	Low	Low	Low	Low	Low	Low	Low	Low
Bedford	Medium-High	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Bland	Low	Low	Low	Low	Low	Low	Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Low	Low	Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Brunswick	Medium	Low	Low	Low	Low	Low	Low	Low
Buchanan	Medium	Low	Low	Low	Low	Medium	High	Medium-Low
Buckingham	Low	Low	Low	Low	Low	Low	Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Campbell	Medium	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Caroline	Medium	Low	Low	Low	Low	Low	Low	Low
Carroll	Medium	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Charles City	Low	Low	Low	Low	Low	Low	Low	Low
Charlotte	Low	Low	Low	Low	Low	Low	Low	Low
Charlottesville, City of	Medium	High	Low	Low	Low	Low	Medium-High	Medium-Low
Chesapeake, City of	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Chesterfield	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Clarke	Low	Medium	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Colonial Heights, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Covington, City of	Low	Medium-High	Low	Low	Low	Low	Medium-High	Medium-Low
Craig	Low	Low	Low	Low	Low	Low	Low	Low
Culpeper	Medium	Medium	Low	Low	Low	Low	Low	Low
Cumberland	Low	Low	Low	Low	Low	Low	Low	Low
Danville, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Dickenson	Low	Low	Low	Low	Low	Low	Low	Low
Dinwiddie	Medium	Low	Low	Low	Low	Low	Low	Low
Emporia	Low	Medium-High	Low	Low	Low	Low	Low	Low
Essex	Low	Low	Low	Low	Low	Low	Low	Low
Fairfax	High	High	Low	Low	Low	Low	Low	Medium-Low
Fairfax, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Falls Church, City of	Low	High	Low	Low	Low	Low	Low	Low
Fauquier	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Floyd	Low	Low	Low	Low	Low	Low	Low	Low
Fluvanna	Medium	Medium	Low	Low	Low	Low	Low	Low
Franklin	Medium	Medium	Low	Low	Low	Low	Medium-High	Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Frederick	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Fredericksburg, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Galax, City of	Low	Medium-High	Low	Low	Low	Low	Medium-High	Medium-Low
Giles	Low	Low	Low	Low	Low	Medium-Low	Medium	Low
Gloucester	Medium	Medium	Low	Low	Low	Low	Low	Low
Goochland	Medium	Medium	Low	Low	Low	Low	Low	Low
Grayson	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Greene	Medium	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Greensville	Low	Low	Low	Low	Low	Low	Low	Low
Halifax	Medium	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Hampton, City of	Medium-High	High	Low	Low	Low	Low	Low	Low
Hanover	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Harrisonburg, City of	Medium	High	Low	Low	Low	Low	Medium	Medium-Low
Henrico	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Henry	Medium	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Highland	Low	Low	Low	Low	Low	Low	Low	Low
Hopewell, City of	Medium	High	Low	Low	Low	Low	Medium-High	Medium-Low
Isle of Wight	Medium	Medium	Low	Low	Low	Low	Low	Low
James City	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
King and Queen	Low	Low	Low	Low	Low	Low	Low	Low
King George	Medium	Medium	Low	Low	Low	Medium	Medium-Low	Medium-Low
King William	Low	Low	Low	Low	Low	Low	Low	Low
Lancaster	Low	Medium	Low	Low	Low	Low	Low	Low
Lee	Medium	Low	Low	Low	Low	Low	Low	Low
Lexington, City of	Low	High	Low	Low	Low	Low	Low	Low
Loudoun	High	Medium-High	Low	Low	Low	Low	Medium-High	Medium-Low
Louisa	Medium	Medium	Low	Low	Low	Low	Low	Low
Lunenburg	Low	Low	Low	Low	Low	Low	Low	Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Low	Medium-High	Medium-Low
Madison	Low	Low	Low	Low	Low	Medium	High	Medium-Low
Manassas, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Manassas Park, City of	Low	High	Low	Low	Low	Low	Low	Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Low	Medium-High	Medium-Low
Mathews	Low	Medium	Low	Low	Low	Low	Low	Low
Mecklenburg	Medium	Low	Low	Low	Low	Low	Low	Low
Middlesex	Low	Medium	Low	Low	Low	Low	Low	Low
Montgomery	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Nelson	Low	Low	Low	Low	Low	Medium	High	Medium-Low
New Kent	Low	Medium	Low	Low	Low	Low	Low	Low
Newport News, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Norfolk, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Northampton	Low	Medium	Low	Low	Low	Low	Low	Low
Northumberland	Low	Low	Low	Low	Low	Low	Low	Low
Norton	Low	Medium-High	Low	Low	Low	Low	Medium-High	Medium-Low
Nottoway	Low	Low	Low	Low	Low	Low	Low	Low
Orange	Medium	Medium	Low	Low	Low	Low	Low	Low
Page	Medium	Medium	Low	Low	Low	Low	Low	Low
Patrick	Medium	Low	Low	Low	Low	Low	Low	Low
Petersburg, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Pittsylvania	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Poquoson	Low	Medium-High	Low	Low	Low	Low	Low	Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Powhatan	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince Edward	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince George	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince William	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Pulaski	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Radford, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Rappahannock	Low	Low	Low	Low	Low	Low	Low	Low
Richmond	Low	Low	Low	Low	Low	Low	Medium-High	Low
Richmond, City of	High	High	Low	Low	Low	Medium-Low	Low	Medium-Low
Roanoke	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Roanoke, City of	Medium-High	High	Low	Low	Low	Low	Medium	Medium-Low
Rockbridge	Medium	Low	Low	Low	Low	Low	Medium	Low
Rockingham	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Russell	Medium	Low	Low	Low	Low	Low	Low	Low
Salem, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Scott	Medium	Low	Low	Low	Low	Low	Low	Low
Shenandoah	Medium	Medium	Low	Low	Low	Low	Low	Low
Smyth	Medium	Medium	Low	Low	Low	Low	Low	Low
Southampton	Low	Low	Low	Low	Low	Low	Low	Low
Spotsylvania	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Stafford	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Staunton, City of	Medium	Medium-High	Low	Low	Low	Medium-Low	Low	Medium-Low
Suffolk	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Surry	Low	Low	Low	Low	Low	Low	Low	Low
Sussex	Low	Low	Low	Low	Low	Low	Low	Low
Tazewell	Medium	Medium	Low	Low	Low	Medium-Low	Low	Medium-Low
Virginia Beach, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Warren	Medium	Medium	Low	Low	Low	Low	Low	Low
Washington	Medium	Medium	Low	Low	Low	Low	Low	Low
Waynesboro, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Westmoreland	Low	Medium	Low	Low	Low	Low	Low	Low
Williamsburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Winchester, City of	Medium	High	Low	Low	Low	Low	Medium	Medium-Low
Wise	Medium	Medium	Low	Low	Low	Low	Medium-High	Medium-Low
Wythe	Medium	Medium	Low	Low	Low	Low	Low	Low
York	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low

For the 2023 plan, the overall hazard ranking for landslide is low. Potential detrimental impacts associated with the hazard are included in Table 3-94.

Table 3-94 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts are expected to be moderate to catastrophic for the impacted area, the worst disaster the Commonwealth has experienced is the landslides associated with Tropical Storm Camille in 1969, 150 deaths.
Health and Safety of Response Personnel	Localized impacts could be serious as local responders are working within the impacted area, if they live within the impacted area then they may be displaced or isolated for an extended period of time. In addition, response by first responders to landslides is inherently dangerous due to slope instability and risk of additional failure.
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 severe.
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 impacts expected to be severe for the impacted areas. With a high potential for debris, HAZMAT may be an issue. In addition, increased sedimentation in streams is also a problem.
Economic and Financial Condition	Local economic and financial conditions may be impacted for a long period of time depending on duration and geographical area of the event, as well as the size and capabilities of the local jurisdiction.
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.

Community Lifelines Impacted by Landslides

Based on the hazard analysis and description of vulnerability and impacts of landslides in Virginia, landslides impact the following community lifelines:

- Food, Water, Shelter
- Safety and Security
- Transportation

3.8.11 Land Subsidence

3.8.11.1 Background

Subsidence, also known as vertical land movement, is the gradual lowering or sudden sinking of the Earth’s surface. Subsidence is often caused by the removal of water, oil, natural gas, or mineral resources out of the ground by pumping, fracking, or mining activities, but can also be the result of natural events. Land subsidence can increase flooding, alter wetland and coastal ecosystems, and damage infrastructure and historical sites. Historical evidence shows that much of the coastal region in Virginia is already experiencing some degree of sea level rise and land subsidence.

While land subsidence is possible in many areas, this assessment will focus on the southern Chesapeake Bay and Hampton Roads area because subsidence there is documented and potentially harmful enough to be analyzed as a hazard. Vulnerability to sea level rise associated with subsidence can be looked at in terms of economic losses resulting from future flood event damages. Additional insight may be gained from examining expectations for future land use and development patterns and highlighting what infrastructure and real estate will potentially be affected by rising tides.

3.8.11.2 Location and Spatial Extent

The southern Chesapeake Bay region is experiencing land subsidence and rising water levels due to global sea level rise; land subsidence and rising water levels combine to cause relative sea level rise. This land subsidence helps explain why the region has the highest rates of sea level rise on the Atlantic Coast of the US. Data indicate that land subsidence has been responsible for more than half the relative sea level rise measured in the region. Land subsidence increases the risk of flooding in low-lying areas, which in turn has important economic, environmental, and human health consequences for the heavily populated and ecologically important southern Chesapeake Bay region.

When groundwater is pumped from an aquifer system, pressure in the aquifer decreases. The pressure change is reflected by water levels in wells, with water levels decreasing as aquifer system pressure decreases. This is happening over most of the southern Chesapeake Bay region, with the greatest water level decreases seen near the pumping centers of Franklin and West Point, Virginia (Figure 3-127). The aquifer system in the region has been compacted by extensive groundwater pumping in the region at rates of 1.5 to 3.7 millimeters per year; this compaction accounts for more than half of observed land subsidence in the region. Water levels have decreased over the entire Virginia Coastal Plain in the Potomac Aquifer, which is the aquifer that supplies approximately three-quarters of the groundwater withdrawn from the Virginia Coastal Plan aquifer system. It is also the deepest and the thickest aquifer in the southern Chesapeake Bay region[8].

There are other causes of land subsidence, but there is currently little or no evidence that these other causes are important to regional subsidence processes in the southern Chesapeake Bay region. However, glacial isostatic adjustment, or the flexing of the Earth's crust in response to glacier formation and melting, is also suspected to be a contributor to land subsidence in the region.

Land subsidence in the Hampton Roads area was first documented in 1940. Repeated surveys between 1940 and 1971 documented that land surfaces across the region were sinking at an average rate of 2.8 millimeters per year. Figure 3-127 provides a visual representation of the 1940-1971 rates of subsidence. In 2013, the area was re-measured and average rates were observed to be 3.1 millimeters per year[10] and a more recent publication in 2020 found an overall subsidence rate of -3.6 ± 2.3 millimeters per year for Hampton Roads.

Figure 3-127 - Aquifer-System Compaction Caused by Groundwater Withdrawals[9]

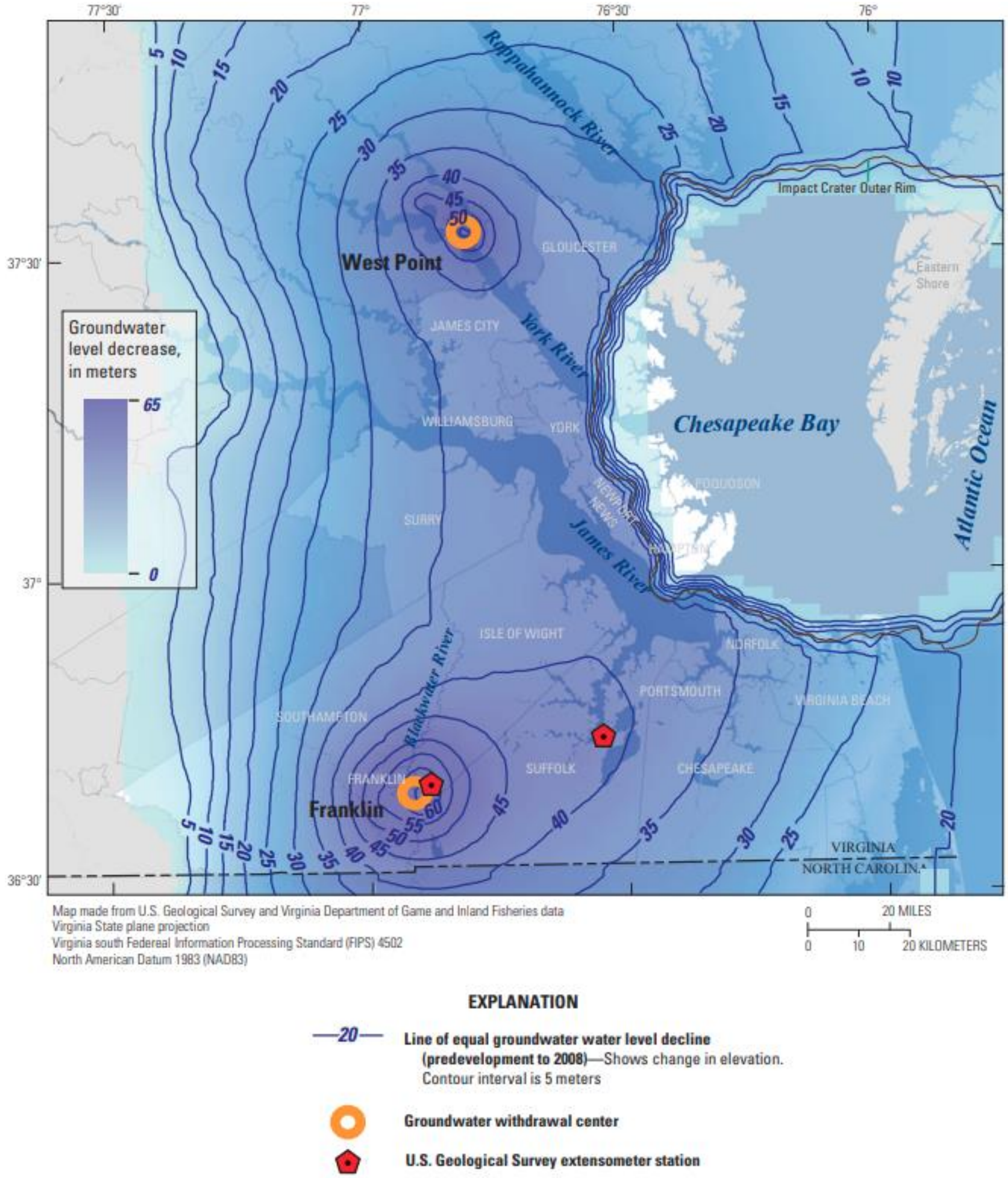
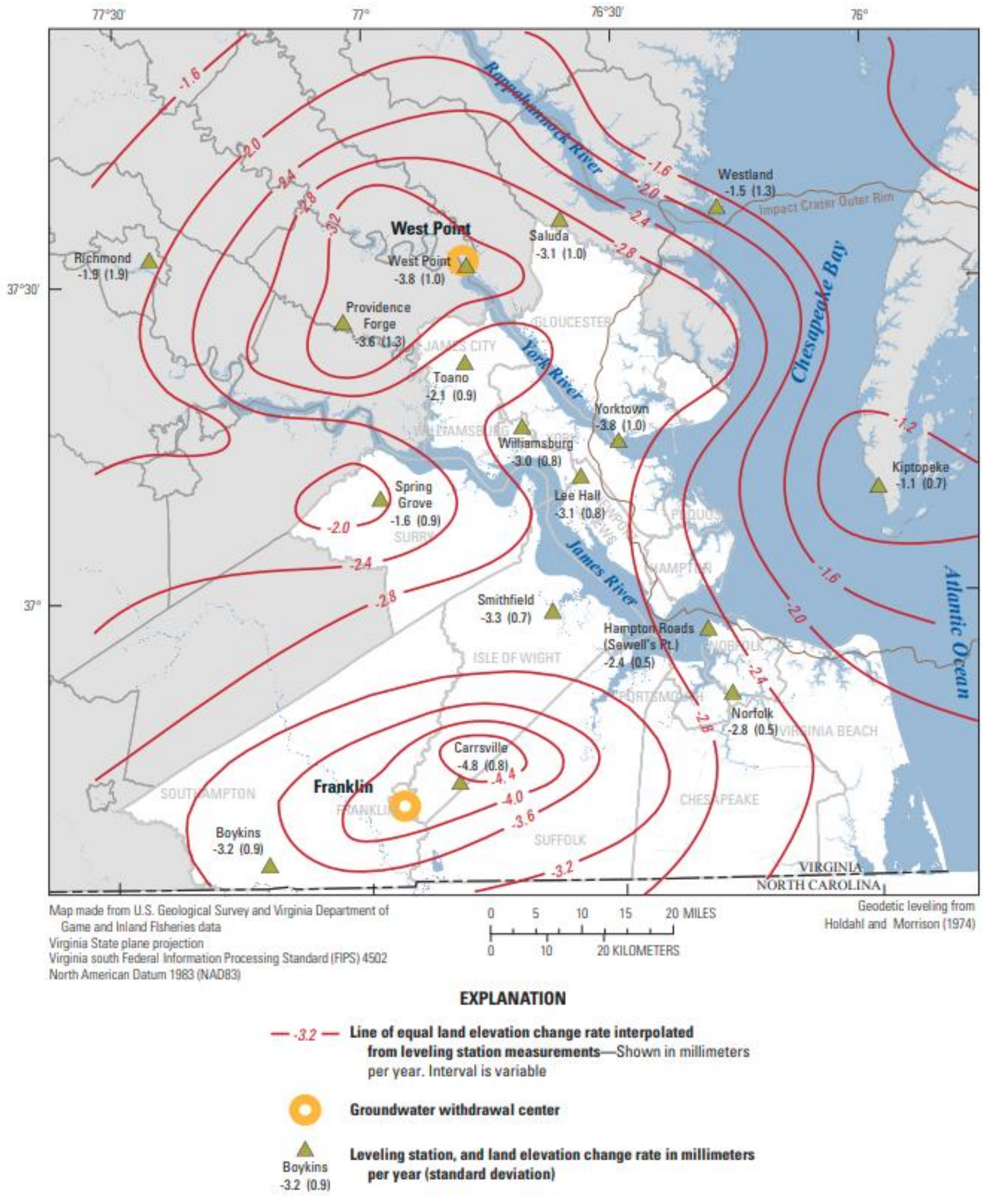


Figure 3-128 - Land elevation change rates from 1940 through 1971



Recent measurements from InSAR satellite analysis show fine-scale patterning and variability of subsidence, especially across Hampton Roads. This analysis as well as others noted below are ongoing studies and could reveal more variability and differential vulnerability for infrastructure (e.g., landfills, filled creeks, dredge spoil areas) across urban Hampton Roads that could be utilized for mitigation efforts.

Ongoing studies:

- Brett Buzzanga dissertation (2021) https://digitalcommons.odu.edu/oeas_etds/181/
- Buzzanga et al. (2020) https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GL090013
- Ben Hamlington and NASA Sea Level Change Team have a new SLR projection tool that includes Sewells Point available here: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

3.8.11.3 Significant Historical Events

There is significant documentation of the subsidence occurring in the southern Chesapeake Bay/Hampton Roads area of Virginia, but there have been no federal disaster declarations or NCEI recorded events for land subsidence-related events. Land subsidence is a site-specific hazard. Currently there is no comprehensive, long-term record of significant historical subsidence events in Virginia.

3.8.11.4 Probability of Future Occurrence

From the USGS report Land Subsidence and Relative Sea level Rise in the Southern Chesapeake Bay Region:

As relative sea levels rise, shorelines retreat and the magnitude and frequency of near-shore coastal flooding increase. Although land subsidence can be slow, its effects accumulate over time. This has been an expensive problem in the Houston-Galveston area and the Santa Clara Valley (Galloway and others, 1999) and likely contributes to current flooding problems in the southern Chesapeake Bay region. Analysis by McFarlane (2012) found that between 59,000 and 176,000 residents living near the shores of the southern Chesapeake Bay could be either permanently inundated or regularly flooded by 2100. This estimate was based on 2010 census data, using the spring high-tide as a reference elevation and assuming a 1-m relative sea level rise. Damage to personal property was estimated to be $9 billion to $26 billion, and 120,000 acres of ecologically valuable land could be inundated or regularly flooded, under these same assumptions. Historic and cultural resources are also vulnerable to increased flooding from relative sea level rise in the southern Chesapeake Bay, particularly at shoreline sites near tidal water, such as the 17th century historic Jamestown site.

Land subsidence can also increase flooding in areas away from the coast. Low-lying areas, such as the Blackwater River Basin, can be subject to increased flooding as the land sinks. Locations along the Blackwater River in the city of Franklin and the counties of Isle of Wight and Southampton have experienced large floods in recent years (Federal Emergency Management Agency, 2002). Land subsidence may be altering the topographic gradient that drives the flow of the river and possibly contributing to the flooding[5].

Impact and Vulnerability

Subsidence has the potential to negatively impact assets and residents. Much of the Hampton Roads area is already subject to flooding, both from rainfall/riverine sources and coastal storms. Any further decrease in land elevation would only exacerbate these conditions. Subsidence can damage wetland and coastal marsh ecosystems by exposing shorelines to increased wave action and washovers. Damage to infrastructure in the area – such as buildings, bridges, and pipelines – can be caused by relative groundwater rise or land settling. Storm and wastewater sewers in urban areas may be vulnerable because subsidence can alter the flow through the sewers, causing increase flooding and more frequent sewer discharge from overflows[12].

Risk

Risk, strictly defined as probability multiplied by impact, cannot be fully estimated for land subsidence due to the lack of historical data and details of state assets, including valuations. To assess risk, this assessment focused on the state assets located in the southern Chesapeake Bay/Hampton Roads region.

3.8.11.5 State Facility Risk

To determine which facilities are at risk for land subsidence, the state facilities in the Hampton Roads/southern Chesapeake Bay region were examined. The results of this analysis indicate 1,975 buildings at risk from land subsidence. Table 3-95 shows the distribution of building risk for state facilities. Annualized loss estimates were not calculated for state facilities due to the lack of building detail data available (including valuation), and the unknown probability of future occurrence.

Table 3-95 - Number of State Facilities Located in Land Subsidence Areas, by Agency

Agency	Number of Buildings in Land Subsidence Areas
Virginia Department of Alcoholic Beverage Control	8
Virginia Department of Behavioral Health and Development Services	69
Virginia Department of Conservation and Recreation	188
Virginia Department of Emergency Management	40
Virginia Department of Environmental Quality	1
Virginia Department of Forensic Science	2
Virginia Department of Wildlife Resources	34
Virginia Department of Military Affairs	194
Virginia Department of Motor Vehicles	9
Virginia Department of Corrections	102
Virginia Department of Forestry	19
Virginia Department of Veterans Services	7
Jamestown-Yorktown Foundation	31
Christopher Newport University	42
Norfolk State University	45
Old Dominion University	113
Tidewater Community College	12
Virginia Community College System	52
Virginia Department of Agriculture and Consumer Services	3
Virginia Central Healthcare System	552

Agency	Number of Buildings in Land Subsidence Areas
Virginia Department of Transportation	269
Virginia Employment Commission	6
Virginia Institute of Marine Science	83
Virginia Polytechnic Institute and State University (Virginia Tech)	49
Virginia Port Authority	69
Virginia State Police	18
Other Agencies	33
Total:	**1,975**

3.8.11.6 Critical Facility Risk

Risk for critical facilities was calculated in the same fashion described above for state facilities. Approximately one percent of state-owned assets are critical facilities in the Hampton Roads/southern Chesapeake Bay region. Table 3-96 shows the number of critical facilities identified in the area. Utilities, fuel service/storage, and hazardous materials represent many critical facilities in potential risk areas. Annualized loss estimates were not calculated for critical facilities due to the limited information on mapped critical facilities (including valuation data), and the unknown probability of future occurrence.

Table 3-96 - Critical Facilities in Land Subsidence Risk Area

Critical Facility Use	Number in Land Subsidence Area
Airfield	3
Animal Health	1
Armory	6
Childcare	2
Communications	5
Fire Service/Support/Suppression	2
Food Service/Storage	14
Fuel Storage/Delivery	49
Hazardous Materials Storage	33
Medical Services/Support/EMS	12
Public Safety/Security	14
Research	21
Special Populations/Housing	1
Utilities	68
Total:	**231**

3.8.11.7 Land Subsidence Risk to Energy Pipelines

Soil movement associated with land subsidence can destabilize the structural supports of pipelines, possibly leading to pipeline ruptures. However, land subsidence is a slow-moving hazard and, presumably, pipeline owners would be able to take mitigative measures as components are replaced or upgraded.

Future Conditions

The NOAA Coastal Flood Exposure Mapper tool (http://www.coast.noaa.gov/floodexposure/#/map) uses recent land cover data to show where areas being developed may be impacted by varying levels of sea level rise. This tool can help provide planners with information needed to focus sea level rise mitigation efforts geographically.

From Chesapeake Bay Land Subsidence and Sea Level Change: An Evaluation of Past and Present Trends and Future Outlook:

Linear trend analysis of monthly mean sea level (mmsl) data from ten Chesapeake Bay water level stations with a common time span have provided insight into temporal and spatial differences in relative sea level rise (RSLR) with approximately the same confidence interval at each station after decadal signal extraction (DSE). Time-segment comparisons indicate small increases in RSLR at four of five Chesapeake Bay stations with data arranged in two periods of equal, non-overlapping spans: 1944-1975 and 1976-2007. Although none of the increases are statistically significant, the methodology used here (DSE analysis) is still sensitive to recent changes on the order of ±0.05 mm/yr. Excluding Washington, DC (WASH), which has significant serial correlation for this period, 1976-2007 RSLR rates at nine stations show an average increase of 0.10 mm/yr compared to NOAA RSLR rates for the same nine stations as reported in Zervas (2009). The 1976-2007 RSLR rate at Sewells Point (SWPT) as determined in this study, for example, is 4.52 ± 0.66 mm/yr compared to 4.44 ± 0.27 mm/yr reported by Zervas (2009) for the 1927-2006 period at SWPT, an increase of 0.08 mm/yr above the NOAA rate[13].

Factors such as such as changes to regional ocean currents, upstream flood control, thermal expansion, and glacial ice melt will have greater influence on how fast Virginia's sea levels rise in the future[53]. Virginia's sea levels are already rising much quicker than most of the country due to these issues, and scientists project that future rates will accelerate further[54]. Much of the expected relative sea level rise is unavoidable and likely to increase in the face of global climate change and shoreline communities will have to adapt, but an important component of relative sea level rise, land subsidence, probably could be prevented or reduced in the future if groundwater pumping and water use strategies were changed.

The probability of land subsidence cannot be expressed in terms of specific return periods or recurrence intervals as it can be for other hazards. For the Hampton Roads area, the probability of land subsidence is high, given that this is a documented, continuous phenomenon that is unlikely to cease in the foreseeable future.

Jurisdictional Risk

To be able to include land subsidence in the risk assessment some general assumptions were made. Geographical Extent, using USGS land subsidence topography maps, was the primary basis for establishing risk. In lieu of probability of future occurrence, areas with more land subsidence were assumed to be at greater risk and were assigned a higher GE ranking than other jurisdictions.

These parameters in the land subsidence risk assessment are illustrated in Table 3-97, along with the total ranking. There are currently no land subsidence related records in NCEI; as a result, the lowest ranking score (1) was assigned to the annualized data for population vulnerability, events, damages, and fatalities and injuries to be able to compare land subsidence to the other hazards, as described in Section 3.7.

3.8.11.8 Local Plan Risk Assessment

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision. Eleven of the total 20 local plans considered land subsidence. The local plans that included land subsidence did not provide loss estimates for the hazard. Of the plans that provided a general description of land subsidence, some of them intersected US Census data with the USGS karst zones to estimate the population located within a land subsidence zone. The consensus in the local plans is that it is not feasible to easily estimate potential damages.

3.8.11.9 Comparison with Local Ranking

The only jurisdiction that ranked subsidence as high risk was Hampton Roads. Lenowisco PDC, Central Virginia, and Central Shenandoah all ranked land subsidence as having medium risk. In most cases, the local plans combined land subsidence with other hazards (i.e., karst or sea level rise). Therefore, the overall risk for land subsidence is low among the 11 regional plans that ranked the hazard.

3.8.11.10 Changes in Development

Most local hazard mitigation 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Hampton Roads plan incorporated the NOAA Flood Exposure Mapper Tool to identify development patterns and exposure with different sea level rise scenarios.

Table 3-97 - Land Subsidence Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Low	Medium	Low	Low	Low	Low	Low	Low
Albemarle	Low	Medium	Low	Low	Low	Low	Low	Low
Alexandria, City of	Low	High	Low	Low	Low	Low	Low	Low
Alleghany	Low	Low	Low	Low	Low	Low	Low	Low
Amelia	Low	Low	Low	Low	Low	Low	Low	Low
Amherst	Low	Medium	Low	Low	Low	Low	Low	Low
Appomattox	Low	Low	Low	Low	Low	Low	Low	Low
Arlington	Low	High	Low	Low	Low	Low	Low	Low
Augusta	Low	Medium	Low	Low	Low	Low	Low	Low
Bath	Low	Low	Low	Low	Low	Low	Low	Low
Bedford	Low	Medium	Low	Low	Low	Low	Low	Low
Bland	Low	Low	Low	Low	Low	Low	Low	Low
Botetourt	Low	Medium	Low	Low	Low	Low	Low	Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Brunswick	Low	Low	Low	Low	Low	Low	Low	Low
Buchanan	Low	Low	Low	Low	Low	Low	Low	Low
Buckingham	Low	Low	Low	Low	Low	Low	Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Campbell	Low	Medium	Low	Low	Low	Low	Low	Low
Caroline	Low	Low	Low	Low	Low	Low	Low	Low
Carroll	Low	Medium	Low	Low	Low	Low	Low	Low
Charles City	Low	Low	Low	Low	Low	Low	Low	Low
Charlotte	Low	Low	Low	Low	Low	Low	Low	Low
Charlottesville, City of	Low	High	Low	Low	Low	Low	Low	Low
Chesapeake, City of	High	Medium-High	Low	Low	Low	Low	Medium	Medium-Low
Chesterfield	Low	Medium-High	Low	Low	Low	Low	Low	Low
Clarke	Low	Medium	Low	Low	Low	Low	Low	Low
Colonial Heights, City of	Low	High	Low	Low	Low	Low	Low	Low
Covington, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Craig	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Culpeper	Low	Medium	Low	Low	Low	Low	Low	Low
Cumberland	Low	Low	Low	Low	Low	Low	Low	Low
Danville, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Dickenson	Low	Low	Low	Low	Low	Low	Low	Low
Dinwiddie	Low	Low	Low	Low	Low	Low	Low	Low
Emporia	Low	Medium-High	Low	Low	Low	Low	Low	Low
Essex	Low	Low	Low	Low	Low	Low	Low	Low
Fairfax	Low	High	Low	Low	Low	Low	Low	Low
Fairfax, City of	Low	High	Low	Low	Low	Low	Low	Low
Falls Church, City of	Low	High	Low	Low	Low	Low	Low	Low
Fauquier	Low	Medium	Low	Low	Low	Low	Low	Low
Floyd	Low	Low	Low	Low	Low	Low	Low	Low
Fluvanna	Low	Medium	Low	Low	Low	Low	Low	Low
Franklin	Medium	Medium	Low	Low	Low	Low	Medium	Medium-Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Low	Medium	Low
Frederick	Low	Medium	Low	Low	Low	Low	Low	Low
Fredericksburg, City of	Low	High	Low	Low	Low	Low	Low	Low
Galax, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Giles	Low	Low	Low	Low	Low	Low	Low	Low
Gloucester	Medium	Medium	Low	Low	Low	Low	Medium	Medium-Low
Goochland	Low	Medium	Low	Low	Low	Low	Low	Low
Grayson	Low	Low	Low	Low	Low	Low	Low	Low
Greene	Low	Medium	Low	Low	Low	Low	Low	Low
Greensville	Low	Low	Low	Low	Low	Low	Low	Low
Halifax	Low	Low	Low	Low	Low	Low	Low	Low
Hampton, City of	Medium-High	High	Low	Low	Low	Low	Medium	Medium-Low
Hanover	Low	Medium	Low	Low	Low	Low	Low	Low
Harrisonburg, City of	Low	High	Low	Low	Low	Low	Low	Low
Henrico	Low	Medium-High	Low	Low	Low	Low	Low	Low
Henry	Low	Medium	Low	Low	Low	Low	Low	Low
Highland	Low	Low	Low	Low	Low	Low	Low	Low
Hopewell, City of	Low	High	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Isle of Wight	Medium	Medium	Low	Low	Low	Low	Medium	Medium-Low
James City	Medium-High	Medium-	Low	Low	Low	Low	Medium	Medium-Low
King and Queen	Low	Low	Low	Low	Low	Low	Low	Low
King George	Low	Medium	Low	Low	Low	Low	Low	Low
King William	Low	Low	Low	Low	Low	Low	Low	Low
Lancaster	Low	Medium	Low	Low	Low	Low	Low	Low
Lee	Low	Low	Low	Low	Low	Low	Low	Low
Lexington, City of	Low	High	Low	Low	Low	Low	Low	Low
Loudoun	Low	Medium-High	Low	Low	Low	Low	Low	Low
Louisa	Low	Medium	Low	Low	Low	Low	Low	Low
Lunenburg	Low	Low	Low	Low	Low	Low	Low	Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Madison	Low	Low	Low	Low	Low	Low	Low	Low
Manassas, City of	Low	High	Low	Low	Low	Low	Low	Low
Manassas Park, City of	Low	High	Low	Low	Low	Low	Low	Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Mathews	Low	Medium	Low	Low	Low	Low	Low	Low
Mecklenburg	Low	Low	Low	Low	Low	Low	Low	Low
Middlesex	Low	Medium	Low	Low	Low	Low	Low	Low
Montgomery	Low	Medium	Low	Low	Low	Low	Low	Low
Nelson	Low	Low	Low	Low	Low	Low	Low	Low
New Kent	Low	Medium	Low	Low	Low	Low	Low	Low
Newport News, City of	High	High	Low	Low	Low	Low	Medium	Medium-Low
Norfolk, City of	High	High	Low	Low	Low	Low	Medium	Medium-Low
Northampton	Low	Medium	Low	Low	Low	Low	Low	Low
Northumberland	Low	Low	Low	Low	Low	Low	Low	Low
Norton	Low	Medium-High	Low	Low	Low	Low	Low	Low
Nottoway	Low	Low	Low	Low	Low	Low	Low	Low
Orange	Low	Medium	Low	Low	Low	Low	Low	Low
Page	Low	Medium	Low	Low	Low	Low	Low	Low
Patrick	Low	Low	Low	Low	Low	Low	Low	Low
Petersburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Pittsylvania	Low	Medium	Low	Low	Low	Low	Low	Low
Poquoson, City of	Low	Medium-	Low	Low	Low	Low	Medium	Medium-Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Low	Medium	Medium-Low
Powhatan	Low	Medium	Low	Low	Low	Low	Low	Low
Prince Edward	Low	Medium	Low	Low	Low	Low	Low	Low
Prince George	Low	Medium	Low	Low	Low	Low	Low	Low
Prince William	Low	Medium-High	Low	Low	Low	Low	Low	Low
Pulaski	Low	Medium	Low	Low	Low	Low	Low	Low
Radford, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Rappahannock	Low	Low	Low	Low	Low	Low	Low	Low
Richmond	Low	Low	Low	Low	Low	Low	Low	Low
Richmond, City of	Low	High	Low	Low	Low	Low	Low	Low
Roanoke	Low	Medium-High	Low	Low	Low	Low	Low	Low
Roanoke, City of	Low	High	Low	Low	Low	Low	Low	Low
Rockbridge	Low	Low	Low	Low	Low	Low	Low	Low
Rockingham	Low	Medium	Low	Low	Low	Low	Low	Low
Russell	Low	Low	Low	Low	Low	Low	Low	Low
Salem, City of	Low	High	Low	Low	Low	Low	Low	Low
Scott	Low	Low	Low	Low	Low	Low	Low	Low
Shenandoah	Low	Medium	Low	Low	Low	Low	Low	Low
Smyth	Low	Medium	Low	Low	Low	Low	Low	Low
Southampton	Low	Low	Low	Low	Low	Low	Medium	Low
Spotsylvania	Low	Medium	Low	Low	Low	Low	Low	Low
Stafford	Low	Medium-High	Low	Low	Low	Low	Low	Low
Staunton, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Suffolk, City of	Medium-High	Medium	Low	Low	Low	Low	Medium	Low
Surry	Low	Low	Low	Low	Low	Low	Medium	Low
Sussex	Low	Low	Low	Low	Low	Low	Low	Low
Tazewell	Low	Medium	Low	Low	Low	Low	Low	Low
Virginia Beach, City of	High	High	Low	Low	Low	Low	Medium	Medium-Low
Warren	Low	Medium	Low	Low	Low	Low	Low	Low
Washington	Low	Medium	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Waynesboro, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Westmoreland	Low	Medium	Low	Low	Low	Low	Low	Low
Williamsburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Winchester, City of	Low	High	Low	Low	Low	Low	Low	Low
Wise	Low	Medium	Low	Low	Low	Low	Low	Low
Wythe	Low	Medium	Low	Low	Low	Low	Low	Low
York	Medium-High	Medium-High	Low	Low	Low	Low	Medium	Medium-Low

For the 2023 plan, the overall hazard ranking for land subsidence is low. Potential detrimental impacts associated with the hazard are included in Table 3-98.

Table 3-98 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts are expected to be moderate to severe in the impact area.
Health and Safety of Response Personnel	Limited unless involves broken utility lines.
Continuity of Operations	Limited, unless a facility is impacted.
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 severe.
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 impacts expected to be moderate for the impacted areas. Always a potential for utility line breaks.
Economic and Financial Condition	Limited. Depending on the magnitude of the event, local economy and finances may be impacted.
Public Confidence in the Jurisdiction's Governance	Localized impacts expected to cause property owners confidence in state and local land use/development policies to waiver.

Community Lifelines Impacted by Land Subsidence

Based on the hazard analysis and description of vulnerability and impacts of land subsidence in Virginia, land subsidence does not impact any community lifelines. This is a result of the long-term nature of the hazard which allows for continuous adjustment and mitigation.

3.8.12 Non-Tornadic Wind

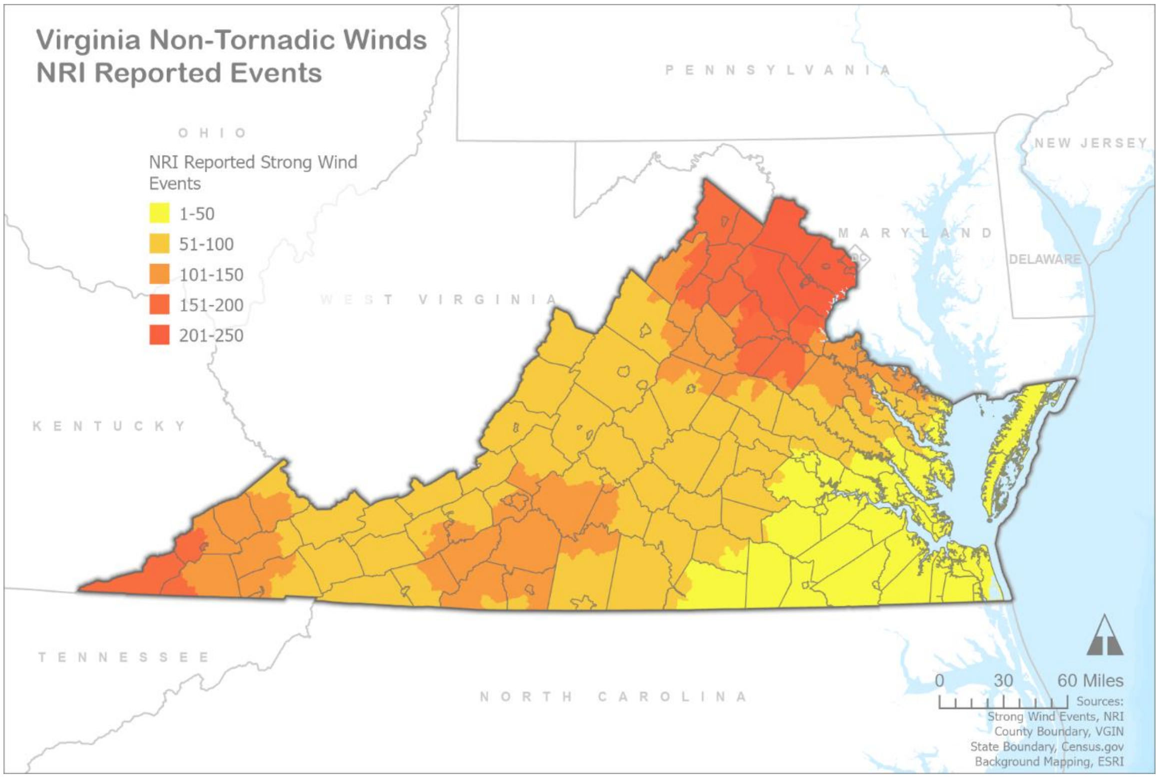
3.8.12.1 Background

Non-tornadic winds include severe thunderstorms, windstorms, and derechos and may occur along with other hazards such as extreme rainfall, thunderstorms, and lightning. A derecho is a widespread straight-line windstorm linked to a band of severe thunderstorms. They are mainly a warm-weather phenomenon, occurring mostly in June and July in the Northern Hemisphere. Derechos are also seen as a thunderstorm complex, producing a band of winds at least 240 miles in length with wind speeds of at least 58 mph or greater along most of its length[2]. Derechos can produce damage comparable to tornadoes.

3.8.12.2 Location and Spatial Extent

Non-tornadic winds can occur statewide, but the record of historic events indicates that severe winds (excluding winds associated with tropical storms) have historically occurred in the Northern Virginia region and in far southwest Virginia. Figure 3-127 provides a depiction of the NRI reported events for counties in Virginia. Events have occurred throughout the Commonwealth, with over 200 events reported in each of the following: Fauquier, Prince William, Fairfax, Loudoun and Arlington Counties, and the cities of Manassas, Manassas Park, Alexandria, Fairfax and Falls Church.

Figure 3-129 - Location and spatial extent of historical strong wind events



3.8.12.3 Significant Historical Events

Significant winds are often associated with other events such as hurricanes, nor'easters, and tornadoes; it can be challenging to isolate severe non-tornadic winds from these occurrences. The NCEI storm events database contains over 500 incidences of thunderstorm winds exceeding 60 knots between 1950 and 2021. The most severe events and those that resulted in fatalities are included in Table 3-99.

Table 3-99 - Historical non-tornadic wind events

Year	Location	Description	Fatalities	Injuries	Damages (K)
1984	Fairfax City	Not Available	1	0	
1984	Newport News	Not Available	1	0	
1989	Fluvanna	Not Available	1	0	
1990	Spotsylvania	Not Available	1	3	
1996	Washington	Numerous trees and powerlines were downed around Bristol and Abingdon. A tree limb, nearly three feet in diameter fell onto a car killing the driver and injuring a passenger.	1	1	8
1997	Alleghany / Clifton Forge / Covington	A logger was killed when a very localized area of high winds caused a tree to fall on him. The tree that fell was not being cut down and other workers attempts to alert the man failed. The very freak accident occurred about 2 miles south of Hematite in Alleghany County.	1	0	0
1999	Waynesboro	Afternoon highs in the 90s and very moist and unstable air combined to produce scattered thunderstorms across the northern portion of Virginia. Several of these storms produced winds in excess of	1	0	0.5

Year	Location	Description	Fatalities	Injuries	Damages (K)
		55 MPH, heavy downpours between 5:00 PM and 6:30 PM EDT. Winds were estimated between 60 and 70 MPH in the community of Opal in Southern Fauquier County around 5:45 PM EDT and a wind gust of 60 MPH was reported at Sperryville in Rappahannock County at 5:20 PM EDT. These severe winds downed trees and power lines in several locations of Rappahannock and Fauquier Counties, and in isolated locations in Prince William and Stafford Counties. An observer in Opal reported 1.22 inches of rainfall in only 30 minutes as the storms passed through. In the city of Waynesboro, a 42-year-old woman was killed as winds from a passing thunderstorm toppled a 25-foot-tall locust tree onto her as she was trying to free a pet from an outdoor kennel around 6:00 PM EDT.			
1999	Halifax	High winds from the remnants of Hurricane Floyd on the evening of the 15th and the 16th, downed trees and powerlines. One tree was toppled onto a mobile home in Paces, killing a woman and injuring a two-week-old infant.	1	1	50K
2000	Isle Of Wight	A powerful storm system off the North Carolina and Virginia coast produced high winds and waves over the James River. One man was killed, and three others were treated for hypothermia from the still-cold water when their 16-foot fishing boat capsized in the James River. Effects from the high winds did not extend very far inland.	3	1	
2000	Prince George / Hopewell	A powerful storm system off the Virginia and North Carolina coast produced high winds and waves over the James River. One man drowned and another man was injured when their 17-foot fishing boat capsized on the James River east of Hopewell due to the weather. Few effects from the wind were experienced inland.	1	1	
2002	Roanoke City	Thunderstorms during the morning and afternoon of the 13th produced damaging winds. Thunderstorm winds downed trees in Northern Halifax County, Charlotte Court House, Sugar Grove, Danville, Graysontown, Indian Valley, Christiansburg, 3 miles west of Ferum, Gladys, 6 miles northeast of Appomattox, trees and power lines in Ridgeway, and large tree limbs in Riner. A large tree was downed in Roanoke onto workers setting up a tent. One was killed and 2 others injured. Trees and power lines were downed from Wylliesburg to 1.5 miles east of Wylliesburg. One tree fell onto a car causing damage. Thunderstorm winds downed large trees in several areas from 26 miles southwest of Buckingham to Buckingham, and in Dillwyn. One house 6 miles southwest of Buckingham had a roof blown off.	1	2	0.5
2003	Buckingham	Thunderstorms during the afternoon and evening hours on the 9th produced hail up to golf ball size, damaging winds, and dangerous lightning. A severe thunderstorm during the afternoon of the 9th tracked from about 7 miles northeast of Centenery to 7 miles east northeast of Dillwyn. At times the damage path was 2 miles wide with sporadic damage to buildings and 3 commercial chicken houses destroyed. Numerous large trees were downed and uprooted along the path of the storm. In addition to the damaging winds, this storm also produced golf ball size hail along its track. A fatality also occurred when a tree was toppled onto a house in Arvonia. Thunderstorm winds downed numerous trees in	1		350

Year	Location	Description	Fatalities	Injuries	Damages (K)
		Nathalie with many reports of damage to automobiles and houses. Thunderstorm winds knocked down trees 4 mile east-northeast of Newcastle, broke off 2 inch diameter tree limbs 1 miles south of Bedford City, snapped off trees and tore down a conveyor tower 2 miles east northeast of Newcastle, knocked down numerous trees which blocked roads in Buchanan and Turbeville, toppled trees and power lines, damaged the a barn and tore some shingles off a house from 2 miles northwest of Huddleston to Huddleston, snapped off trees and knocked down a school zone traffic light sign in Altavista, knocked down numerous trees, damaged a house, and moved a metal shed 100 feet in Hurt, knocked down numerous trees in Huddleston, knocked down numerous trees Hurt, and from Clover to 3 miles southeast of Dryburg. A woman was injured when she was struck by lightning in Roanoke.			
2006	Gloucester	The remnants of Ernesto along the Mid Atlantic coast combined with strong high pressure over New England produced very strong winds across eastern and southeast Virginia. Sustained winds in mph ranged from the lower 40s to near 60 with maximum gusts ranging from the mid-50s to as high as the mid-70s. Some higher sustained winds included 60 mph (52 knots) at York River Range Light and York River US Coast Guard, and 56 mph (49 knots) at Wallops Island (WAL). Some higher maximum gusts included 76 mph (66 knots) at York River Range Light, and 75 mph (65 knots) at York River USCG. The high winds caused numerous downed trees and power outages, along with significant structural damage. Two fatalities occurred when a downed tree fell on a residence in Gloucester.	2		1000
2007	Loudoun	A low-pressure system moved out of the Southern Plains and strengthened off the southeast coast February 12th through 14th, bringing accumulating wintry precipitation to much of northern Virginia beginning during the afternoon and evening hours of February 12th and continued through the early morning hours of February 14th. The heaviest precipitation occurred February 13th as the low-pressure system intensified off the coast. |Snow and sleet accumulations ranged from 1 to 7 inches and ice accumulations ranged from a tenth to three quarters of an inch. This mix of sleet, snow and freezing rain created a very hard and thick layer of ice. Many snowplows were not equipped to handle such heavy precipitation, leading to longer wait times for roadways and sidewalks to be cleared. Icy road conditions lead to dozens of car accidents across the region. Schools were closed for much of the week. Several restaurants and florists reported reduced Valentines Day sales due to the hazardous road conditions. The Washington Post reported that a 15-year-old girl in Bluemont was killed when a strong wind gust felled portions of a large old tree. Wind gusts around the region ranged from 20 to 25 mph with gusts as high as 35 mph.	1	1	0
2008	Fairfax	A stalled front resided across the Mid Atlantic during the afternoon and evening of June 4th, allowing moisture and instability to pool along the boundary. This combined with several strong upper-level disturbances resulted in numerous thunderstorms during the afternoon and evening. Many of these thunderstorms became severe. While penny sized hail	1	0	10

Year	Location	Description	Fatalities	Injuries	Damages (K)
		was reported in spots, damaging winds from the thunderstorms was widespread. EF-1 tornadoes were confirmed near Stevensville in Culpeper County, in Millwood in Clarke County and near Hartwood in Stafford County. Broadcast media reported a tree fell on a moving car on in Annandale, killing the passenger.			
2008	Sussex	The combination of intense low pressure departing to the northeast and cold high pressure building in from the west, produced strong winds and some minor wind damage across portions of central and eastern Virginia. Wind gust of 33 knots (38 mph) was measured at AKQ. Few trees were downed. Gusty winds caused a tree to fall onto passenger side of a vehicle on Highway 35 near Newville Road, resulting in one fatality and one injury. The fatality was a 52-year-old female. A male driver was injured.	1	1	2
2011	James City	Strong gradient wind caused a tree to be blown down across the Colonial Parkway in Jamestown in southeast Virginia. The falling tree struck a vehicle and killed the passenger of the vehicle.	1	1	5
2011	Wythe	A strong closed upper-level low pressure moved across the Ohio valley, producing a variety of extreme weather across southwest Virginia. In advance of this system, strong southeast winds produced wind damage across the higher elevations. These southeast winds also provided strong upslope lifting along the Blue Ridge. This helped produce heavy rainfall amounts of 2 to 3 inches and areas of flash flooding. Enough heating occurred ahead of the cold front on the 16th to trigger severe thunderstorms along and east of the Blue Ridge, resulting in widespread thunderstorm wind damage and two tornadoes. Behind the storms, strong northwest winds knocked down many trees given the very wet soil conditions. Strong winds combined with saturated soil to topple a tree into a mobile home killing one woman and severely injuring another in Wytheville.	1	1	2
2011	Norfolk	Scattered severe thunderstorms well in advance of a cold front produced damaging winds and large hail across portions of south central and southeast Virginia. Wind gusts pushed a crane against a building pinning a shipyard employee.	1	0	2
2011	Loudoun	A cold front passed through the area during the 3rd. A southerly flow ahead of the front caused enough warm and moist air for moderate instability to develop. The combination of lift associated with the front and instability triggered showers and thunderstorms. Some thunderstorms became severe with damaging winds and large hail. A fatality occurred when a tree fell onto a cyclist along the C and O Canal Towpath.	1	0	0
2012	Goochland	Strong winds knocked down a tree which struck and killed. a landscaper in Goochland County.	1	0	2
2012	Albemarle	A strong upper-level disturbance passed through the region in a northwest flow aloft. Extremely hot and humid conditions caused high amounts of instability. The upper-level disturbance triggered a line of thunderstorms that moved through the area. Due to the high instability, thunderstorms caused widespread wind damage. A male was fatally wounded from a falling tree.	1	0	
2012	Franklin	A derecho of historic proportion rolled through the region and caused widespread, significant damage.	1	0	750

Year	Location	Description	Fatalities	Injuries	Damages (K)
		Numerous power outages occurred. Some customers were without power for 12 days which coincided with a prolonged period of excessive heat. The derecho had its origin around Chicago, Illinois around 1:00 pm EST. By 9:00 pm EST the derecho had reached Southside Virginia. By midnight EST it had reached the Atlantic coast. Thunderstorm winds blew numerous trees down across the county. A mobile home suffered major damage as a fallen tree split the structure in half. Several other homes across the northern part of the county suffered minor to moderate damage from fallen trees in the Boones Mill to Burnt Chimney and Smith Mountain Lake areas. A firefighter was initially injured by a falling tree while responding to a call in his vehicle. The individual later died as a result of the injuries. Damage values are estimated.			
2012	Albemarle	A strong upper-level disturbance passed through the region in a northwest flow aloft. Extremely hot and humid conditions caused high amounts of instability. The upper-level disturbance triggered a line of thunderstorms that moved through the area. Due to the high instability, thunderstorms caused widespread wind damage. A female driver was fatally wounded when a tree fell onto her as she exited her car after encountering a fallen tree in the roadway. Three other males were also injured by the falling tree.	1	3	
2012	Fairfax	A strong upper-level disturbance passed through the region in a northwest flow aloft. Extremely hot and humid conditions caused high amounts of instability. The upper-level disturbance triggered a line of thunderstorms that moved through the area. Due to the high instability, thunderstorms caused widespread wind damage. A fatality occurred in Springfield when a female was crushed by a tree that fell into her house.	1	0	
2012	Fairfax	A strong upper-level disturbance passed through the region in a northwest flow aloft. Extremely hot and humid conditions caused high amounts of instability. The upper-level disturbance triggered a line of thunderstorms that moved through the area. Due to the high instability, thunderstorms caused widespread wind damage. A fatality occurred when a tree fell onto a vehicle as the motorist was exiting the vehicle.	1	0	
2012	Commonwealth	Severe thunderstorms and straight-line winds exceeding 80 mph impacted Virginia on the evening of June 29 and the morning hours of July 1. A large portion of the Commonwealth lost power for several days, during a significant heat wave.	15		
2014	Washington	A frontal boundary triggered thunderstorms during the afternoon for a second day in a row across southwest Virginia. Trees and powerlines were downed by the storm.. Broadcast media personnel reported a pedestrian was struck by a falling tree in Abingdon.. At the time of the event the peak wind gusts were only recorded at 24 mph via the CWOP station 1 mile south of Abingdon.	1	0	10
2014	Northampton	Scattered severe thunderstorms associated with a cold front produced damaging winds, large hail, and one tornado across portions of southeast Virginia. Downburst straight line wind damage occurred from the southern portions of Cherrystone Campground southward into Cape Charles, then eastward through Cheriton to Oyster. The most significant damage occurred from Cherrystone Campground eastward to	3	31	750/1.5M

Year	Location	Description	Fatalities	Injuries	Damages (K)
		just east of Route 13 in Cheriton and southward to just north of the intersection of Route 13 and Route 184 east of Cape Charles. Numerous trees were downed, snapped off or large limbs were blown out. A couple of trees were downed on homes. Several large camping trailers were overturned in Cherrystone Campground. 3 people died when a tree fell on the tents in which they were taking shelter.			
2016	Shenandoah	A few gusty showers and isolated thunderstorms developed due to an upper-level low nearby along with a stationary boundary. A tree fell onto a pickup truck. One fatality was reported.	1	0	
2017	Henrico	Scattered severe thunderstorms in advance of low pressure and its associated cold front produced damaging winds and six tornadoes across portions of central and eastern Virginia.	1	0	5
2018	James City	Intense low pressure spinning off the southern New England coast produced very strong northerly winds across portions of central and eastern Virginia. The very strong winds downed numerous trees, produced structural damage, and caused power outages. The very strong winds downed trees and caused power outages. A 44-year-old male died when a large oak tree fell on his vehicle.	1	0	25
2018	Eastern Chesterfield	Intense low pressure spinning off the southern New England coast produced strong northerly winds across portions of central Virginia. The strong winds downed several trees, produced some structural damage, and caused scattered power outages. The strong winds downed several trees, produced some structural damage, and caused scattered power outages. Wind gust of 49 knots (56 mph) was measured at the Chesterfield County Airport. Also, a six-year-old male died several hours after a tree fell on the family's mobile home.	1	0	20
2019	Lunenburg	Scattered severe thunderstorms in advance of a cold front produced damaging winds and one tornado across portions of central and eastern Virginia. Multiple trees were downed on the west side of town. A tree fell onto a home resulting in a fatality.	1	0	20
2019	Stafford	A warm front crossed central and northern Virginia from south to north during the morning hours of April 14th, allowing for increasing warm and moist air to move overhead. During the afternoon and evening, low pressure moved through the Ohio Valley and into the eastern Great Lakes, leading to an increase in the wind field across all levels and therefore an increase in deep layer shear. Instability remained somewhat limited but was enough to produce showers and scattered thunderstorms during the afternoon and evening hours, some of which became severe. A second round of showers and thunderstorms then moved across central and northern Virginia as a strong cold front crossed the region during the late evening and overnight hours. These thunderstorms took the form of a quasi-linear convective system which became severe and produced locally damaging winds. A tree fell onto a house on injuring an 82-year-old male and killing a 78-year-old female who were asleep in the house at the time.	1	1	
2019	Nottoway	Scattered severe thunderstorms in advance of a frontal boundary produced damaging winds across portions of central and eastern Virginia. A large tree	1	2	2

Year	Location	Description	Fatalities	Injuries	Damages (K)
		was downed during a training exercise at Fort Pickett, killing one person and injuring two other people.			
2021	Amherst	A large thunderstorm complex moved east from the Ohio and Tennessee Valleys across southwest Virginia. The system caused dozens of trees to be toppled across the region. Heavy rainfall from these storms also caused localized flooding in the City of Roanoke, where rainfall rates were in excess of 4 inches per hour at one point, between a 5-year and 10-year rainfall event per NOAA Atlas 14 Point Frequency Estimates. Rainfall amounts across the City of Roanoke ranged from 1.50 to 1.75 inches, not unusual for thunderstorm activity, but still enough to cause localized flooding given the more urbanized nature of the impacted area. Thunderstorm winds blew down a tree directly upon an enclosed trailer, killing a 34-year-old male.Damage values are estimated.	1	0	15

3.8.12.4 Probability of Future Occurrence

Thunderstorms with high winds can occur any day of the year but are most common in the summer months when temperatures are warmer. Non-tornadic wind events are generally determined by visual sightings or post-storm damage assessments. This has resulted in non-meteorological biases and a limited temporal and spatial dataset, making long-term assessments and projections challenging.

Impact and Vulnerability

Non-tornadic winds have the potential to negatively impact assets and residents. Winds can damage trees, homes, power lines, and other infrastructure causing injury or death. Vulnerability to non-tornadic winds is largely based on building construction materials and standards.

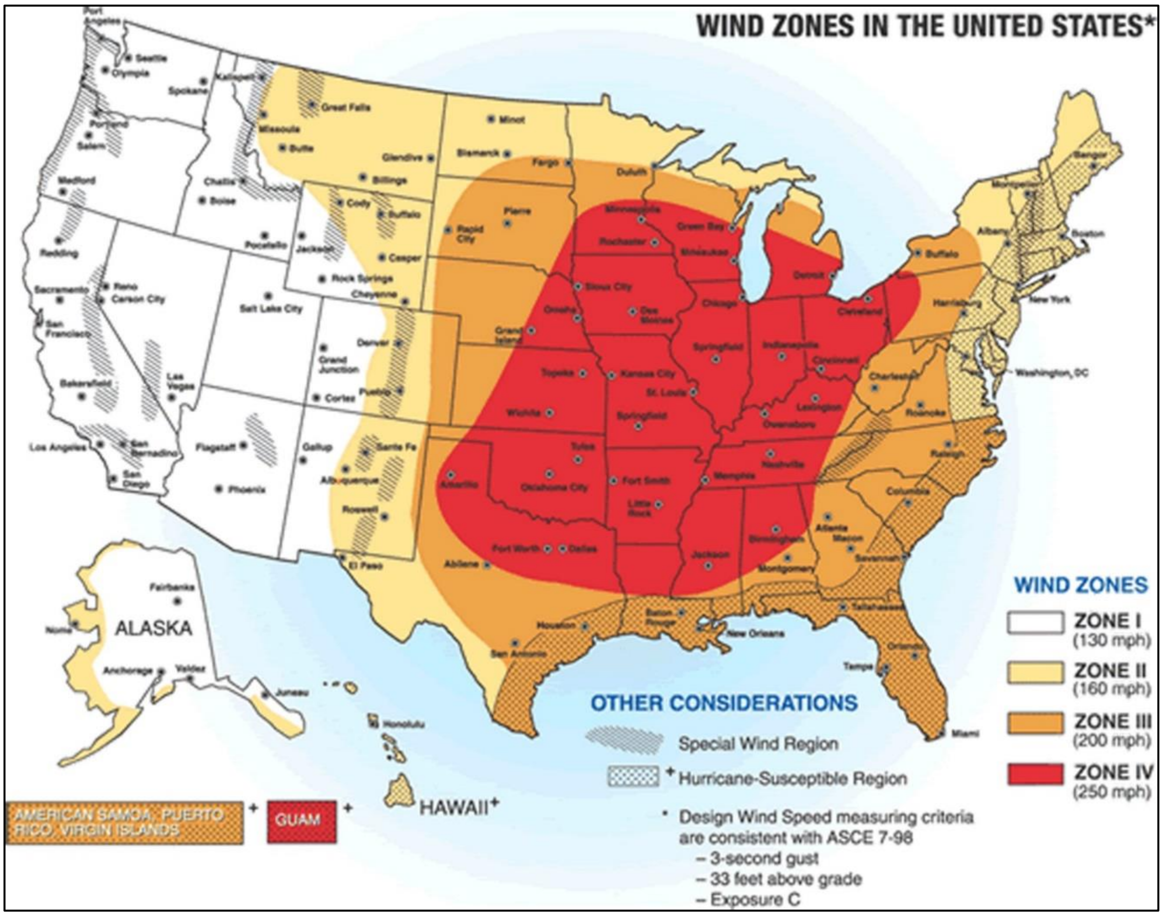
Most office buildings are designed for a 50-year mean recurrence interval wind event (two-percent annual probability. The American Society of Civil Engineers (ASCE) publication 7-10, Minimum Design Loads for Buildings and Other Structures, requires office buildings where more than 300 people congregate in one area to be designed for a 1-percent-annual-chance mean recurrence interval wind event; therefore, these office buildings are designed to resist stronger, rarer storms than most office buildings[4]. Other office buildings that must be designed for a 1-percent-annual-chance mean recurrence interval wind event include:

- Buildings that will be used for severe storm or other emergency shelter.
- Buildings housing a day care center with capacity greater than 150 occupants.
- Buildings designated for emergency preparedness, communication, or emergency operation center or response.
- Buildings housing critical national defense functions.
- Buildings containing enough hazardous materials.

A wind zone map for the U.S. is shown in Figure 3-130 below, design wind speed measuring criteria are consistent with ASCE 7-98 (3 second gust, 33 ft above grade, and Exposure C). The map shows how the frequency and strength of extreme windstorms vary across the United States.

Wind speeds in Zone IV (red), where the risk of extreme windstorms is greatest, can be as high as 250 miles per hour. Based on this map the eastern part of Virginia is within a Zone II (160 mph) and within a Hurricane Susceptible Region. The western part of the state is within a Zone III (200 mph), with a small region defined as "Special Wind Region" in the southwestern corner of the state. The entire state of Virginia is at risk to high winds. There may be areas where more than one hazard overlaps with these high wind zones (i.e., seismic or earthquake zones) causing a location to be at double the risk or "double jeopardy".

Figure 3-130 - Wind Zones within the United States[lxxvi]



The NRI includes a Risk Index Rating for Strong Wind that is summarized in Table 3-100. The data indicate that the most vulnerable jurisdiction in the Commonwealth for strong winds is the City of Roanoke.

Table 3-100 - Communities With Highest Risk Index Ratings for Strong Winds

Locality	NRI Risk Index Rating
City of Roanoke	Relatively High
Danville	Relatively Moderate
Bristol	
Lynchburg	
Martinsville	
Henry County	
Richmond	
Petersburg	
Halifax County	
Lee County	
Norton	
Charlottesville	
Winchester	
Harrisonburg	
Staunton	
Shenandoah County	
Page County	

Source: NRI

Strong winds can occur anywhere, thus the entire building stock, population and agriculture value of Virginia is exposed and at risk to strong wind. NRI background information indicates that more than 1% of economic loss due to strong wind has historically been attributed to agriculture impacts. Higher risk communities have a strong density of development, historic losses from derechos, strong winds and straight-line winds, and agricultural assets. Above-ground utilities could expect impacts and transportation assets in affected areas would be impacted by downed trees and debris. Older structures are at higher risk than newer structures due to the use of building codes to protect structures against high winds. The average age of the housing stock in Virginia is 40 years. Of the approximately 3.3 million homes in the Commonwealth, slightly more than 1 million were built prior to 1970; almost 119,000 were constructed prior to 1919.

Risk

The risk associated with non-tornadic wind in Virginia has not been formally quantified, due to the difficulty in assessing the rate of incidence, and the lack of complete data on impacts. Non-tornadic winds can typically occur in every part of the state. Risk should be considered uniform across the Commonwealth.

For the 2023 plan, the overall hazard ranking for non-tornadic wind is medium-high.

3.8.12.5 State Facility Risk

Non-tornadic winds could impact state facilities in a variety of ways. Structures are subject to damage from roof and window blowouts, which can cause additional damage to a structure's interior and contents. Wind-blown debris could cause damage to all state facilities, even state-owned vehicles. Park facilities may experience damage from debris, downed trees, damage to habitat and damage to trails, structures, farms and exhibits. State-owned farms are also subject to damage from non-tornadic winds, although as with drought, the wind is most likely to cause damage to crop output rather than structures. Roads and bridges may be shut down due to downed trees, and debris could cause limited damage to road surfaces or bridge components.

Older structures are more likely to experience wind damage than newer structures because of the requirement that newer structures be designed according to standards in the Virginia USBC. Only 7,023 of the state's 11,068 structures (63%) in the Virginia Department of General Services database contain a date of original construction, and many of those dates appear to be incorrect placeholders. Analysis of the dated structures indicates that 3,075 state assets were constructed prior to 1970, thus putting them at higher risk of damage from high winds. Many of the oldest facilities are associated with historic properties, colleges and universities, and state parks. The database that includes construction dates does not include valuation, so the asses value of these properties is undetermined at this time.

The NRI highest risk rating is for the City of Roanoke. State-owned assets in the City of Roanoke are summarized in Table 3-101.

Table 3-101 - State-owned assets in the City of Roanoke at risk of Non-Tornadic Wind

Agency	Asset Value
DEQ – Air Monitoring Shed	$2,900
Veterans Services – Veterans Care Center, 3 buildings	$20,347,500
Roanoke Higher Education Center, 2 buildings	$47,956,700
Virginia Tech – Roanoke City Office, School of Medicine, Biomedical Research Expansion	$179,491,100

Future Conditions

Higher air temperature and moisture associated with climate change increase the risk of extreme convection which in turn increases the risk of severe thunderstorm conditions. Climate models consistently project environmental changes that would result in increased frequency and intensity of severe thunderstorms. However, confidence in the exact details of this projected increase is low due to data gaps.

Jurisdictional Risk

3.8.12.6 Local Plan Risk Assessment

Five of the 20 local hazard mitigation plans considered non-tornadic winds, while 13 plans evaluated severe winds. There were two incidences of local plans including both hazards, but the remaining plans addressed only one or neither. A clear distinction between these two classifications of wind was not readily available. The local plans generally did not provide loss estimates for this hazard. Some plans provided narrative descriptions of the vulnerability and impact on their residents. For example, the LENOWISCO Planning District plan identified vulnerability by determining the percentage of the population residing in mobile homes or in homes built before 1939. The West Piedmont PDC and the Richmond Crater plans used Hazus to estimate building damage from hurricane and other severe winds and the estimated annualized losses.

3.8.12.7 Local Plan Comparison

Overall, 16 out of the 20 the local and regional plans ranked non-rotational wind and/or "severe-wind". Out of the 16 that provided a ranking, 4 ranked non-tornadic wind as a high hazard, 8 ranked severe wind as a high hazard, 1 ranked non-tornadic wind as medium hazard and 5 ranked severe winds a medium hazard. The overall hazard ranking for non-rotational and severe wind for the 16 local and regional plans was high. As stated earlier in the section, the 2023 HMP ranked non-tornadic wind as a medium-high hazard.

3.8.12.8 Changes in Development

Most 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. Some plans note that the impact and damages from non-rotational or severe winds can be reduced with proper planning, including building design and codes (see for example the George Washington Regional Commission and the Richmond Crater plans). However, the specifics of such mitigations are not addressed in the plans. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Some of the coastal communities discussed development of residential structures in high hazard areas and the need to evaluate engineering practices before development or elevation occurs.

Community Lifelines Impacted by Non-Tornadic Wind

Based on the hazard analysis and description of vulnerability and impacts of non-tornadic wind in Virginia, non-tornadic wind impacts the following community lifelines:

- Food, Water, Shelter
- Energy
- Communications
- Transportation

3.8.13 Pandemic

3.8.13.1 Background

A pandemic is a widespread occurrence of an illness caused by an infectious agent or its toxic products that develops when the agent or its product is transmitted from an infected person, animal, or arthropod to a susceptible host. Infectious agents include viruses, bacteria, fungi, parasites, or aberrant proteins called prions. The infectious agent might spread by one of several mechanisms, including contact with the infected individual or his or her body fluids, contact with contaminated items or a vector, or contact with droplets or aerosols. An infection, which is the actual spread of the infectious agent or its toxic product, is not synonymous with disease because an infection may not lead to the development of clinical signs or symptoms.

The term "infectious" describes the ability of an organism to enter, survive and multiply in the host, while the infectiousness of a disease indicates the comparative ease with which the disease is transmitted to other hosts. An infection, however, is not synonymous with an infectious disease, as an infection may not cause important clinical symptoms or impair host function[1].

The potential impact of pandemic is often recognized to be very high following any natural disaster. Pandemic associated with natural disasters include water-borne diseases such as diarrheal diseases, Hepatitis A and E, and vector-borne diseases as such West Nile Virus and Dengue. Increases in endemic diseases and the risk of outbreaks, however, are dependent upon many factors that must be systematically evaluated with a comprehensive risk assessment in real-time. This allows the prioritization of interventions to reduce the impact of pandemics post-disaster. Rapid detection of cases of epidemic-prone diseases is essential to ensure rapid control. The Virginia Department of Health has a surveillance/early warning system established to quickly detect outbreaks and monitor priority epidemic diseases.

Zika virus, pandemic influenza, Ebola, Middle East Respiratory Syndrome (MERS), tuberculosis, hepatitis A, and pertussis (also known as whooping cough) are examples of infectious diseases that can or have led to pandemic that can affect humans. For domestic and farm animals in Virginia, there are also several communicable illnesses that could impact animal populations; examples include Eastern Equine Encephalitis (EEE), avian influenza, and rabies[2].

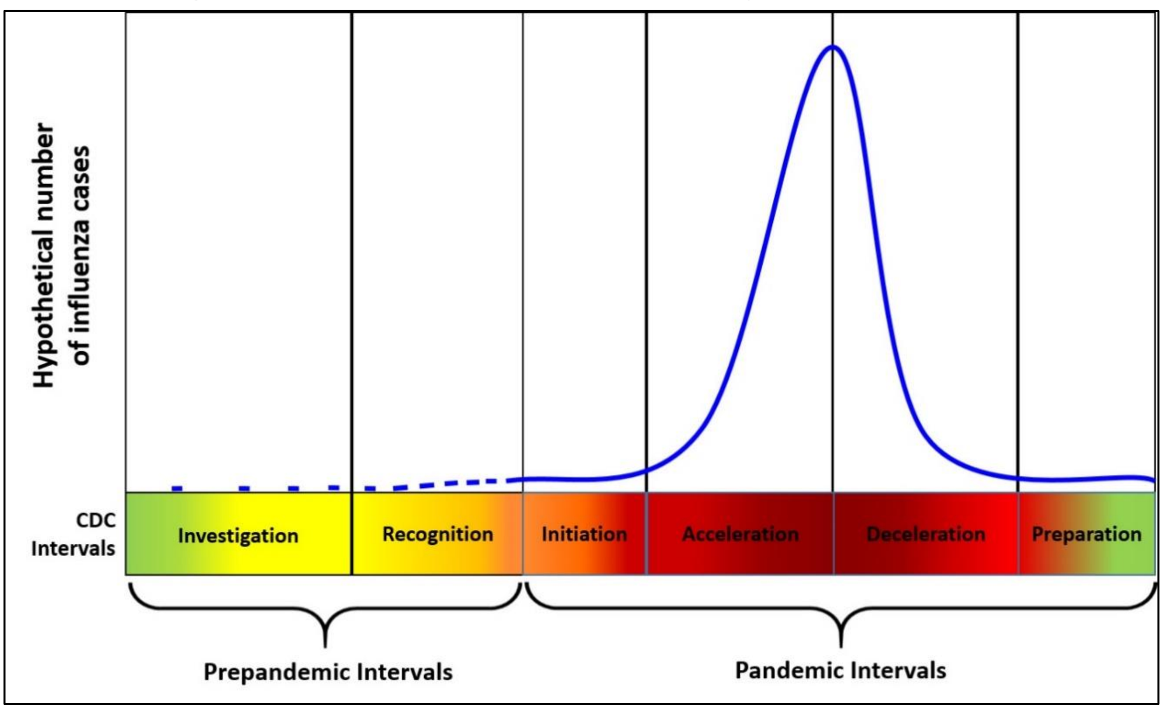
An influenza pandemic is an epidemic of an influenza virus that spreads on a worldwide scale and infects a large proportion of the human population. In contrast to the regular seasonal epidemics of influenza, these pandemics occur irregularly. Pandemics can cause high levels of mortality.

The Centers for Disease Control and Prevention (CDC) uses a Pandemic Intervals Framework to describe the progression of an influenza pandemic, as shown in Table 3-102. This framework is used to guide influenza pandemic planning and provides recommendations for risk assessment, decision-making, and action in the US. These intervals provide a common method to describe pandemic activity which can inform public health actions. The duration of each pandemic interval might vary depending on the characteristics of the virus and the public health response (Figure 3-131).

Table 3-102 - CDC pandemic intervals framework[lxxvii]

Interval	Description
1) Investigation of cases of novel influenza A virus infection in humans	When novel influenza A viruses are identified in people, public health actions focus on targeted monitoring and investigation. This can trigger a risk assessment of that virus
2) Recognition of increased potential for ongoing transmission of a novel influenza A virus	When increasing numbers of human cases of novel influenza, an illness is identified and the virus has the potential to spread from person-to-person, public health actions focus on control of the outbreak, including treatment of sick persons.
3) Initiation of a pandemic wave	A pandemic occurs when people are easily infected with a novel influenza A virus that can spread in a sustained manner from person-to-person.
4) Acceleration of a pandemic wave	The acceleration (or "speeding up") is the upward epidemiological curve as the new virus infects susceptible people. Public health actions at this time may focus on the use of appropriate non-pharmaceutical interventions in the community (e.g., school, and child-care facility closures, social distancing), as well the use of medications (e.g., antivirals) and vaccines, if available. These actions combined can reduce the spread of the disease and prevent illness or death.
5) Deceleration of a pandemic wave	The deceleration (or "slowing down") happens when pandemic influenza cases consistently decrease in the US. Public health actions include continued vaccination, monitoring of pandemic influenza A virus circulation and illness, and reducing the use of non-pharmaceutical interventions in the community (e.g., school closures).
6) Preparation for future pandemic waves	When pandemic influenza has subsided, public health actions include continued monitoring of pandemic influenza A virus activity and preparing for potential additional waves of infection. It is possible that a 2nd pandemic wave could have higher severity than the initial wave. An influenza pandemic is declared ended when enough data shows that the influenza virus, worldwide, is similar to a seasonal influenza virus in how it spreads and the severity of the illness it can cause.

Figure 3-131 - A graphical illustration of the intervals for a hypothetical virus pandemic.



Source: CDC 2021, accessed online at: https://www.cdc.gov/flu/pandemic-resources/national-strategy/intervals-framework.html

3.8.13.2 Location and Spatial Extent

A pandemic is characterized by human-to-human spread of the virus over a very wide area, crossing international boundaries and affecting many people. While many countries may not be affected early on in a pandemic, the CDC collaborates with the World Health Organization (WHO) and other international agencies to monitor and assess influenza viruses and illness. These organizations send strong signals to the public when research indicates a pandemic is imminent in their country, region, state, or locality, and that the time to finalize the communication and implementation of planned mitigation measures is short.

Previous pandemics have been characterized by waves of activity spread over months and separated by oceans. Once the level of disease activity drops, a critical communications task is balancing this information with the possibility of another wave. Pandemic waves can be separated by months and an immediate "at-ease" signal may be premature. Pandemic waves can also be specific to a country or a subregion or state within a country, making local messaging a critical component in controlling the spread of the virus.

In the modern global economy characterized by international trade and shipping, business and leisure travel to other countries can help spread an early-phase pandemic across the globe far more quickly than in past centuries. While quarantines and travel restrictions may help restrict the spread in later intervals, the damage wrought by virus carriers early on is irreversible.

3.8.13.3 Significant Historical Events

Pre-colonial Virginia was very familiar with illness and death. Typhoid fever and dysentery killed at least 30-percent of the non-Native residents of Jamestown, and lead to the abandonment of the settlement in 1624. Later settlers also fell victim to an array of communicable and infectious diseases, many caused by famine or vitamin deficiencies, and others caused by pathogens previously unknown to Europeans. Historical records link thousands of early colonial deaths to dysentery, typhoid fever, and amebiasis caused by Endamoeba histolytica[3]. Flu pandemics have occurred throughout history. There have been about three influenza pandemics in each century for the last 300 years. Since 1918, five significant events stand out, each with different characteristics, as shown in Table 3-103.

Table 3-103 - Significant Disease Occurrences

Year	Description
1918 – 1919	H1N1 Pandemic: Illness from the 1918 flu pandemic came on quickly. Some people felt fine in the morning but died by nightfall. People who caught the flu but did not die from it often died from complications caused by bacteria, such as pneumonia. Approximately 20% to 40% of the worldwide population became ill, and an estimated 50 million people died, including early 675,000 people in the US. Unlike earlier pandemics and seasonal flu outbreaks, the 1918 pandemic flu saw high mortality rates among healthy adults. In fact, the illness and mortality rates were highest among adults 20 to 50 years old. The reasons for this remain unknown.
1957 – 1958	H2N2 Pandemic: In February 1957, a new flu virus was identified in the Far East. Immunity to this strain was rare in people younger than 65. A pandemic was predicted. To prepare, health officials closely monitored flu outbreaks. Vaccine production began in late May 1957 and was available in limited supply by August 1957. In the summer of 1957, the virus came to the US quietly with a series of small outbreaks. When children returned to school in the fall, they spread the disease in classrooms and brought it home to their families. Infection rates peaked among school children, young adults, and pregnant women in October 1957. By December 1957, the worst seemed to be over. However, a dangerous “second wave” of illness came in January and February of 1958. Most influenza–and pneumonia–related deaths occurred between September 1957 and March 1958. Although the 1957 pandemic was not as devastating as the 1918 pandemic, about 69,800 people in the US died. The elderly had the highest rates of death.

Year	Description
1968 – 1969	H3N2 Pandemic: In early 1968, a new flu virus was detected in Hong Kong. The first cases in the US were detected as early as September 1968. Illness was not widespread in the US until December 1968. Deaths from this virus peaked in December 1968 and January 1969. Those over the age of 65 were most likely to die. The number of deaths between September 1968 and March 1969 was 33,800, making it the mildest flu pandemic in the 20th century. The same virus returned in 1970 and 1972. The virus was similar in some ways to the 1957 pandemic flu virus, which might have provided some immunity. Additionally, the virus hit in December of 1968, when school children were on vacation. This caused a decline in flu cases because children were not at school to infect one another or spread into their homes. Lastly, improved medical care and antibiotics that are more effective for secondary bacterial infections were available for those who became ill.
2009 – 2010	H1N1 Pandemic: In the spring of 2009, a new flu virus spread quickly across the US and the world. The first US case of H1N1 (swine flu) was diagnosed on April 15, 2009. By April 21, the CDC was working to develop a vaccine for this new virus. On April 26, the US government declared H1N1 a public health emergency. By June, 18,000 cases of H1N1 had been reported in the US. A total of 74 countries were affected by the pandemic. H1N1 vaccine supply was limited in the beginning. People at the highest risk of complications got the vaccine first. By November 2009, 48 states had reported cases of H1N1, mostly in young people. That same month, over 61 million vaccine doses were ready. Reports of flu activity began to decline in parts of the country, which gave the medical community a chance to vaccinate more people. An estimated 80 million people were vaccinated against H1N1, which minimized the impact of the illness. The CDC estimates that 43 million to 89 million people had H1N1 between April 2009 and April 2010. They estimate between 8,870 and 18,300 H1N1 related deaths. On August 10, 2010, the WHO declared an end to the global H1N1 flu pandemic.
2012	From April to June 2012, a multi-state outbreak of *E. coli* impacted 18 people in nine states, including Virginia. Most of the ill were in Louisiana, but one confirmed case occurred in Virginia. The outbreak suspected to be linked to contaminated commercial food, but no source was identified before the outbreak ended.[9]
2013	*Cyclospora cayetanensis* is a parasite that causes an intestinal infection in humans called cyclosporiasis. In 2013, a total of 631 people in the US becameill, most in June and July of that year. Four cases were identified in Virginia. The outbreak was eventually traced to multiple sources and suppliers.[8]
2014	35 sentinel chickens tested positive for EEE in the Hampton Roads area in 2013, down from 40 that tested positive in 2012. One horse in the central region was infected and euthanized.[7]
2015	In 2015, three EEE-infected horses were reported in the eastern region and one West Nile Virus (WNV) infected horse was reported in the northern region. Testing of sentinel chickens revealed 21 WNV-positive chickens in the Chesapeake, Norfolk, Suffolk, and Virginia Beach area, and 19 EEE-positive chickens in the Chesapeake, Norfolk, Suffolk, and Virginia Beach area.[6]
2016	In 2016, the Virginia Department of Health investigated a statewide outbreak of hepatitis A caused by widespread distribution of a commercial food product that was contaminated with the hepatitis A virus (HAV). A total of 110 Virginia residents infected with HAV were linked to the outbreak, with illness onsets occurring from May to October 2016. Approximately 35% of patients were hospitalized and no deaths were reported. Adults were more commonly affected, with patients ranging in age from 14-70 years (median 36); only 20% of persons affected were 19 years or younger. The product that was contaminated was imported frozen strawberries, which were used in smoothies. Of patients who could recall the type of smoothie consumed (n=96), 100% reported drinking a smoothie containing frozen strawberries. FDA testing identified the virus in the strawberries, which had been imported from Egypt.[5]
2016	Prior to December 2015, there were no documented cases of Zika virus disease in Virginia. As of February 2017, there were 114 confirmed cases of Zika virus disease in Virginia. Half of these cases were in the Northern Health Planning Region; 17% were in the Northwest Region, 15% were in the Central Region, 10% were in the Southwest Region, and the remaining 9% were in the Eastern Region.[4]
2020 - 2022	SARS-CoV-2 or COVID-19 Pandemic: In early 2020, a novel, infectious respiratory disease began to spread worldwide and eventually impacted all aspects of life throughout the world for over a year. Scientists determined that COVID-19 spread by droplets or aerosols from the nose and mouth when an infected person coughed, sneezed or exhaled. Infected people were able to spread the disease before having symptoms or feeling sick, and asymptomatic people could also spread the disease without ever exhibiting a single symptom. Several variants circulated globally as the virus mutated over time. In the case of COVID-19, the variants were determined at times to be more contagious than others.

Agriculture, including livestock, is the largest industry in Virginia, generating an economic impact of $52 billion annually. Many Virginia commodities and products rank in the top 15 among the states, including leaf tobacco (3rd), tomatoes (5th), apples (6th), grapes and peanuts (8th), and cotton (15th). Virginia ranks 6th in the nation for turkeys and 10th for broiler chickens.[11] Virginia has low-level outbreaks of vector-borne diseases regularly. Mosquito-borne illnesses, such as Eastern Equine Encephalitis (EEE) and West Nile Virus (WNV) occur regularly, and the state's surveillance, detection, and reporting systems are effective at containing cases before they spread.

In 1983 and 2002, outbreaks of low pathogenic avian influenza occurred in Virginia. As detailed in a 2006 report from the Virginia Department of Environmental Quality:

In 1983 an avian influenza outbreak cost Virginia poultry farmers and industry $40 million, resulting in the disposal of 5,700 tons of poultry carcass material. Approximately 88% of the material was disposed of on site in burial trenches, and the remaining 655 tons of carcass were disposed of in a local sanitary landfill (McClaskey, 2004). The cost of on-site burial and landfill was $25 per ton or $142,000. Concerns about contaminated groundwater from these sites and the discovery, during the excavation of a school building site in the late 1990s, of relatively intact poultry carcasses buried for more than 15 years affected future decisions and responses.

Eighteen years later the poultry industry in the central Shenandoah Valley was affected by an even larger avian influenza outbreak, costing the industry an estimated $130 million. At the time of the outbreak in 2002, more than 56 million commercial turkeys and chickens were being grown on over 1,000 poultry farms. On March 12, low pathogenic avian influenza was confirmed in a turkey breeder flock near Penn Laird, Virginia. One month later more than 60 flocks tested positive. A total of 197 farms were infected, and 4.7 million birds were destroyed to eradicate the virus. Turkeys accounted for 78% of the positive farms and bird losses.[12]

3.8.13.4 Probability of Future Occurrence

Based on historical experience and the fact that at the time of this planning process an ongoing pandemic threatens public health, the Commonwealth of Virginia is expected to experience waves of pandemic flu and communicable disease outbreak in the future.

The future incidence of pandemic - either human or animal - is highly unpredictable, which makes it difficult to assess the probability of a future occurrence. Unlike other hazards, near-term conditions cannot reliably be extrapolated from past trends. Infectious agents that can cause pandemics are constantly transmitted across Virginia, thus the real challenge is to assess the timing, location, and severity of the outbreak. Improvements in medical technology are constantly altering the impacts of pandemics, as well.

No sources of information on long-term historic frequency of pandemics or future probability of pandemics were identified for inclusion in this plan. As a result, while the future probability of some type of pandemic outbreak may be estimated at 100%, the exact severity and timing of future outbreaks cannot be quantified at this time.

Impact and Vulnerability

Virginia has extensive livestock operations throughout the state, many of which are subject to disease outbreaks. As of 2016, broilers accounted for $918 million in farm cash receipts in Virginia. Cattle/calves accounted for $714 million in farm cash receipts, and turkeys accounted for $326 million. Milk accounted for $478 million in cash receipts; all other animals (including horses, aquaculture, and other livestock) accounted for $216 million.[14] All told, livestock and animal products account for more than 11-percent of Virginia's $52 billion agriculture industry.

There are more than eight million people that reside in Virginia, and all are at risk of exposure to a pandemic or disease. The VDH collects reports on certain categories of disease and publishes this information in annual reports. Table 3-104 provides a snapshot of this information, by the most populated jurisdictions in the state (as of the 2020 Census estimate).

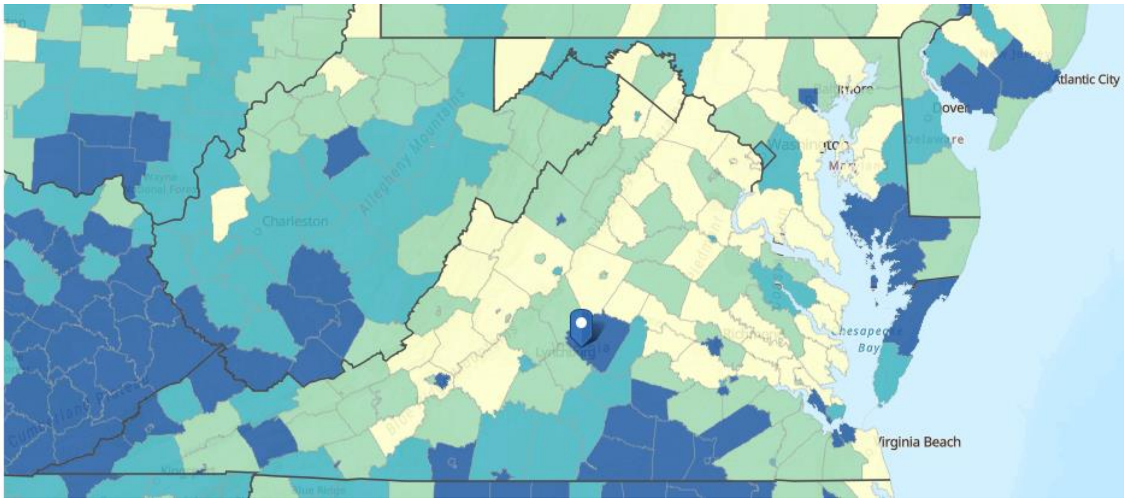
Table 3-104 - Communicable Disease Cases Reported for Virginia's Most Populated Jurisdictions

Jurisdiction / Population	Illness	Cases reported – 2012	Cases reported – 2013	Cases reported – 2014	Cases reported – 2015	4-Year Average
Fairfax County 1,142,234	Hepatitis A	14	8	6	12	10
	Tuberculosis	92	59	58	66	69
	Pertussis	55	33	46	25	40
Virginia Beach 452,745	Hepatitis A	1	0	0	1	>1
	Tuberculosis	8	7	10	13	10
	Pertussis	34	40	19	7	25
Prince William County 451,721	Hepatitis A	3	4	4	1	3
	Tuberculosis	16	13	14	26	17
	Pertussis	34	15	25	8	201
Loudoun County 375,629	Hepatitis A	3	1	1	4	2
	Tuberculosis	15	7	10	10	11
	Pertussis	19	18	25	20	21
Chesterfield County 335,687	Hepatitis A	1	1	1	5	2
	Tuberculosis	5	5	0	3	3
	Pertussis	12	3	10	6	8

Short-term or contained outbreaks can be devastating for the people affected by them, but are unlikely to have significant, long-term impacts on the rest of the population or the state's economy. Long-term or uncontained outbreaks may have more impacts, as people may be unable to report to work for extended periods of time, either because they are sick or because they have been exposed to someone who is and are therefore quarantined. Tourism may also be impacted, as visitors are unwilling to travel to areas experiencing outbreaks. The COVID-19 pandemic highlighted the economic impacts in early 2020 as much of the state's economy shutdown to control the spread of the pandemic.

The CDC recognizes, however, that while an entire population may have some level of exposure risk, some populations need additional support before, during and after a pandemic. In order to help communities better prepare for and respond to disease outbreaks and other hazards, the agency developed their own social vulnerability index. Based on the 2018 CDC tool, the counties with the highest overall social vulnerability are shown in dark blue in Figure 3-142.

Figure 3-132 - CDC Social Vulnerability Map – Pandemic Exposure in Virginia by Jurisdiction



Risk

For the 2023 plan update, the overall hazard ranking for pandemic is medium-low. Potential detrimental impacts associated with the hazard are included in Table 3-105.

Table 3-105 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Local emergency services can be severely impacted if a significant number of first responders for the area are compromised or unable to work.
Health and Safety of Response Personnel	Local emergency services can be severely impacted if a significant number of first responders for the area are compromised or unable to work. High probability of illness in affected population; potential exists for fatalities depending on severity and duration of illness; children and elderly immune suppressed most vulnerable.
Continuity of Operations	Continuity of Operations Plans may be activated if a significant number of staff or leadership is unable to report to work due to illness.
Property, Facilities, and Infrastructure	Limited or no impacts for the built environment.
Delivery of Services	Local services can be severely impacted if a significant number of staff for the area are compromised or unable to work.
The Environment	Limited or no impacts for the environment. Diseases that cause widespread deaths of animals, both captive and wild, or widespread deaths of human would influence the environment in terms of disposal of the carcasses and disposal of human remains and the handling of bio-hazardous waste
Economic and Financial Condition	Local economy could face moderate impacts for the duration of the event, dependent on the number of people unable to work and businesses unable to open.
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.

3.8.13.5 State Facility Risk

Risk associated with communicable disease has not been quantified in terms of geographic extent for this revision; thus, state facility risk has not been calculated. Generally, communicable disease related damages do not impact infrastructure; however, state facilities that house large numbers of people (correctional facilities, mental health institutions, etc.) have additional risk as a result of their operations.

3.8.13.6 Critical Facility Risk

Risk associated with communicable disease has not been quantified in terms of geographic extent; thus, critical facility risk has not been calculated. Generally, communicable disease related damages do not impact infrastructure; however, as experienced during the COVID-19 pandemic, the nature of the disease may impact continuity of operations for infrastructure. According to VDEM, nuclear power plants and other essential services were impacted by reduction in available personnel due to the highly transmissible nature of COVID-19 and finding staff to perform tasks and avoid infection had associated costs.

Future Conditions

Weather and climate have significant effects on both human and animal health. With changes in climate, the frequency, severity, duration, and location of weather and climate phenomena, changes should be expected, such as rising temperatures, heavy rains, and droughts. Changes in weather and climate can affect health by changing the severity and/or frequency of health problems, and by creating unanticipated or unforeseen health problems or threats that have not previously existed.

Many diseases are vector-borne, usually transmitted by mosquitoes, ticks, and fleas. Vectors can transmit an array of pathogens, such as viruses, bacteria, and protozoa, which can cause illness in humans (or humans and animals). The seasonality and prevalence, as well as distribution patterns, of vector-borne illnesses are influenced by climate factors, such as temperature and humidity. It is anticipated that changes in climate may have both short-term and long-term effects on both vector-borne disease transmissions and infection patterns. This will affect seasonal risk and possibly lead to broad geographic changes in disease patterns over time. Because of the number of factors involved in predicting how changes in climate may impact communicable disease transmission, it is difficult to predict how climate change will impact vector-borne illness transmission. In addition, it is possible that changes in climate may allow or encourage the emergence of new or significantly altered illnesses.[15]

Jurisdictional Risk

The hazard ranking for pandemic is based primarily on the population count and population density for each jurisdiction. No geographic extent data were available for probability estimation; each jurisdiction was assigned a value of low (1) for ranking purposes. Property and crop damages were ranked as low for this hazard, as the hazard is unlikely to impact property and crops. Injuries and fatalities and events were estimated as medium (3) for all jurisdictions, to account for each jurisdiction’s susceptibility to pandemic.

3.8.13.7 Local Plan Risk Assessment

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, and loss estimations. When available, this information supplements the text and figures of each of the sections in this revision. Five of the 20 local plans included pandemic as a hazard but none provided loss estimates for this hazard.

3.8.13.8 Local Plan Comparison

Of the 20 local hazard mitigation plans, six considered pandemic/communicable disease/infection in their document; see Table 3-106. It was a high hazard for Accomack-Northampton PDC and the Middle Peninsula PDC and a low hazard for Richmond Regional and Crater PDCs, Hampton Roads PDC, Northern Neck PDC, and Central Virginia PDC. The overall hazard ranking for pandemic for the 6 local and regional plans was medium. As stated above, the 2023 HMP ranked pandemic as a medium-low hazard.

3.8.13.9 Changes in Development

Development patterns have little influence on risk beyond the factors that influence social vulnerability, such as access to transportation. Pandemics do not generally impact infrastructure and buildings, although economic impacts that transfer to the real estate industry could conceivably impact available land and development patterns in the aftermath of a pandemic.

Table 3-106 - Pandemic Hazard Ranking Parameters and Risk

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Albemarle	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Alexandria, City of	Medium-High	High	Medium	Low	Low	Medium	Low	Medium
Alleghany	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Amelia	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Amherst	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Appomattox	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Arlington	High	High	Medium	Low	Low	Medium	Low	Medium
Augusta	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Bath	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Bedford	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Bland	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Botetourt	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Bristol, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Brunswick	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Buchanan	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Buckingham	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Buena Vista, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Campbell	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Caroline	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Carroll	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Charles City	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Charlotte	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Charlottesville, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium
Chesapeake, City of	High	Medium-High	Medium	Low	Low	Medium	Low	Medium
Chesterfield	High	Medium-High	Medium	Low	Low	Medium	Low	Medium
Clarke	Low	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Colonial Heights, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low
Covington, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Craig	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Culpeper	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Cumberland	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Danville, City of	Medium	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Dickinson	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Dinwiddie	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Emporia	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Essex	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Fairfax	High	High	Medium	Low	Low	Medium	Low	Medium
Fairfax, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low
Falls Church, City of	Low	High	Medium	Low	Low	Medium	Low	Medium-Low
Fauquier	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Floyd	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Fluvanna	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Franklin	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Franklin, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Frederick	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Fredericksburg, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low
Galax, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Giles	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Gloucester	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Goochland	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Grayson	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Greene	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Greensville	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Halifax	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Hampton, City of	Medium-High	High	Medium	Low	Low	Medium	Low	Medium
Hanover	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Harrisonburg, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low
Henrico	High	Medium-High	Medium	Low	Low	Medium	Low	Medium
Henry	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Highland	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Hopewell, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Isle of Wight	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
James City	Medium-High	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
King and Queen	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
King George	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
King William	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Lancaster	Low	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Lee	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Lexington, City of	Low	High	Medium	Low	Low	Medium	Low	Medium-Low
Loudoun	High	Medium-High	Medium	Low	Low	Medium	Low	Medium
Louisa	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Lunenburg	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Lynchburg, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Madison	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Manassas, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low
Manassas Park, City of	Low	High	Medium	Low	Low	Medium	Low	Medium-Low
Martinsville, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Mathews	Low	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Mecklenburg	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Middlesex	Low	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Montgomery	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Nelson	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
New Kent	Low	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Newport News, City of	High	High	Medium	Low	Low	Medium	Low	Medium
Norfolk, City of	High	High	Medium	Low	Low	Medium	Low	Medium
Northampton	Low	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Northumberland	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Norton	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Nottoway	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Orange	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Page	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Patrick	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Petersburg, City of	Medium	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Pittsylvania	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Poquoson	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Portsmouth, City of	Medium-High	High	Medium	Low	Low	Medium	Low	Medium
Powhatan	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Prince Edward	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Prince George	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Prince William	High	Medium-High	Medium	Low	Low	Medium	Low	Medium
Pulaski	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Radford, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Rappahannock	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Richmond	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Richmond, City of	High	High	Medium	Low	Low	Medium	Low	Medium
Roanoke	Medium-High	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Roanoke, City of	Medium-High	High	Medium	Low	Low	Medium	Low	Medium
Rockbridge	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Rockingham	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Russell	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Salem, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low
Scott	Medium	Low	Medium	Low	Low	Medium	Low	Medium-Low
Shenandoah	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Smyth	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Southampton	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Spotsylvania	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Stafford	Medium-High	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Staunton, City of	Medium	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Suffolk	Medium-High	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Surry	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Sussex	Low	Low	Medium	Low	Low	Medium	Low	Medium-Low
Tazewell	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Virginia Beach, City of	High	High	Medium	Low	Low	Medium	Low	Medium-Low
Warren	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Washington	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Waynesboro, City of	Medium	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Westmoreland	Low	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Williamsburg, City of	Low	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low
Winchester, City of	Medium	High	Medium	Low	Low	Medium	Low	Medium-Low
Wise	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
Wythe	Medium	Medium	Medium	Low	Low	Medium	Low	Medium-Low
York	Medium-High	Medium-High	Medium	Low	Low	Medium	Low	Medium-Low

Community Lifelines Impacted by Pandemic

Based on the hazard analysis and description of vulnerability and impacts of pandemics in Virginia, pandemic may impact the following community lifelines:

- Health and Medical
- Safety and Security

3.8.14 Tornado

3.8.14.1 Background

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, often accompanied by lightning or large hail. According to the NWS, tornado wind speeds normally range from 40 mph to more than 200 mph.

In the US, tornadoes are classified on the Enhanced Fujita Scale (EF-Scale), assigning numeric scores from zero to five based on the severity of observed damages. The traditional Fujita scale, introduced in 1971, was used to rate the intensity of historical tornadoes until 2007. Starting in February of 2007, the EF Scale was implemented, with somewhat lower wind speeds at the higher F-numbers, and more refined structural damage indicator definitions. Table 3-107 compares the old and new tornado intensity scales.

The most violent tornadoes (EF5) have rotating winds of 200 mph or more and can cause extreme destruction and turn normally harmless objects into deadly missiles. Tornadoes with winds greater than 75 mph begin to cause significant structural damage to most buildings, but tornadoes with lower wind speeds can also cause damage, for example, by causing a tree to fall into a house. Each year, an average of over 1,200 tornadoes is reported nationwide, resulting in an average of 80 deaths and 1,500 injuries (NOAA, 2002 and 2014). Most tornadoes are a few dozen yards wide and touch down briefly, but even small, short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve out a path over a mile wide and tens of miles long.

Waterspouts are weak tornadoes that form over warm water and are most common along the Gulf Coast and southeastern states. Waterspouts occasionally move inland, becoming tornadoes that cause damage and injury. However, most waterspouts dissipate over the open water causing threats only to marine and boating interests. Most go unreported unless they cause damage.

Table 3-107 - Operational EF Scale Classifications in Relation to F Scale[3]

Fujita Scale			Derived EF Scale		Operational EF Scale	
F #	Fastest ¼ mile (mph)	3 Second Gust (mph)	EF #	3 Second Gust (mph)	EF #	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

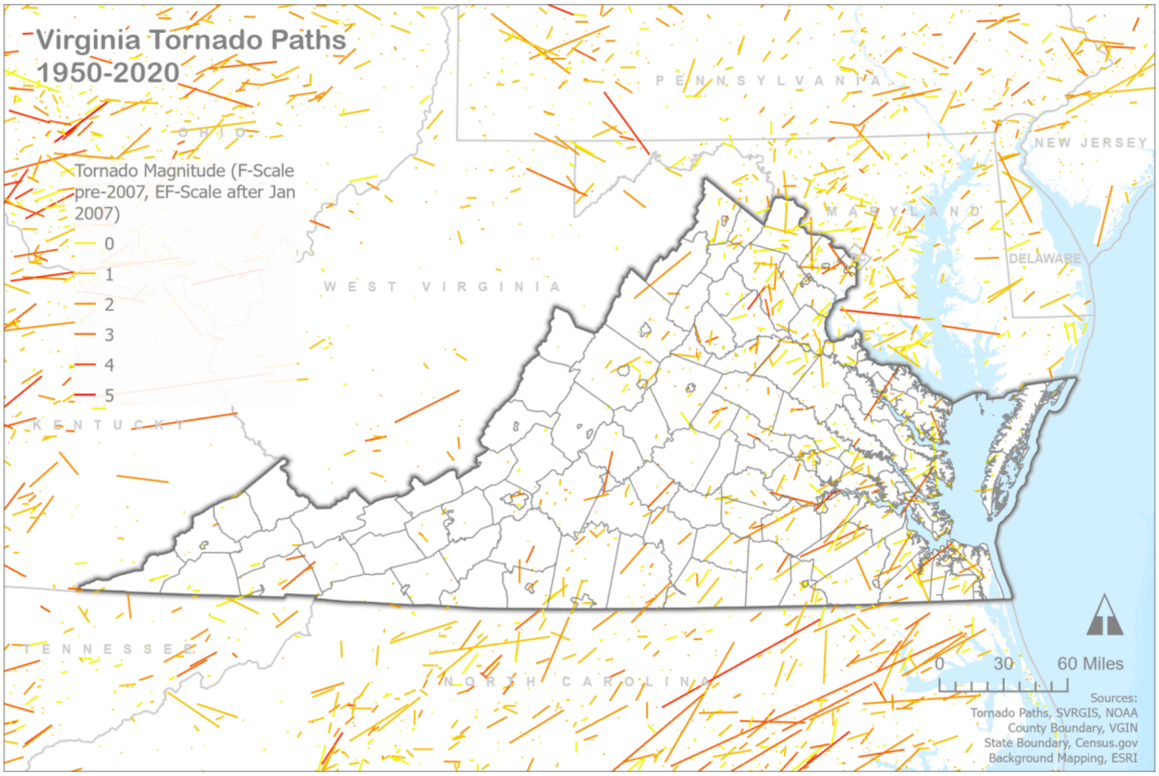
Source: NWS Storm Prediction Center

3.8.14.2 Location and Spatial Extent

In Virginia, tornadoes primarily occur from April through September, although tornadoes have been observed in every month. They are more likely to occur during the spring and early summer months of March through June and can occur at any time of day but are likely to form in the late afternoon and early evening. Tornadoes associated with tropical cyclones are somewhat more predictable. These tornadoes occur frequently in September and October when the incidence of tropical storm systems is greatest. They usually form around the perimeter of the storm, and most often to the right and ahead of the storm path or the storm center as it comes ashore. These tornadoes commonly occur as part of large outbreaks and generally move in an easterly direction.

Compared to other states, Virginia ranks 28th in terms of the number of tornado touchdowns reported between 1950 and 2020; Midwestern and southern states ranked significantly higher[1]. Low-intensity tornadoes appear to occur most frequently; tornadoes rated EF2 or higher are very rare in Virginia, although EF2, EF3, and even a few EF4 storms have occurred[2]. The combination of WSR-88D (Weather Surveillance Radar, 1988, Doppler) and increased widespread use of GPS has resulted in increased efficiency in the identification and location of tornadoes, particularly those on the weaker end of the EF scale. This change in technology must be considered when examining the historic record and the frequency of tornadoes, especially those of weaker rating. The record of tornado occurrence and path is included as Figure 3-133. Tornadoes are most likely to occur on the eastern half of Virginia.

Figure 3-133 - Summary of tornado occurrence and destruction path 1950 - 2020.



A recent article from 2019 called "Exploring Spatial Patterns of Virginia Tornadoes Using Kernal Density and Space-Time Cube Analysis (1960-2019) by Michael J. Allen, et.al.", further details the statistically significant increase in tornado activity in Virginia and its spatial dimensions. The analysis concluded that most of the 726 tornadoes between 1960–2019 occurred in Eastern Virginia, along the Piedmont and Coastal Plain. Spatial analysis results identify significant, non-random clusters of tornado activity and increasing frequency. This is important to note as it reflects an increased risk of tornado activity in Virginia.

3.8.14.3 Significant Historical Events

Numerous low-intensity tornadoes are reported almost every year in Virginia. Of the more intense tornadoes that have occurred, a few of the most significant occurrences are documented in Table 3-108, primarily from the NCEI database.

Table 3-108 - Historical tornado occurrences

Year	Description
1929	On May 2, 1929, five tornadoes were reported in southwest Virginia, killing 22 people, and injuring over 150 more. These tornadoes caused at least a half a million dollars in damages as four schools were destroyed.
1944	On March 4, 1944, what is thought to have been an F3 tornado tracked 30 miles through Lee, Wise, and Scott counties and injuring 32 people. Another tornado struck Washington County, injuring seven people, and causing approximately $500,000 in total losses.
1951	On June 13, 1951, an F3 tornado went through the City of Richmond creating a four- mile path and over one million in damages. Reports suggest that it was a multi-vortex tornado with four visible vortices.
1993	On August 6, 1993, four tornadoes were reported across southeast Virginia, ranging in intensity from F2 to F4. The F4 tornado impacted commercial and residential areas in Petersburg, Colonial Heights, and Hopewell, killing 4 people, injuring 246, and causing about $50 million in damages.
1999	On September 4, 1999, an F2 tornado caused about $7.7 million in damages in Hampton, as well as many injuries.

Year	Description
2004	On the afternoon of September 17, 2004, thunderstorms produced twelve tornadoes across the state, causing over $65 million in damages, with $54 million of the damages occurring at a factory in Fieldale.
2008	On April 28, 2008, an F3 tornado traveled from north of Suffolk to the Norfolk Naval Air Station, causing a total of $30 million in commercial and residential damage, with at least a dozen homes destroyed.
2008	On May 8, 2008, an EF2 tornado caused $10 million in damages in Berea (North of Fredericksburg); 160 homes damaged, with 25 rendered uninhabitable.
2011	On October 8, 2011, an EF2 tornado caused $3.9 million in damages in Pulaski County, resulting in 9 injuries. More than 200 homes reported having some damage with approximately 30 of those homes damaged beyond repair. On that same day, a tornado in Drapers Valley caused $1.4 million in damages.
2011	On April 16, 2011, fifteen tornadoes were reported in Virginia, ranging in intensity from an EF0 to an EF3. Of these tornadoes, 4 caused over a million dollars in property damages: Gloucester County $7.7 million, Augusta County $2.2 million, Dinwiddie County $1.5 million and Middlesex County $6 million. Because of these storms, there were 2 fatalities and 34 injuries.
2011	On April 28, 2011, twelve tornadoes were reported in Virginia, ranging in intensity from an EF0 to an EF3. Of these tornadoes, two caused over a million dollars in property damages and 5 deaths: Washington County $3 million and Smyth County $2.25 million.
2011	On October 13, 2011, eight tornadoes were reported in Virginia, ranging in intensity from an EF0 to an EF1. One of the EF1 tornadoes caused $1 million in property damages in New Kent, as this tornado damaged more than 30 homes.
2012	On March 2, 2012, an EF1 tornado caused $1.65 million in damages in Lee County of which $350,000 constitutes residential property loss, while $1.3 million is the estimated loss for agricultural property.
2016	On February 24, 2016, an EF3 tornado spanning a 16-mile stretch caused damages in Campbell and Appomattox Counties. The tornado caused seven reported injuries and one fatality.
2017	Scattered, severe thunderstorms in advance of low pressure and a cold front produced damaging winds, large hail, and two EF2 tornadoes across portions of southeast Virginia. The tornadoes resulted in approximately $7.9 million in damages.
2018	Thunderstorms ahead of the cold front became strong enough to produce six tornadoes across portions of southwest Virginia. While the first tornado originally formed in Caswell County of North Carolina and crossed into Virginia, the other five all touched down in Virginia. These tornadoes caused significant damage within the cities of Danville and Lynchburg and within the town of Elon in Amherst County. It is the first time ever since storm data records began in 1950 that a tornado struck inside the city limits of Lynchburg. The tornadoes resulted in 12 injuries and approximately $20 million in damages.
2018	Scattered severe thunderstorms associated with tropical cyclone Florence produced damaging winds and ten tornadoes across portions of central and south-central Virginia. One injury, one death, and $1 million in damages were reported.
2020	The center of Tropical Storm Isaias tracked north just inland of the Middle Atlantic Coast from late Monday night, August 3rd through Tuesday morning, August 4th. Outer bands north and east of the Tropical Storm produced seven tornadoes across portions of eastern and southeast Virginia. The tornadoes resulted in five injuries and approximately $11 million in damages.

Table 3-109 highlights the number of tornadoes between 2017 and March 31, 2022, in Virginia. Since 2017 there has been a total of 119 tornadoes resulting in $62,661,500 in property damages throughout the Commonwealth. Note in 2018 there was 1 fatality recorded.

Table 3-109 - Yearly Tornado Summary in Virginia, 2017 to March 31, 2022

Year	Number of Tornadoes	Direct Injury	Direct Fatality	Property Damage	Crop Damage
2022	3	0	0	$620,000	0
2021	11	0	0	$1,193,000	0
2020	16	5	0	$22,219,500	$100,000
2019	25	0	0	$2,208,000	0
2018	33	13	1	$26,427,000	0
2017	31	0	0	$9,994,000	$40,000

3.8.14.4 Probability of Future Occurrence

Tornado formation is a complex process; the simplest way to estimate the probability of future tornadoes is to analyze historical tornado incidence data and generate descriptive statistics, such as the frequency of occurrence. Records of historical tornadoes are maintained by the NCEI and by the NWS' Storm Prediction Center (SPC). Tornado incidence is rare, especially in Virginia, and the available historic data are insufficient to estimate tornado probability conclusively. Therefore, while the data can be used to show the geographic variation in tornado frequency, such data should not be taken as an exact determination of tornado probability.

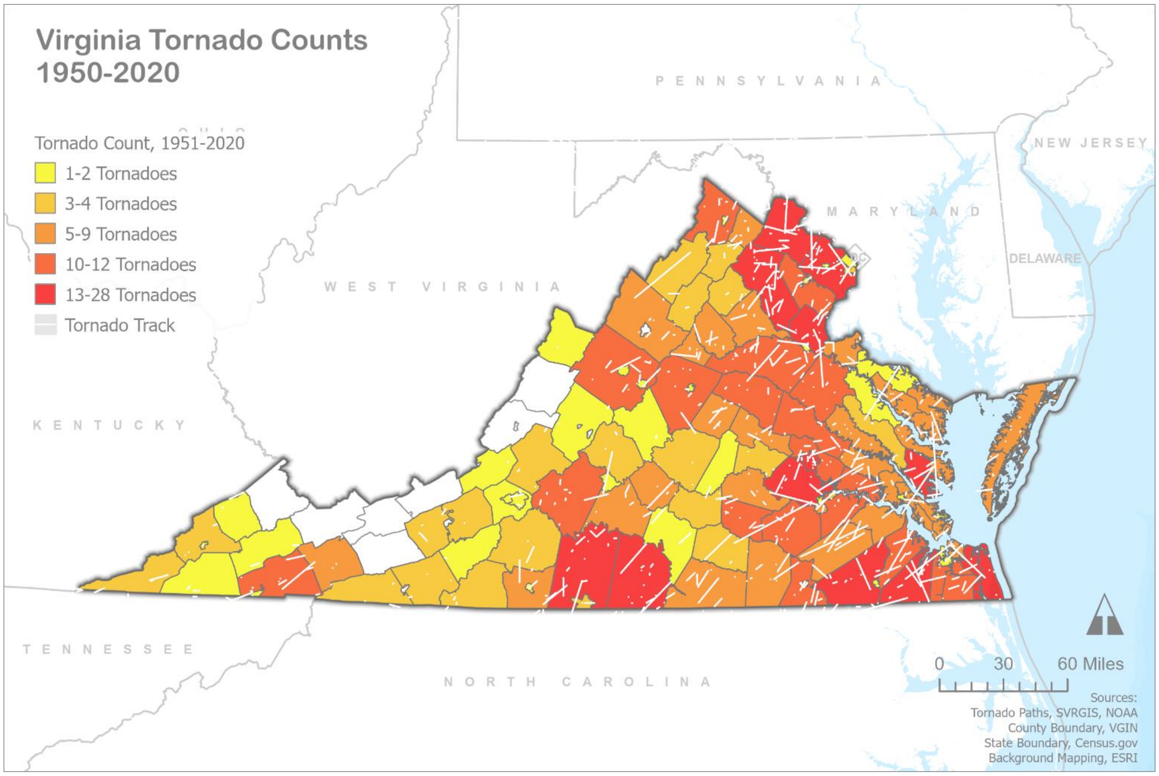
John Hart, at the NWS SPC in Norman, Oklahoma, has developed a graphical program, SeverePlot[7], to display a database of tornado occurrence that was derived from the NCEI *Storm Events Database*. This database dates from 1950 to 2006 and contains data on hail and high wind. Bryan Smith, NWS in Indianapolis, has converted the SeverePlot program data into shape files which are ready to use in GIS software; these files are collectively referred to as SVRGIS[8]. Other researchers have developed tornado databases extending further back into history, or which contain additional attributes. However, the SVRGIS dataset, based on SeverePlot data, was sufficient for this analysis.

A review of the historic tornado database is limited as reporting only goes back to 1950. Next, there are vastly higher numbers of low-intensity (EF0 and EF1) tornadoes reported in recent decades. The consensus among climatologists is not that there are more low-intensity tornadoes occurring in recent years; rather, it is that with increased population and advanced technology (such as WSR-88D, discussed earlier), more of these low-intensity tornadoes are observed and documented than were in the past. Finally, while tornadoes are reported throughout the state, there are more tornadoes reported in areas of higher population. This may be due in part to the fact that many population centers are in areas where tornadoes are likely to occur, but the correlation is probably also indicative of observation rather than absence. Conversely, the mountainous counties in the western part of the state have lower populations and, in some cases, no reported historical tornadoes; tornado occurrence is still possible, albeit less probable.

The frequency analysis conducted on the available tornado data consisted of tabulating the area impacted by tornadoes for individual counties. The tornado hazard frequency is calculated as the total number of tornadoes within the jurisdiction, divided by the number of years in the period of record.

The results of the tornado frequency analysis show a higher incidence of tornadoes in the northern and eastern parts of the state, and a lower incidence of tornadoes in the mountainous western parts of the state. These results can be seen in Figure 3-134. The average number of tornadoes in Virginia is 11.1 per year with an average intensity of 0.72, light to moderate damage. Despite concerns about biases in the historical data, the results of the probability analysis provide a possible depiction of the relative tornado risk in different regions of the state. Finally, while the overall statewide probability of tornadoes is low relative to many other states, the probability of tornadoes in Virginia should not be discounted.

Figure 3-134 - Annual Tornado Hazard Frequency



Impact and Vulnerability

Tornado vulnerability is based on building construction materials and standards, availability of safe rooms, and advanced warning system capabilities. Low-intensity tornadoes may not destroy a well-constructed building, although even the most well-constructed buildings are vulnerable to the effects of a more intense (EF2 or higher) tornado. In cases involving intense tornadoes, the best defense against injury or death is a properly engineered safe room or tornado shelter.

The net impact of a tornado depends on the storm intensity and the vulnerability of development in its path. An intensity-damage relationship for tornadoes would need to consider a variety of variables; such a relationship has not been established for Virginia. Theoretically, an intensity-damage relationship could be estimated based on an analysis of reported damages, but such an analysis was beyond the scope of this planning process. In FEMA's Benefit-Cost Toolkit, the calculations to determine whether tornado shelter construction is justified are based on injuries and fatalities prevented, not total economic loss.

The destruction caused by tornadoes ranges from light to devastating depending upon the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damages to structures of light or wood-framed construction such as residential homes (particularly mobile homes) and tend to remain localized in impact. Assigning an EF Scale rating to a tornado involves the following assessment of storm and impacts:

- Conduct an aerial and ground survey over the entire length of the damage path;
- Locate and identify damage indicators in the damage path;
- Consider the wind speeds of all damage indicators and assign an EF Scale category for the highest wind speed consistent with wind speeds from the other damage indicators;
- Record the basis for assigning an EF scale rating to a tornado event; and
- Record other pertinent data related to the tornado event.

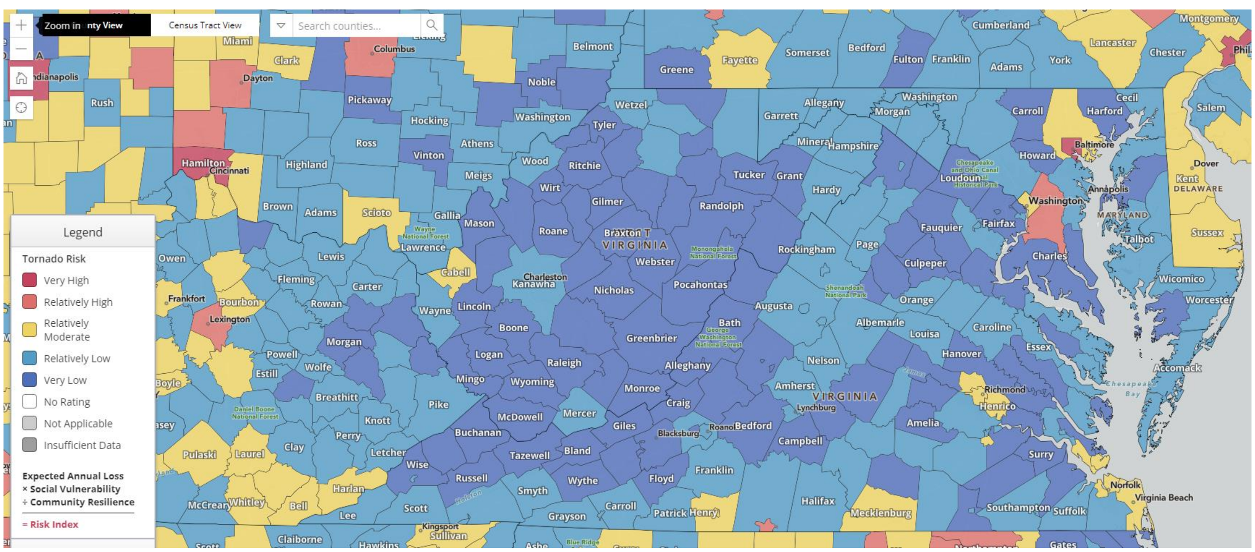
National Risk Index – Tornado

The National Risk Index (NRI) includes three components: a natural hazards component (Expected Annual Loss), a consequence enhancing component (Social Vulnerability), and a consequence reduction component (Community Resilience). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index.

For the purposes of this SHMP/HIRA update the qualitative summary for tornado are reviewed for each community (county tract).

As shown in Figure 3-135, the greatest risk is identified as relatively moderate along portions of southern Chesapeake Bay in areas like Norfolk, Virginia Beach, and Hampton. Other areas with the greatest risk further inland are Richmond, Mecklenburg, and Henry. There are no communities with Relatively High or Very High NRI tornado ratings in Virginia.

Figure 3-135 - Tornado National Risk Rating Map



As discussed previously, these measurements are calculated using average past conditions, but they cannot be used to predict future outcomes for a community. The NRI is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies.

Risk

The 2023 State HMP ranked tornado as a medium-high hazard.

Tornadoes are high-impact, low-probability hazards. A formal calculation of annualized tornado risk, as a function of probability and impact, has not been performed for this analysis. Tornado probability has been quantified in terms of historical hazard frequency, and despite concerns regarding population bias in the original reporting, the results of the tornado hazard frequency analysis provide a reasonable estimation of the relative tornado hazard probability across the state. However, tornado impact has not been quantified in the form of an intensity-damage relationship that could be used for tornado damage prediction.

Rough estimates of annualized losses due to tornadoes can be generated based on the NCEI *Storm Events Database*, which documents the damage costs associated with recorded tornadoes. In the 31 years between 1990 and 2021, NCEI reports an annualized average of approximately $13.5 million in damages per year, in 2021 dollars, as a result of tornadoes and waterspouts.

For this HIRA, tornado hazard zones were developed from the annual tornado hazard frequency results. This scoring system, as shown in Table 3-110, is used to identify facilities at risk, and to identify the jurisdictions exposed to the greatest tornado hazards.

Table 3-110 - Tornado Hazard Frequency Scores

Tornado Hazard Zone	Annual Tornado Hazard Frequency
Low	.00 - .045
Medium-Low	.045 - .106
Medium	.107 - .197
Medium-High	.198 - .288
High	.289 - .409

3.8.14.5 State Facility Risk

State facility risk was determined by intersecting the VAPS facilities with the annual tornado hazard frequency layer. Risk for building polygons was determined by taking the area weighted average for the building and assigning a risk category based on the results. Intensity-damage information due to tornadoes has not been quantified at this time; as a result, annualized loss estimates have not been calculated for state facilities.

As shown in Table 3-111 when these categories are applied to the Virginia state-owned/operated facilities database (VAPS), many facilities are identified as being in the medium-high and high tornado hazard zones. Since the more urbanized eastern portions of the state are also the areas of higher tornado hazard, these results are not unexpected.

Table 3-111 - State Facilities in Tornado Hazard Zones

Tornado Hazard Zone	Number of State Facilities
Low	5,343
Medium-Low	1,569
Medium	4,187
Medium-High	1,522
High	179
Unable to Determine	3
Total	**12,803**

The results of this analysis indicate 179 buildings are at high risk for tornadoes. Eleven different state agencies are situated within the high-risk zone. These agencies and the number of buildings are listed in Table 3-112. The buildings listed represent slightly more than one percent of the buildings owned by the state.

Table 3-112 - State Agencies with Assets in the High-Risk Zone

Agency	Number of Buildings in High Hazard
Virginia Department of Alcoholic Beverage Control	4
Virginia Department of Conservation and Recreation	23
Department of Wildlife Resources	4
Virginia Department of Motor Vehicles	6
Gunston Hall	27
George Mason University	6
Northern Virginia Community College	1
Virginia Community College System	19
Virginia Department of Transportation	49
Virginia Polytechnic Institute and State University (Virginia Tech)	39
Total	**179**

3.8.14.6 Critical Facility Risk

Critical facilities were intersected with the annual tornado hazard frequency layer to determine the corresponding risk zone. The results of this analysis are in Table 3-113. Many food service/storage, fuel storage/delivery, and hazardous materials storage facilities are identified as being in the medium-high or high tornado hazard zones. Less than one percent of critical facilities are in high tornado hazard zones. Intensity-damage information due to tornadoes has not been quantified at this time; as a result, annualized loss estimates have not been calculated for critical facilities.

Although locations were not reviewed as part of this HIRA, tornado risk to electric substations and powerlines is high due to the destructive nature of the high winds involved.

Table 3-113 - Critical Facilities in Tornado Hazard Zones

Critical Facility Use	Low Risk	Medium- Low Risk	Medium Risk	Medium-High Risk	High Risk
Airfield	0	0	2	0	0
Animal Health	0	0	9	0	0
Armory	0	6	4	4	0
Childcare	6	0	4	0	0
Communications	31	11	30	4	1
Emergency Operations Center	1	0	0	0	0
Fire Service/ Support/Suppression	12	8	12	3	0
Food Service/Storage	30	10	32	14	2
Fuel Storage/Delivery	187	102	147	68	6
Hazardous Materials Storage	141	87	140	58	3
Medical Services /Support/EMS	70	3	53	2	0
Public Safety/Security	66	32	84	19	0
Research	105	3	59	11	0
Special Populations Housing / Shelters	11	2	13	1	0
Utilities	249	81	235	75	8
Total:	**911**	**348**	**824**	**261**	**20**

3.8.14.7 Tornado Risk to Energy Pipelines

Severe wind and flying debris associated with tornadoes can affect pipelines by damaging the infrastructure that supports pipeline operations such as power and telephone and satellite communications. Some pipelines require above ground facilities for their operations, like pump stations. Wind and flying debris can damage these facilities, causing pipelines to be shutdown. In addition, severe wind events can make pipeline operation sites inaccessible, making it more difficult to repair damaged equipment and restore operations. In some cases, pipeline operators may proactively shutdown pipeline operations prior to the onset of severe weather, to mitigate potential damages; this may cause supply interruptions.

Future Conditions

Tornado activity in the US has become more variable, particularly over the 2000s, with a decrease in the number of days per year with tornadoes and an increase in the number of tornadoes on these days. Researchers are working to better understand how the fundamental elements required for tornado formation – atmospheric instability and wind shear – interact with changing climate conditions. It is likely that a warmer, wetter climate will allow for more frequent atmospheric instability. However, it is also possible that a warmer climate will dampen the probability of wind shear. Recent trends observed in the Midwest are inconclusive. It is also possible that climate change could shift the traditional timing or expected locations for tornadoes and have less impact on the total number of tornado occurrences.

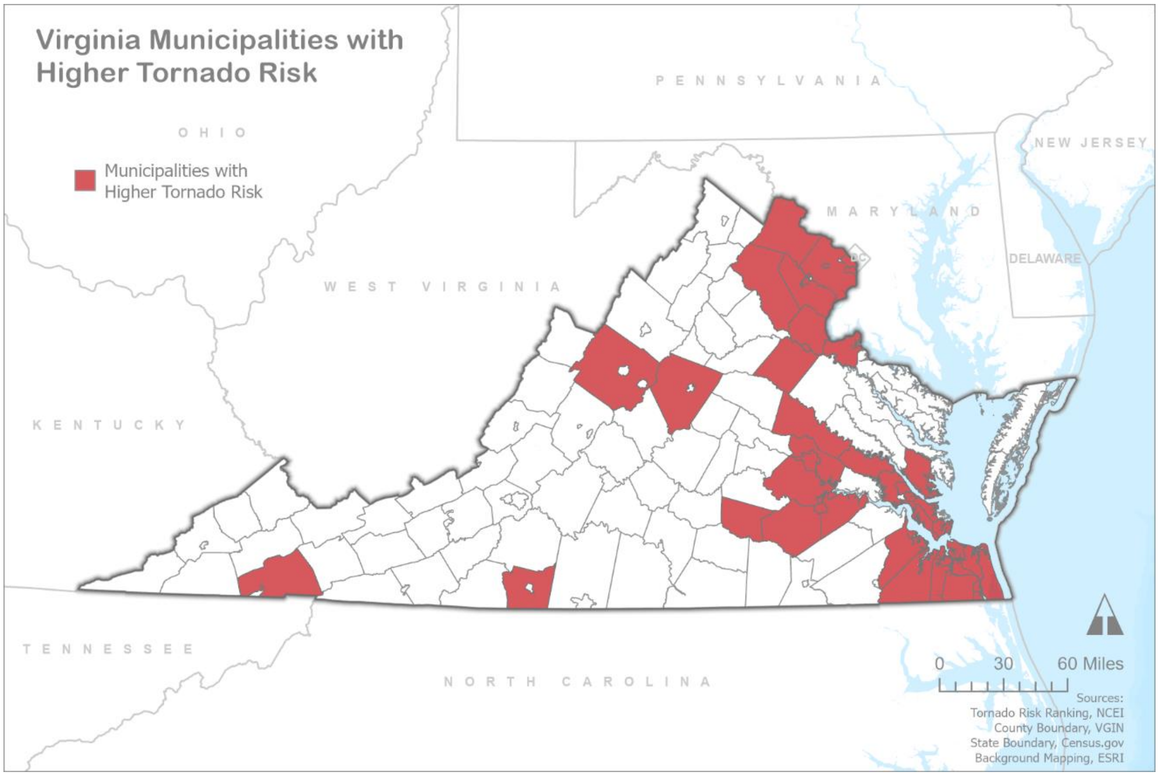
Adding to the complexity of the determination is that tornadoes are too geographically small to be well simulated by existing climate models. Models can simulate some of the conditions that contribute to forming the storms that typically spawn tornadoes, and multiple studies have found that the conditions that produce the most severe storms are likely to occur more frequently in a warmer world, even if the total number of thunderstorms decreases (because of fewer weak storms). However, this does not conclusively show whether tornadoes should or will follow the same trend as their parent storms[10].

Jurisdictional Risk

The jurisdictional tornado hazard rank is based on NCEI *Storm Events Database* parameters, as well as the tornado hazard frequency analysis. The Geographic Extent score for a given jurisdiction is higher in areas with a higher tornado hazard frequency. These scores were assigned by calculating the area-weighted average tornado hazard frequency in each jurisdiction. Figure 3-136 shows the geographic extent of municipalities with the higher tornado risk throughout the Commonwealth of Virginia.

The overall tornado hazard rankings for jurisdictions in the Commonwealth were based on the geographic extent scores, population, and measures of historical impact from NCEI, including property damage, crop damage, and fatalities and injuries. The overall tornado hazard rank for the Commonwealth shows that the jurisdictions facing the greatest tornado risk are mostly in the eastern and northern parts of the state, although a few jurisdictions in southern and southwest Virginia also receive an elevated risk rating. Some jurisdictions were not classified as being high risk to tornadoes in previous plans, but recent tornado events in these jurisdictions have elevated them to this ranking (for example, Gloucester, Washington, and New Kent Counties).

Figure 3-136 - Municipalities with Higher Tornado Risk, Virginia.



Although some jurisdictions may have few (or no) reported tornadoes in the historical record, tornadoes can still occur in these jurisdictions.

3.8.14.8 Local Plan Risk Assessment

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision. Nineteen of the 20 local plans gave tornado a hazard rank and provided a general description of tornadoes, statistics, and impacts. Some of the plans included tornado in the wind hazard for their region. A lot of ambiguity exists in how jurisdictions define specific hazards. This variability can drastically impact how the local plans are compared to each other.

Seven plans calculated annualized loss for tornado using the NCEI *Storm Events Database*. The database was also used in the ranking for this revision. Table 3-114 provides the local annualized loss values. Since both the local and statewide plan revisions relied on NCEI data, the values should be nearly identical. The difference in the loss estimates can be attributed to several factors, including the period of the events and when the data set was obtained from NCEI. The statewide analysis uses events from 1950 through 2021, and the local plan updates were all completed at various times. NCEI used many different storm event categories in their database. The categories used in this analysis are fully described previously, while the categories used by the local plans were not provided.

Table 3-114 - Local plan annualized tornado loss estimates since 2017

PDC/Jurisdiction	Annualized Tornado Loss
Hampton Roads	$24,300,000
Northern Neck	$173,366
Northern Virginia	$209,662
Rappahannock-Rapidan RC	$262,527
Richmond Crater	$1,488,825
West Piedmont	$2,481,050
Thomas Jefferson	$5,000,000-7,000,000

3.8.14.9 Local Plan Comparison

Overall, all 20 of the local and regional plans ranked tornado. Out of the 20 local/regional plans 8 ranked tornado as a high hazard, 7 ranked as a medium hazard, and 5 ranked as a low hazard. The overall hazard ranking for tornado for the 20 local and regional plans was medium. As stated above, the 2023 HMP ranked tornado as a medium-high hazard.

3.8.14.10 Changes in Development

Most 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. One local plan addressed how or if tornado hazards are considered for changes in development.

Table 3-115 shows the hazard rank for tornado. Relative to the rest of Virginia, the southeastern and northern jurisdictions have the highest risk for tornado. This ranking, based on NCEI records, does not distinguish winds resulting from tropical and non-tropical weather systems. Some of the impacts in the NCEI records may have been coded as non-tornadic winds and hurricane (and included in this wind section). However, sorting these damages out would be very difficult given the available information.

Table 3-115 - Tornado Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Medium-High	Low	High	High	Medium
Albemarle	Medium-High	Medium	Medium-High	High	Low	Medium-High	Medium-High	Medium
Alexandria, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Alleghany	Low	Low	Low	Low	Low	Low	Low	Low
Amelia	Low	Low	Low	High	Low	Medium-High	Medium-High	Medium-Low
Amherst	Medium	Medium	Low	Low	Low	Low	Low	Low
Appomattox	Low	Low	Medium-Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Arlington	High	High	Low	High	Low	Low	Low	Medium
Augusta	Medium-High	Medium	Medium	High	Low	High	High	Medium-High
Bath	Low	Low	Low	Low	Low	Low	Low	Low
Bedford	Medium-High	Medium	Low	High	Low	Medium	Medium	Medium
Bland	Low	Low	Low	Low	Low	Low	Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Low	Low	Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Brunswick	Medium	Low	Low	High	Low	High	High	Medium
Buchanan	Medium	Low	Low	Low	Low	Low	Low	Low
Buckingham	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Campbell	Medium	Medium	Medium	High	Low	Medium-High	Medium-High	Medium
Caroline	Medium	Low	Low	Medium	Low	High	High	Medium
Carroll	Medium	Medium	Medium-Low	Medium-High	Low	Medium-Low	Medium-Low	Medium-Low
Charles City	Low	Low	Low	Medium-High	Low	Low	Low	Low
Charlotte	Low	Low	Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Charlottesville, City of	Medium	High	Low	Medium	Low	Low	Low	Medium-Low
Chesapeake, City of	High	Medium-High	Low	High	Low	Medium-High	Medium-High	Medium
Chesterfield	High	Medium-High	Medium-Low	High	Low	High	High	Medium-High
Clarke	Low	Medium	Low	Medium	Low	Medium-High	Medium-High	Medium
Colonial Heights, City of	Medium	High	High	High	Low	Low	Low	Medium
Covington, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Craig	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Culpeper	Medium	Medium	Medium-Low	High	Low	High	High	Medium
Cumberland	Low	Low	Low	Low	Low	Low	Low	Low
Danville, City of	Medium	Medium-High	Low	Medium-High	Low	Low	Low	Medium-Low
Dickenson	Low	Low	Low	Medium	Low	Low	Low	Low
Dinwiddie	Medium	Low	High	High	Low	Medium-High	Medium-High	Medium
Emporia	Low	Medium-High	Low	Low	Low	Low	Low	Low
Essex	Low	Low	High	High	High	Medium-Low	Medium-Low	3
Fairfax	High	High	High	High	Low	High	High	High
Fairfax, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Falls Church, City of	Low	High	Low	High	Low	Low	Low	Medium-Low
Fauquier	Medium-High	Medium	Low	High	Low	High	High	Medium
Floyd	Low	Low	Low	Low	Low	Low	Low	Low
Fluvanna	Medium	Medium	Low	Medium-High	Medium-	Medium-High	Medium-High	Medium
Franklin	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Frederick	Medium-High	Medium	Low	High	Medium	Medium-High	Medium-High	Medium
Fredericksburg, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Galax, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Giles	Low	Low	Low	Low	Low	Low	Low	Low
Gloucester	Medium	Medium	High	High	Low	High	High	Medium-High
Goochland	Medium	Medium	Low	Medium-High	Low	Medium-High	Medium-High	Medium
Grayson	Low	Low	Medium	Low	Low	Low	Low	Low
Greene	Medium	Medium	Medium	High	Low	Medium-Low	Medium-Low	Medium
Greensville	Low	Low	Low	Medium-High	Low	Medium	Medium	Medium-Low
Halifax	Medium	Low	Medium-High	High	Low	High	High	Medium
Hampton, City of	Medium-High	High	Medium	High	Low	Medium-High	Medium-High	Medium-High
Hanover	Medium-High	Medium	Low	High	Low	High	High	Medium
Harrisonburg, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Henrico	High	Medium-High	Low	High	Low	High	High	Medium-High
Henry	Medium	Medium	Medium-High	High	Low	Medium	Medium	Medium
Highland	Low	Low	Low	Low	Low	Low	Low	Low
Hopewell, City of	Medium	High	Medium	High	Low	Medium-Low	Medium-Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Isle of Wight	Medium	Medium	Low	Medium-High	Low	High	High	Medium
James City	Medium-High	Medium-High	Medium	High	Low	Medium-High	Medium-High	Medium
King and Queen	Low	Low	Low	Medium-High	Low	Medium-High	Medium-High	Medium-Low
King George	Medium	Medium	Low	Medium-High	Low	Medium	Medium	Medium
King William	Low	Low	Low	High	Low	Medium	Medium	Medium-Low
Lancaster	Low	Medium	Low	High	Low	Medium	Medium	Medium-Low
Lee	Medium	Low	Low	High	Low	Medium	Medium	Medium-Low
Lexington, City of	Low	High	Low	Low	Low	Low	Low	Medium-Low
Loudoun	High	Medium-High	Low	High	Medium-Low	High	High	Medium-High
Louisa	Medium	Medium	Low	Medium-High	Low	High	High	Medium
Lunenburg	Low	Low	Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Madison	Low	Low	Low	Medium-High	Low	Medium-High	Medium-High	Medium-Low
Manassas, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Manassas Park, City of	Low	High	Low	Low	Low	Low	Low	Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Mathews	Low	Medium	Low	Medium	Low	High	High	Medium
Mecklenburg	Medium	Low	Low	High	Medium-	Medium-High	Medium-High	Medium
Middlesex	Low	Medium	Low	High	High	Medium-High	Medium-High	Medium
Montgomery	Medium-High	Medium	Low	High	Low	Low	Low	Medium-Low
Nelson	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
New Kent	Low	Medium	Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Newport News, City of	High	High	Low	High	Low	Medium-High	Medium-High	Medium
Norfolk, City of	High	High	Low	High	Low	High	High	Medium-High
Northampton	Low	Medium	Medium-Low	Medium	Low	Medium-High	Medium-High	Medium
Northumberland	Low	Low	Medium-Low	Medium	Low	Medium	Medium	Medium-Low
Norton	Low	Medium-High	Low	Low	Low	Low	Low	Low
Nottoway	Low	Low	Low	Medium-High	Low	High	High	Medium
Orange	Medium	Medium	Low	High	Low	High	High	Medium
Page	Medium	Medium	Low	Medium-High	Low	Low	Low	Medium-Low
Patrick	Medium	Low	Low	Medium	Medium-High	Medium-Low	Medium-Low	Medium-Low
Petersburg, City of	Medium	Medium-High	Low	High	Low	Medium-Low	Medium-Low	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Pittsylvania	Medium-High	Medium	Low	High	Low	High	High	Medium
Poquoson	Low	Medium-High	Low	Low	Low	Low	Low	Low
Portsmouth, City of	Medium-High	High	Low	High	Low	Medium	Medium	Medium
Powhatan	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Prince Edward	Medium	Medium	Low	Medium	Low	Low	Low	Medium-Low
Prince George	Medium	Medium	Low	Medium-High	Low	Medium-High	Medium-High	Medium
Prince William	High	Medium-High	Medium	High	Low	High	High	High
Pulaski	Medium	Medium	Medium-Low	High	Low	Low	Low	Medium-Low
Radford, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Rappahannock	Low	Low	Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Richmond	Low	Low	Low	High	Low	High	High	Medium
Richmond, City of	High	High	Medium	High	Low	Medium-High	Medium-High	Medium-High
Roanoke	Medium-High	Medium-High	Low	High	Low	Medium-Low	Medium-Low	Medium
Roanoke, City of	Medium-High	High	Low	Medium	Low	Low	Low	Medium-Low
Rockbridge	Medium	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Rockingham	Medium-High	Medium	Low	Medium-High	Low	Medium-High	Medium-High	Medium
Russell	Medium	Low	Low	Medium	Low	Medium	Medium	Medium-Low
Salem, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Scott	Medium	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Shenandoah	Medium	Medium	Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Smyth	Medium	Medium	Low	High	Low	Medium-High	Medium-High	Medium
Southampton	Low	Low	Low	Medium-High	Low	High	High	Medium
Spotsylvania	Medium-High	Medium	Low	Medium-High	Medium-Low	High	High	Medium
Stafford	Medium-High	Medium-High	Low	High	Low	High	High	Medium
Staunton, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Suffolk	Medium-High	Medium	High	High	Low	High	High	High
Surry	Low	Low	Low	Medium-High	Low	Medium-High	Medium-High	Medium-Low
Sussex	Low	Low	Medium	High	Low	Medium-High	Medium-High	Medium
Tazewell	Medium	Medium	Low	Low	Low	Low	Low	Low
Virginia Beach, City of	High	High	Medium	Medium-High	Low	High	High	High
Warren	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Washington	Medium	Medium	High	High	High	High	High	High

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Waynesboro, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Westmoreland	Low	Medium	Low	High	Medium	Medium	Medium	Medium
Williamsburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Winchester, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Wise	Medium	Medium	Low	High	Low	Medium-Low	Medium-Low	Medium-Low
Wythe	Medium	Medium	Low	Low	Low	Low	Low	Low
York	Medium-High	Medium-High	Low	Low	Low	Medium-High	Medium-High	Medium

For the 2023 plan, the overall hazard ranking for tornado is medium-high. Potential detrimental impacts associated with the hazard are included in Table 3-116.

Table 3-116 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts are expected to be severe for the event area, and moderate for the outlying areas.
Health and Safety of Response Personnel	Localized impacts could be serious as local responders are working within the impacted area, if they live within the impacted area then they may be displaced for an extended period.
Continuity of Operations	Damage to facilities/personnel around 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 around the event could be severe.
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 impacts expected to be severe for the impacted areas, soil stability impacted, area likely to be vulnerable to landslides. With a high potential for debris, HAZMAT may be an issue.
Economic and Financial Condition	Local economic and financial conditions may be impacted for a long period depending on duration and geographical area of the event, as well as the size and capabilities of the local jurisdiction.
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

Community Lifelines Impacted by Tornado

Based on the hazard analysis and description of vulnerability and impacts of tornadoes in Virginia, tornado impacts the following community lifelines:

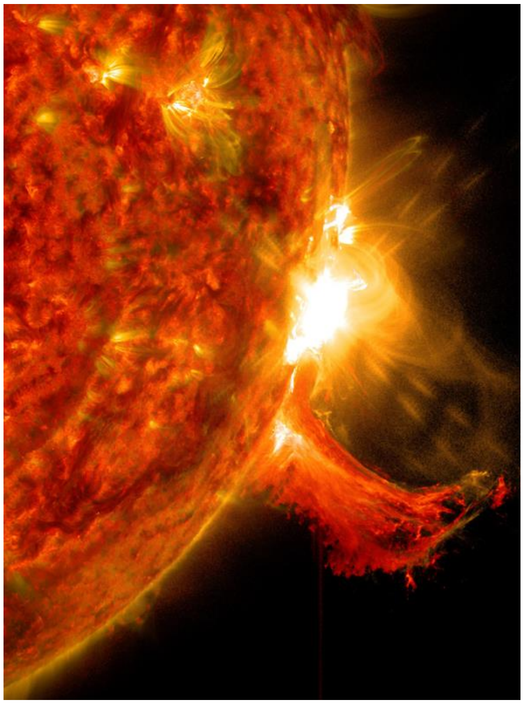
- Food, Water, Shelter
- Energy
- Communications
- Transportation

3.8.15 Space Weather

3.8.15.1 Background

Space weather is the term used to describe conditions in space that affect the Earth and its technological systems. Storms in space originate from the sun and occur in Near-Earth space or in the Earth's atmosphere. These storms generally occur due to eruptions on the sun known as solar flares (Figure 3-137) and coronal mass ejections (CMEs). Rather than the on-Earth weather contributors of water, temperature, and air, solar storms are a result of changes in the continuous flow of solar particles and magnetic fields from the sun, known as solar wind1.

Figure 3-137 - Solar flare image captured by NASA in 2014



Space weather is organized into three categories: geomagnetic storms; solar radiation storms; and radio blackouts. Geomagnetic storms bring electrical currents that can have significant impacts on electrical transmission equipment. These events can result in widespread electrical failures, though most electric power companies have procedures in place to mitigate the impacts. Geomagnetic storms can also interrupt precision GPS, including navigational systems such as those used by the Federal Aviation Administration. These storms can affect satellites, such as those used for radio and television transmissions, military surveillance, credit card transmission, and cell phone transmissions. Solar radiation storms are of concern for operators and passengers of aircraft, particularly for those flying routes near the Earth's poles. NASA is also concerned about solar radiation storms and must implement measures to shield the International Space Station and its crew from this increase in radiation. Radio blackouts affect high frequency (HF) communications, frequencies in the 1 to 30 mega Hertz range, which can significantly impact sectors such as aviation that rely on HF for communications while taking polar routes. Emergency response teams that rely on HF communications can also be impacted during these blackouts[2].

NOAA's Space Weather Prediction Center (SWPC) forecasts space weather to assist users in avoiding or mitigating severe space weather. The SWPC provides real-time monitoring and forecasting of solar events, and issues watches, warnings, and alerts for hazardous weather events. Technology on Earth can be vulnerable to hazardous space weather – in particular, to the effects of solar storms. With dependence on technology increasing, vulnerability to hazardous space weather has increased significantly in the last 100 years.

3.8.15.2 Location and Spatial Extent

The location and spatial extent of space weather is inherent to the hazard. Space weather is generated in space but has the potential to impact any location on Earth. There are no recorded instances since the previous iteration of the plan of solar storm impacts in the Commonwealth of Virginia, and none were reported during the update of this plan.

3.8.15.3 Significant Historical Events

Perhaps the most well-known occurrence of space weather occurred on September 1, 1859. Known as the Carrington Event, this massive solar storm was first detected by amateur astronomer Richard Carrington. He described his observation as 'two patches of intensely bright and white light,' erupting from the spots on the sun. Within minutes, the fireballs vanished.

Within hours, however, the impact of those spots was felt around the Earth. Later that night, telegraph communications began to fail around the globe. There were reports of sparks from telegraph machines; these sparks shocked operators and set paper on fire. Colorful auroras illuminated the night sky around the Earth; these auroras were so bright that there were reports of birds singing and chirping (as though it were day) and laborers rising for the day, believing the sun had risen.

With his naked eye, Richard Carrington had seen the cause of this unusual activity – the energy output can be up to 6×10 25 Joules, which is equivalent to millions of 100 megaton atomic bombs exploding at the same time. This event, and the resulting geomagnetic storm, is the largest to have struck the Earth. Ice core samples have confirmed that the Carrington Event was twice as large as any other solar storm in the previous 500 years3.

As the technology and ability to study space has increased, the ability to determine occurrences of the space weather hazard has improved. Thought it may appear that these events are occurring more frequently than in the past, it is likely a simple change in detection of and disruption from such events.

3.8.15.4 Probability of Future Occurrences

The probability of space weather cannot be expressed in terms of specific return periods or recurrence intervals as it can be with other hazards. Currently, NASA is unable to predict these events; they can only monitor and provide some warning of storms before they impact Earth. While there are some who claim they have developed models to provide a probability of a storm occurring in a given timeframe, these claims have not been embraced or endorsed by NASA at this time.

Given the rarity of events that impact Earth, this hazard has an assigned probability of low.

Impact and Vulnerability

Space weather can impact the Commonwealth through the disruption of both electrical power transmission and HF radio communications. This disruption can result in impacts to the electric power grid and subsequently power distribution throughout the Commonwealth.

Depending on the transformer design, space weather can lead to heating of the surrounding structures due to induced ‘Eddy Currents’ which may damage parts of the transformer. An additional impact of transformer saturation is that the voltages and currents no longer have a simple sinusoidal (60 cycle) form, and this can cause protective equipment elsewhere in the grid to trip when it should not. These equipment ‘trips’ can take needed equipment offline and cause voltage stability problems. An additional issue for the system is that all the transformers that are saturating show up as a significant inductive load on the grid. This means that a system that is near peak levels of demand prior to the geomagnetic storm event may not be able to meet the total power demand when the geomagnetic storm occurs, leading to partial or system wide blackouts[4].

High frequency radio communications may also be disrupted by space weather; the changes in ionospheric density and structure modify the transmission path and even block transmission of

HF radio signals completely. These frequencies are used by amateur (ham) radio operators and many industries such as commercial airlines. They are also used by several government agencies such as FEMA and the DOD.

There are several types of space weather that can impact HF radio communication. In a typical sequence of space weather storms, the first impacts are felt during the solar flare itself. The solar x-rays from the sun penetrate to the bottom of the ionosphere (to around 80 km). There, the x-ray photons ionize the atmosphere and create an enhancement of the D layer of the ionosphere. This enhanced D layer acts both as a reflector of radio waves at some frequencies and an absorber of waves at other frequencies. The Radio Blackout associated with solar flares occurs on the dayside region of Earth and is most intense when the sun is directly overhead.

Another type of space weather, the Radiation Storm caused by energetic solar protons, can also disrupt HF radio communication. The protons are guided by Earth’s magnetic field such that they collide with the upper atmosphere near the north and south poles. The fast-moving protons have an affect like the x-ray photons and create an enhanced D-Layer thus blocking HF radio communication at high latitudes. During auroral displays, the precipitating electrons can enhance other layers of the ionosphere and have similar disrupting and blocking effects on radio communication. This occurs mostly on the night side of the polar regions of Earth where the aurora is most intense and most frequent[5].

Risk

Data on the total financial impact of these events is incomplete. Risk, strictly defined as probability multiplied by impact, cannot be fully estimated for solar storm due to the lack of accepted intensity-damage models for solar storm events. Therefore, projected annualized dollar losses cannot be estimated.

3.8.15.5 State Facility Risk

To determine which facilities are at risk for solar storms, each state facility in Virginia was reviewed. A total of 12,804 facilities have been identified as being state-owned. The review determined that each state-owned facility in the Commonwealth has at least some risk from solar storms, as each facility has some form of electrical wiring that supports the building and most have some form of communication equipment (i.e., telephones, cell towers, radio stations, etc.). While the facilities themselves are not at risk from space weather, some of the systems that support them, namely electrical and communications, may be at risk during a solar event.

Annualized loss estimates were not calculated for state facilities due to the lack of building detail data available (including valuation and specific electrical components and systems), and the lack of probabilities of future occurrences.

3.8.15.6 Critical Facility Risk

Risk for critical facilities was calculated in the same fashion described for state facilities. The results of this analysis indicate that 2,420 critical facilities (or the electrical/communications systems that they rely on) are at risk from solar storms. Annualized loss estimates were not calculated for critical facilities due to the limited information on mapped critical facilities (including valuation data and specifics of electrical and communications equipment), and the lack of probabilities of future occurrences. Table 3-117 details these critical facilities by use.

Table 3-117 - Critical Facilities at Risk from Solar Storms

Critical Facility Use	Number at Risk from Space Weather
Airfield	12
Animal Health	27
Armory	39
Childcare	10
Communications	76
Emergency Operations Center	1
Fire Service/Support/Suppression	35
Food Service/Storage	88
Fuel Storage/Delivery	516
Hazardous Materials Storage	433
Medical Services/Support/EMS	128
Public Safety/Security	200
Research	178
Special Populations Housing / Shelter	27
Utilities	650
Total:	**2,420**

3.8.15.7 Space Weather Risk to Energy Pipelines

Space weather can affect pipelines by damaging the infrastructure that supports pipeline operations such as power and telephone and satellite communications. In some cases, pipeline operators may proactively shutdown pipeline operations prior to the onset of severe weather, to mitigate potential damages, which may cause supply interruptions.

Future Conditions

Most climate scientists agree that space weather could play a role in climate change on Earth, but the clear majority view that role as minimal at best. They attribute changing climate conditions on Earth to more terrestrial forces, rather than those originating in space or with the sun[6].

Jurisdictional Risk

With only a single major, reported event, comparison between hazards based on a common system was not feasible for solar weather.

3.8.15.8 Local Plan Risk Assessment

Currently, only one hazard mitigation plan included space weather in their local plan. The Central Virginia plan ranked space weather as a low hazard. However, it is anticipated that solar storms/space weather may be included in future updates of other local hazard mitigation plans.

3.8.15.9 Comparison with Local Ranking

Currently, only one plan included space weather in their local plan as discussed above.

3.8.15.10 Changes in Development

Most 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use change.

Table 3-118 - Space Weather Hazard Parameter Rankings

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Low	Medium	Low	Low	Low	Low	Low	Low
Albemarle	Low	Medium	Low	Low	Low	Low	Low	Low
Alexandria, City of	Low	High	Low	Low	Low	Low	Low	Low
Alleghany	Low	Low	Low	Low	Low	Low	Low	Low
Amelia	Low	Low	Low	Low	Low	Low	Low	Low
Amherst	Low	Medium	Low	Low	Low	Low	Low	Low
Appomattox	Low	Low	Low	Low	Low	Low	Low	Low
Arlington	Low	High	Low	Low	Low	Low	Low	Low
Augusta	Low	Medium	Low	Low	Low	Low	Low	Low
Bath	Low	Low	Low	Low	Low	Low	Low	Low
Bedford	Low	Medium	Low	Low	Low	Low	Low	Low
Bland	Low	Low	Low	Low	Low	Low	Low	Low
Botetourt	Low	Medium	Low	Low	Low	Low	Low	Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Brunswick	Low	Low	Low	Low	Low	Low	Low	Low
Buchanan	Low	Low	Low	Low	Low	Low	Low	Low
Buckingham	Low	Low	Low	Low	Low	Low	Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Campbell	Low	Medium	Low	Low	Low	Low	Low	Low
Caroline	Low	Low	Low	Low	Low	Low	Low	Low
Carroll	Low	Medium	Low	Low	Low	Low	Low	Low
Charles City	Low	Low	Low	Low	Low	Low	Low	Low
Charlotte	Low	Low	Low	Low	Low	Low	Low	Low
Charlottesville, City of	Low	High	Low	Low	Low	Low	Low	Low
Chesapeake, City of	High	Medium-High	Low	Low	Low	Low	Low	Low
Chesterfield	Low	Medium-High	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Clarke	Low	Medium	Low	Low	Low	Low	Low	Low
Colonial Heights, City of	Low	High	Low	Low	Low	Low	Low	Low
Covington, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Craig	Low	Low	Low	Low	Low	Low	Low	Low
Culpeper	Low	Medium	Low	Low	Low	Low	Low	Low
Cumberland	Low	Low	Low	Low	Low	Low	Low	Low
Danville, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Dickenson	Low	Low	Low	Low	Low	Low	Low	Low
Dinwiddie	Low	Low	Low	Low	Low	Low	Low	Low
Emporia	Low	Medium-High	Low	Low	Low	Low	Low	Low
Essex	Low	Low	Low	Low	Low	Low	Low	Low
Fairfax	Low	High	Low	Low	Low	Low	Low	Low
Fairfax, City of	Low	High	Low	Low	Low	Low	Low	Low
Falls Church, City of	Low	High	Low	Low	Low	Low	Low	Low
Fauquier	Low	Medium	Low	Low	Low	Low	Low	Low
Floyd	Low	Low	Low	Low	Low	Low	Low	Low
Fluvanna	Low	Medium	Low	Low	Low	Low	Low	Low
Franklin	Medium	Medium	Low	Low	Low	Low	Low	Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Frederick	Low	Medium	Low	Low	Low	Low	Low	Low
Fredericksburg, City of	Low	High	Low	Low	Low	Low	Low	Low
Galax, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Giles	Low	Low	Low	Low	Low	Low	Low	Low
Gloucester	Medium	Medium	Low	Low	Low	Low	Low	Low
Goochland	Low	Medium	Low	Low	Low	Low	Low	Low
Grayson	Low	Low	Low	Low	Low	Low	Low	Low
Greene	Low	Medium	Low	Low	Low	Low	Low	Low
Greensville	Low	Low	Low	Low	Low	Low	Low	Low
Halifax	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Hampton, City of	Medium-High	High	Low	Low	Low	Low	Low	Low
Hanover	Low	Medium	Low	Low	Low	Low	Low	Low
Harrisonburg, City of	Low	High	Low	Low	Low	Low	Low	Low
Henrico	Low	Medium-High	Low	Low	Low	Low	Low	Low
Henry	Low	Medium	Low	Low	Low	Low	Low	Low
Highland	Low	Low	Low	Low	Low	Low	Low	Low
Hopewell, City of	Low	High	Low	Low	Low	Low	Low	Low
Isle of Wight	Medium	Medium	Low	Low	Low	Low	Low	Low
James City	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
King and Queen	Low	Low	Low	Low	Low	Low	Low	Low
King George	Low	Medium	Low	Low	Low	Low	Low	Low
King William	Low	Low	Low	Low	Low	Low	Low	Low
Lancaster	Low	Medium	Low	Low	Low	Low	Low	Low
Lee	Low	Low	Low	Low	Low	Low	Low	Low
Lexington, City of	Low	High	Low	Low	Low	Low	Low	Low
Loudoun	Low	Medium-High	Low	Low	Low	Low	Low	Low
Louisa	Low	Medium	Low	Low	Low	Low	Low	Low
Lunenburg	Low	Low	Low	Low	Low	Low	Low	Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Madison	Low	Low	Low	Low	Low	Low	Low	Low
Manassas, City of	Low	High	Low	Low	Low	Low	Low	Low
Manassas Park, City of	Low	High	Low	Low	Low	Low	Low	Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Mathews	Low	Medium	Low	Low	Low	Low	Low	Low
Mecklenburg	Low	Low	Low	Low	Low	Low	Low	Low
Middlesex	Low	Medium	Low	Low	Low	Low	Low	Low
Montgomery	Low	Medium	Low	Low	Low	Low	Low	Low
Nelson	Low	Low	Low	Low	Low	Low	Low	Low
New Kent	Low	Medium	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Newport News, City of	High	High	Low	Low	Low	Low	Low	Low
Norfolk, City of	High	High	Low	Low	Low	Low	Low	Low
Northampton	Low	Medium	Low	Low	Low	Low	Low	Low
Northumberland	Low	Low	Low	Low	Low	Low	Low	Low
Norton	Low	Medium-High	Low	Low	Low	Low	Low	Low
Nottoway	Low	Low	Low	Low	Low	Low	Low	Low
Orange	Low	Medium	Low	Low	Low	Low	Low	Low
Page	Low	Medium	Low	Low	Low	Low	Low	Low
Patrick	Low	Low	Low	Low	Low	Low	Low	Low
Petersburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Pittsylvania	Low	Medium	Low	Low	Low	Low	Low	Low
Poquoson	Low	Medium-High	Low	Low	Low	Low	Low	Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Low	Low	Low
Powhatan	Low	Medium	Low	Low	Low	Low	Low	Low
Prince Edward	Low	Medium	Low	Low	Low	Low	Low	Low
Prince George	Low	Medium	Low	Low	Low	Low	Low	Low
Prince William	Low	Medium-High	Low	Low	Low	Low	Low	Low
Pulaski	Low	Medium	Low	Low	Low	Low	Low	Low
Radford, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Rappahannock	Low	Low	Low	Low	Low	Low	Low	Low
Richmond	Low	Low	Low	Low	Low	Low	Low	Low
Richmond, City of	Low	High	Low	Low	Low	Low	Low	Low
Roanoke	Low	Medium-High	Low	Low	Low	Low	Low	Low
Roanoke, City of	Low	High	Low	Low	Low	Low	Low	Low
Rockbridge	Low	Low	Low	Low	Low	Low	Low	Low
Rockingham	Low	Medium	Low	Low	Low	Low	Low	Low
Russell	Low	Low	Low	Low	Low	Low	Low	Low
Salem, City of	Low	High	Low	Low	Low	Low	Low	Low
Scott	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Shenandoah	Low	Medium	Low	Low	Low	Low	Low	Low
Smyth	Low	Medium	Low	Low	Low	Low	Low	Low
Southampton	Low	Low	Low	Low	Low	Low	Low	Low
Spotsylvania	Low	Medium	Low	Low	Low	Low	Low	Low
Stafford	Low	Medium-High	Low	Low	Low	Low	Low	Low
Staunton, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Suffolk	Medium-High	Medium	Low	Low	Low	Low	Low	Low
Surry	Low	Low	Low	Low	Low	Low	Low	Low
Sussex	Low	Low	Low	Low	Low	Low	Low	Low
Tazewell	Low	Medium	Low	Low	Low	Low	Low	Low
Virginia Beach, City of	High	High	Low	Low	Low	Low	Low	Low
Warren	Low	Medium	Low	Low	Low	Low	Low	Low
Washington	Low	Medium	Low	Low	Low	Low	Low	Low
Waynesboro, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Westmoreland	Low	Medium	Low	Low	Low	Low	Low	Low
Williamsburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Winchester, City of	Low	High	Low	Low	Low	Low	Low	Low
Wise	Low	Medium	Low	Low	Low	Low	Low	Low
Wythe	Low	Medium	Low	Low	Low	Low	Low	Low
York	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low

For the 2023 plan, the overall hazard ranking is negligible. Potential detrimental impacts associated with the hazard are included in Table 3-119.

Table 3-119 - Emergency Management Accreditation Plan Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts are expected to be moderate to severe for affected areas and moderate to light for less impacted areas.
Health and Safety of Response Personnel	Personnel are expected to have communications issues.
Continuity of Operations	Unlikely to execute Continuity of Operations Plan, unless impacts are severe and long-lasting.
Property, Facilities, and Infrastructure	Electrical outages and communication issues are expected.
Delivery of Services	Localized disruption of communications caused by the event may postpone the delivery of some services.
The Environment	Electrical issues could cause increased risk of fire.
Economic and Financial Condition	Local economy may be impacted depending on type of event, local retailers may not be able to open for business.
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.

Community Lifelines Impacted by Space Weather

Based on the hazard analysis and description of vulnerability and impacts of space weather in Virginia, space weather impacts the following community lifelines:

- Energy
- Communications
- Hazardous Materials
- Safety and Security

Furthermore, there are 16 critical infrastructure sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the US that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof. Presidential Policy Directive 21 (PPD-21): “Critical Infrastructure Security and Resilience” identifies DHS as the lead for 10 critical infrastructure sectors including chemical, commercial facilities, communications, critical manufacturing, dams, emergency services, government facilities (with the General Services Administration), information technology, nuclear reactors, materials, and waste, and transportation systems (with the Department of Transportation).[lxxviii]

3.8.16 Wildfires

3.8.16.1 Background

A wildfire is a fire occurring in the natural environment (i.e., grassland, forest, brush land) and is a serious and growing hazard over much of the US. Wildfires are part of the natural management of the Earth’s ecosystems but may also be caused by natural or human factors. Approximately 96-percent of wildfires in Virginia are started by humans; most commonly from debris burning, with the rest resulting from lightning strikes. Weather is one of the most significant factors in determining the severity of wildfires[1]. Wildfires can pose a threat to life and property in rural and developed areas. In rural areas, high intensity wildfire events have significant impacts on vegetation and groundcover that serve to stabilize the soil. Decreased soil stability greatly increases risk of localized landslides and flooding. These risks are greater in areas with steep topography. The effects can carry on for years in the form of increased runoff and erosion.

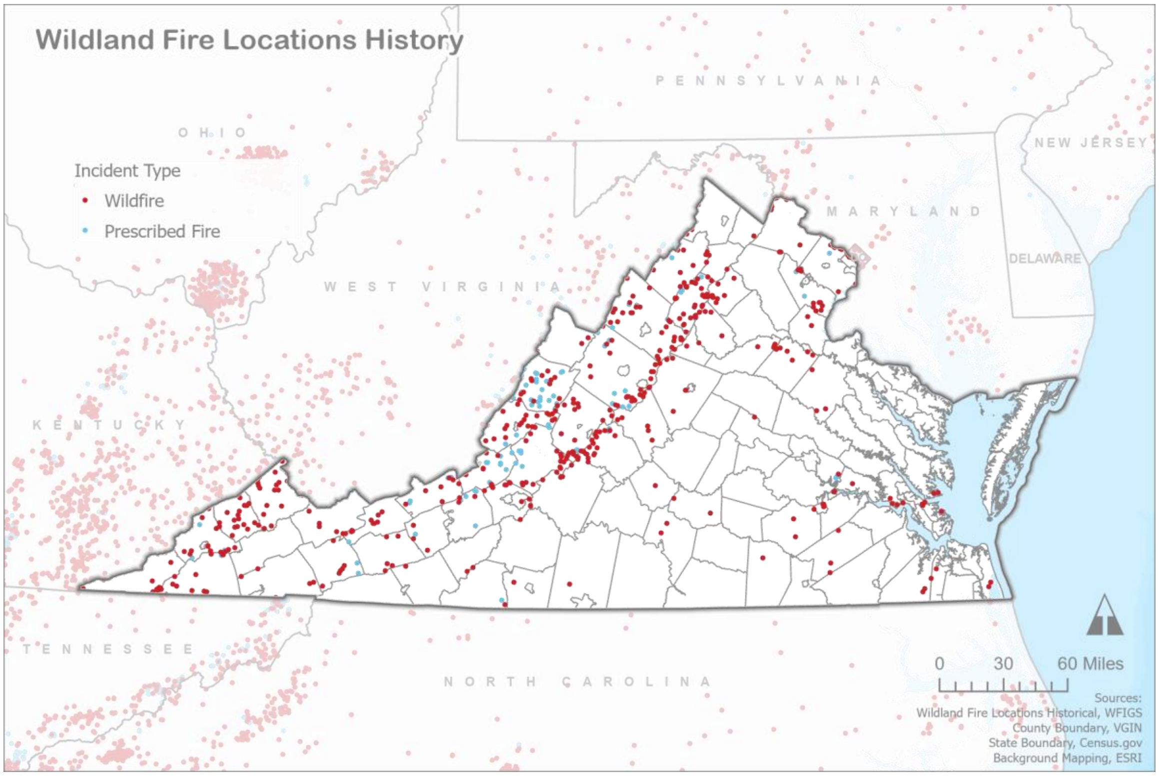
There are three classes of wildland fires: surface fire, ground fire, and crown fire. A surface fire is the most common of these three classes and burns along the floor of a forest, moving slowly and killing or damaging trees. A ground fire (muck fire) is usually started by lightning or human carelessness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

Since 1983, an average of 70,000 wildfires burn each year in the US. The national fire season has historically lasted four months but now lasts six to eight months with fires peaking in July. Data from 2001 to 2017 indicate that burn frequency peaks in July with an average of 1.6 million acres burning across the US each year. In Virginia, spring (March and April) and fall (October and November) are the two main seasons for wildfires.

3.8.16.2 Location and Spatial Extent

According to the 10-year average, approximately 700 wildfires burn each year in Virginia, damaging just under 9,500 acres annually. Many of these historical fires occurred in the western counties of the Commonwealth consistent with the steep topography and ample fuel found in the mountains of Virginia, but wildfire occurrences have been documented from Virginia Department of Forestry (VDOF) statewide **(**Figure 3-138). Seven jurisdictions have been included in federal disaster declarations for wildfire including: Buchanan County, Dickenson County, Scott County, Shenandoah County, Page County, Albemarle County and Nelson County. Nelson County also has the most NCEI wildfire events recorded in the state.

Figure 3-138 - Wildfire Historical Locations in Virginia.



Source: WFIGS

3.8.16.3 Significant Historical Events

Table 3-120 is based on available records from VDOF and includes the dates of significant wildfires in Virginia during the past century.

Table 3-120 - VDOF Historical Wildfire Events

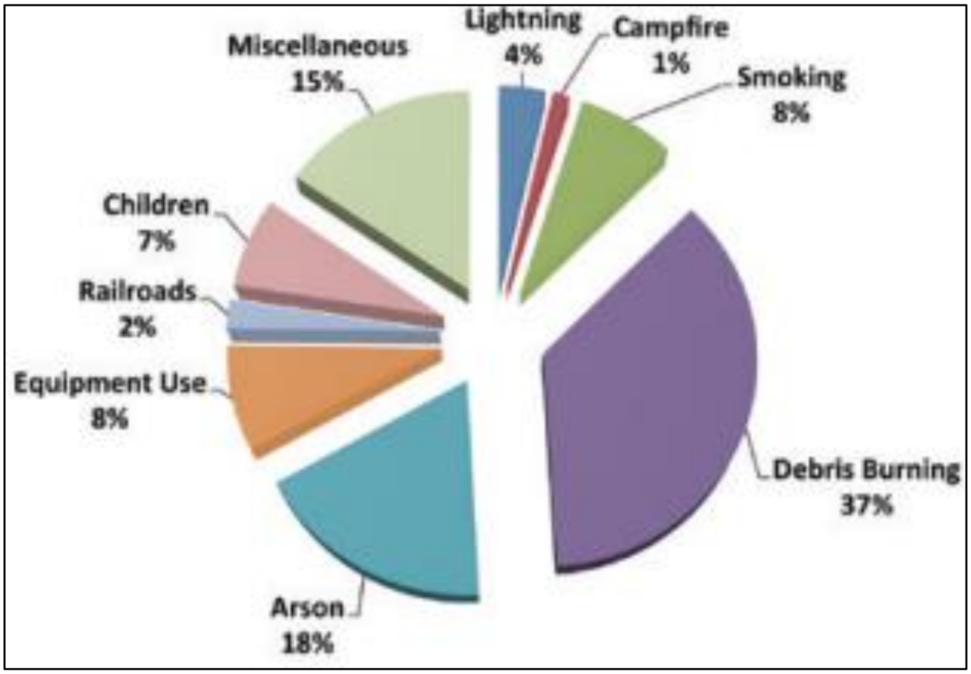
Year	Acres Burned	Damages	Description
1917	305,000	$809,000	Earliest known records in Virginia; over 1,460 fires were reported with two fatalities
1927	27,863		An all-time recorded low of 404 fires were reported for the state of Virginia.
1930	333,023		The year that the great drought occurred in Virginia, with a yearlong fire season and unprecedented, disastrous summer fires, but also because it brought disaster to many farmers and stockmen. Coming as it did immediately following the crash in the fall of 1929, its economic effects were severely felt.' 2,554 fires were recorded across 58 counties.
1941-1943			An average of 2,970 wildfires burn 148,937 acres each of the three years.
1948	7,782		The Smokey Bear Campaign was implemented in 1944. This campaign is one of the most successful advertising campaigns in American history and resulted in the first year that Virginia recorded less than 10,000 acres burned.
1952	111,571		2,494 fires burned 111,571 acres. It was the last time 100,000+ acres were burned in a single year.
1963	44,823		3,300 fires burned 44,823 acres in a year.
1982	11,170		More than 10,000 acres in eastern Virginia were destroyed by numerous spring wildfires.
1987	20,393		A dry summer and fall caused extreme fire conditions throughout the state. Governor Wilder considered cancelling fall hunting season as fires burned in southwest Virginia until a frontal system reduced the fire risk.

Year	Acres Burned	Damages	Description
1995	9,240	$1,258,541	On April 9, dry conditions, gusty winds, and deadwood resulted in 66 acres of forest burned in Buckingham County, 150 acres of forest burned in Franklin County requiring 65 residents to be evacuated, and 24 acres of forest burned in Pittsylvania County, all on the same day. Damage was estimated at about $50,000.
1998	6,480	$1,519,453	Dry conditions and rough terrain led to more than 2,000 acres being burned in one wildfire which occurred in the George Washington and Thomas Jefferson National Forest near Deerfield in Augusta County.
1999	15,663	$3,588,947	1,753 fires burned 15,663 acres. More than 400 acres on Afton Mountain burned on April 2, causing more than $2,000 in property damages. An overheated combine working in a wheat field during dry conditions on July 9 in Clarke County started a fire that burnt 67 acres, including 60 acres of wheat and the combine which resulted in $6,700 and $92,000 in damages respectively. The Cumulative Severity Index rated Northern Virginia at 628 by the end of July. (1-800 rating for fire danger).
2001	19,476	$13,205,274	This is the only year on record that required significant out- of-state resources, which included 12 USFS crews, 6 Florida Division of Forestry engines, and 1 Florida Division of Forestry plane and pilot. This is also the only year that wildfire funding assistance was received from FEMA. Like 1930, drought was a major cause of the large acreage that was burned.
2006	13,763	$12,465,881	Due to gusty winds and dry fuels, the Bull Mountain Fire in Patrick County burned more than 4,000 acres, including some vehicles and outbuildings.
2008	26,541	$12,706,576	February 10 saw the largest single day outbreak of wildfire in Virginia's recorded history. A strong dry cold front came through the Commonwealth bringing exceptionally high winds which lasted for more than 12 hours. The VDOF responded to 354 wildfires which ultimately burned 25,709 acres.
2009	8,779	$6.1 million	Wildfires burned 7,310 acres. Of the $6.1 million in damages, $5 million was timber damage and $1.1 million was property damage.
2010	5,071	$5 million	Wildfires burned 8,485 acres. Of the $5 million in damages, $4 million was timber damage and just under $1 million was property damage.
2011	22,022	$15.7 million	Wildfires burned 14,272 acres. Of the $15.7 million in damages, $11 million was timber damage and $4.7 million was property damage. FEMA fire management assistance was given for the Smith and Coffman Fires which occurred in 2011.
2012	8,033	$3.9 million	633 fires burned 8,033 acres. Almost $2 million of timber was damaged and there was an additional $1.9 million of damage to homes and other buildings[2].
2013	4,730	$5 million	628 fires burned 4,730 acres. More than $2.3 million of timber was damaged and there was an additional $2.7million of damage to homes and other structures[3].
2014	12,675	$8.3 million	872 fires burned 12,675 acres. More than $6.8 million of timber was damaged and damage to homes and other buildings amounted to $1.5 million[4].
2015	4,941	$2 million	647 fires burned 4,941 acres. More than $740,000 of timber was damaged and damage to homes and other buildings amounted to $1.3 million[5].
2016	8,618	$6.9 million	498 fires burned 8,618 acres. More than $6.2 million of timber was damaged and there was an additional $759,000 of damages to homes and other structures[6].
2017	23,081	$14.3 million	693 fires burned a total of 23,081 acres. Nearly $13.6 million of timber was damaged and an additional $726,000 in damages were caused to homes and other buildings.
2018	6,683	$3.5 million	727 fires burned 6,683 acres. Nearly $2.7 million of timber was damaged and an additional $845,058 in damages were caused to homes and other buildings.
2019	1,396	$1.2 million	247 fires burned 1,396 acres. Approximately $833,000 of timber was damaged and an additional $332,800 in damages were caused to homes and buildings.
2020	5,038	unknown	475 fires burned 5,038 acres. Estimates of damages are not included in the VDOF 2020 State of the Forest Report.
2021	6,749	$5.6 million	418 fires burned 6,749 acres. Approximately $4.2 million in timber was damaged and an additional $1.4 million in damages were caused to homes and buildings.

3.8.16.4 Probability of Future Occurrence

The factors influencing wildfire generation vary with changing weather conditions and human activities. Fire probability depends on local weather conditions, outdoor activities such as camping, debris burning, and construction, and the degree of public cooperation with fire prevention measures. Human activities are the leading cause of wildfire incidents in Virginia (as seen in Figure 3-139). Debris burning and the intentional setting of fires were responsible for the greatest number of reported wildfire incidents and acres burned during years 1995-2016. As suburban residential development continues to expand, it is reasonable to expect an increase in human/wildland interactions, resulting in more wildfires.

Figure 3-139 - Wildfire causes in Virginia (2017)



Source: Virginia Department of Forestry

According to VDOF, there are three important factors that determine the formation of wildfire hazards: fuel, topography, and weather. These factors are generally most hazardous in the spring and fall. Low relative humidity combined with windy conditions cause fuels on the forest floor to dry out quickly, increasing wildfire risk. Small diameter twigs and brush, leaf litter, conifer needles, and grasses have rapid fluctuations in moisture content, and can dry out in a matter of hours. This can heighten wildfire risk in a short period.

Drought conditions and other natural disasters (such as hurricanes, tornadoes, and lightning) increase the probability of wildfires by producing fuel in both urban and rural settings. Over long dry periods, even larger fuels such as medium to large diameter dead and dying woody debris can dry out and fuel large wildfires. Not only does this increase the risk of a wildfire igniting, but it also increases the spread, intensity, and overall danger of an event once it has occurred.

Because of the above variables, future wildfire incidents are difficult to predict. There is currently no quantitative estimate of future wildfire probability for specific regions of the state. While a VDOF Wildfire Risk Assessment does indicate the relative propensity for wildfires across the state, this assessment does not assign exact probabilities of occurrence. Because probability for wildfire cannot be categorized into specific return periods or recurrence intervals as it can be for other hazards, the analysis for wildfire was based on the VDOF Wildfire Risk Assessment dataset.

Impact and Vulnerability

Dense smoke and the fine particles and gases inside smoke pose a risk to human health. Smoke irritates the eyes and respiratory system and can cause bronchitis or aggravate heart or lung disease even for residents hundreds of miles downwind. Wildfires raise the temperature of forest soils and potentially wipe away organic value of the soil. And although soils do eventually recover, the impact on watersheds in the interim can be detrimental to the region's water bodies. Burned organic matter in soils may negatively affect infiltration and percolation making soil surfaces water repellant. If water is unable to infiltrate, runoff quantity increases and infiltration to groundwater decreases. Both factors may negatively impact water quality downstream.

Vulnerability to wildfire is constantly in flux at a given location, but is generally influenced by factors such as land cover conditions, weather, and the effectiveness of land management techniques. Highly urbanized areas are less vulnerable to wildfire, but suburban neighborhoods located at the wildland/urban interface are more vulnerable. Individual buildings may be vulnerable to damage from wildfire based on factors such as the clear distance around the structure, and the structure's construction materials.

The primary impacts of most wildfires are timber loss and environmental damage, although the threat to nearby buildings is always present. In the wake of a wildfire, secondary impacts may also include landslides and mudslides caused by the loss of groundcover which played a key role in stabilizing soil.

The VDOF thoroughly tracks the number of acres burned and estimated damages for each incident in the Commonwealth. Timing and coordination resulted in limitations in using this data as part of the ranking methodology. Future revisions of this plan will include this data, with modifications to fit within the ranking framework. Modifications could include further refinement of the VDOF data to distinguish timber damages from structural damages to provide a better understanding of the specific impacts of wildfire.

Risk

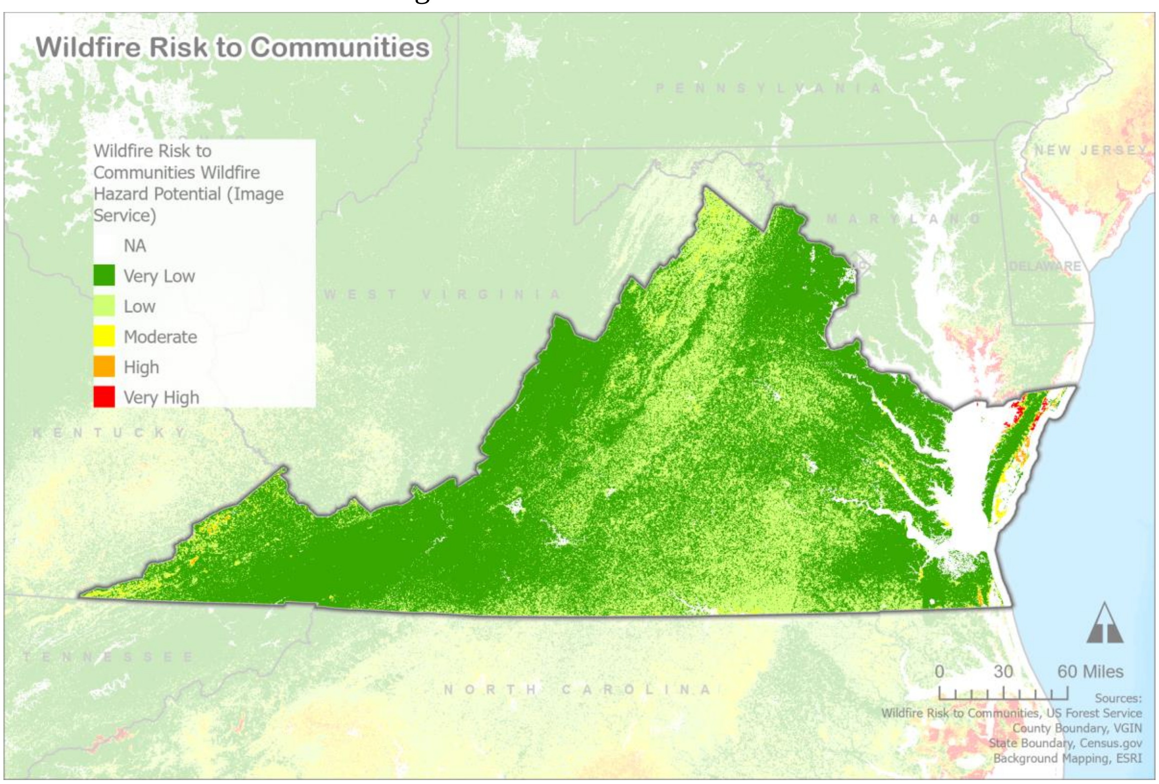
In 2003, VDOF released a GIS-based Wildfire Risk Assessment for the Commonwealth. The data are now part of the Southern Foresters web site at www.southernwildfirerisk.com that serves as a portal for data from several southern states and a tool to evaluate wildfire risk, wildfire behavior, and landscape characteristics. VDOF determined that the following inputs were important in modeling wildfire risk:

- Density of historical wildfires;
- Land cover (fuel);
- Percent slope;
- Slope orientation/aspect;

- Population density;
- Distance to roads;
- Railroad buffer; and
- Road density and developed areas.

Using these data inputs, VDOF examined which factors influence the occurrence and advancement of wildfires and investigated how these factors could be represented in a GIS model. These model parameters were analyzed to estimate the overall wildfire risk. Due to regional differences with data inputs, the modeling process was conducted independently in each of the three physiographic regions (mountain, piedmont, and coastal plain). The results were merged, and the wildfire risks were classified and scored from very low to very high. Figure 3-140 shows the relative wildfire risk. Counties in far southwestern Virginia near Kentucky, where historical events have caused significant damage in the past (e.g., Dickenson County and Wise County) have a higher wildfire risk than several counties bordering West Virginia. Because density of historical wildfires is only one variable influencing model outputs, future risk does not necessarily mirror past history with this hazard. Areas on the Eastern Shore, for example, have less historical exposure to wildfire, but the risk for future events is relatively high, especially along low-lying coastal barriers.

Figure 3-140 - Wildfire Risk in Virginia.



3.8.16.5 State Facility Risk

To determine what facilities were at risk for wildfire, the state facilities were intersected with the wildfire hazard potential layer. The results of this analysis indicate approximately less than one percent of state facilities are in high wildfire risk zones, and approximately one- and one-half-percent are in moderate risk zones. The remaining 98- percent are in low-risk zones. The lack of wildfire probabilities and detailed infrastructure data led to the inability to calculate potential losses due to wildfire. Table 3-121 shows the facilities at risk for wildfire, broken down by the fire risk zone in which they are located.

Table 3-121 - State facilities in Wildfire Risk Zones

Wildfire Risk Zone	Number of State Facilities
Low	12,585
Moderate	198
High	20
Total	**12,803**

The results of this analysis indicate approximately 20 buildings are at a high risk for wildfires, and two different state agencies have facilities within this high potential zone: DCR and the Department of Wildlife Resources.

3.8.16.6 Critical Facility Risk

The lack of wildfire probabilities and detailed critical facility data led to the inability to calculate potential losses due to wildfire. Risk for critical facilities was calculated in the same fashion as mentioned above for state facilities. Table 3-122 shows the breakdown of wildfire risk zones by critical facility type. The results of this analysis indicate less than one percent of critical facilities are in high or moderate wildfire risk zones. Fuel storage/distribution and utilities are the most critical facilities in high wildfire risk zones. Wildfires also pose a threat to electrical grid transmission and distribution lines due to the destructive nature of the fire, and the materials in transformers and other electrical components.

Table 3-122 - Critical facilities in Wildfire Risk Zones

Critical Facility Use	High Risk	Moderate Risk
Airfield	0	0
Animal Health	0	0
Armory	0	0
Childcare	0	0
Communications	0	0
Emergency Operations Center	0	0
Fire Service/ Support/Suppression	0	1
Food Service/Storage	0	2
Fuel Storage/Delivery	1	8
Hazardous Materials Storage	0	8
Medical Services/Support/EMS	0	0
Public Safety/Security	0	4
Research	0	1
Special Populations/Housing/Shelters	0	26
Utilities	2	9
Total:	**3**	**59**

3.8.16.7 Wildfire Risk to Energy Pipelines

Wildfires can damage pipelines because of extreme heat or flame. In addition, other above ground facilities associated with operating the pipeline could be damaged, requiring the pipeline to be shut down. For example, a 2011 wildfire in Raton, New Mexico burned gaskets in Raton Natural Gas Company's pipeline valves[10].

Future Conditions

As the climate warms, the atmosphere can hold more moisture, and precipitation is likely to increase in winter but decline during the summer. Drier soils mean less evaporation, so temperatures increase and there is less recycled moisture in the atmosphere, reducing rain during summer. With increased drying comes increased intensity, frequency, and duration of drought. Increased heat waves and risk of conflagration follow[11].

Jurisdictional Risk

Wildfire hazard ranking is based on NCEI *Storm Events Database*, VDOF data, and population parameters as described in the Ranking Section. The parameters in the risk assessment are described in Table 3-124, along with the total ranking. The geographic extent score for a given jurisdiction is based on the percent of the jurisdiction that falls within the high-risk area as defined by VDOF. Most of the Commonwealth is in the low and medium categories. There are relatively few records in NCEI for wildfire events; as a result, the lowest ranking score (1) was assigned to the majority of the annualized data for events, damages, and deaths and injuries to be able to compare wildfire to the other hazards.

Per the 13-year annualized VDOF timber and property damage data, the Commonwealth can expect approximately $6.9 million in damages per year for wildfire related events. Although an average of 70 structures are damaged or destroyed by wildland fire each year, the agency's firefighting and other measures protect, on average, more than 1,100 others, valued at $130 million[12].

One of the reasons for the difference in the two annualized loss estimates is a result of the VDOF data including all types of damages (such as timber, structures, and personal property) while the NCEI data only documents reported damages to property and crops. Additionally, the VDOF database is a much more complete record of all wildfires in Virginia, while NCEI is known to be an underestimate of the true quantity of events and damages – not just for wildfire, but for all event types. The difference also highlights the fact that wildfire is a predominant hazard in Virginia but seems to be mostly limited to highly forested and rural areas. The following jurisdictions have been assigned a higher risk ranking for wildfire: Clarke County; Albemarle County; Warren County; and Roanoke County.

3.8.16.8 Local Plan Risk Assessment

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

All local plans provided a general description of the hazard. Some of the local plans intersected the VDOF wildfire risk assessment GIS later with critical facilities and/or parcels to determine the percentage of structures at risk. Eight of the 20 local plans provided annualized loss estimates based on VDOF wildfire statistics. The annualized loss values from these plans have been compiled in Table 3-123. The loss values used for the statewide analysis are from the NCEI *Storm Events Database*. The VDOF dataset provides a more complete record of past wildfires and damages to the Commonwealth. Timing and coordination resulted in limitations in using this data as part of the statewide ranking methodology. The completeness of the VDOF data, as compared to the NCEI data, is evident in comparing the local results for Commonwealth RC ($229,381) to the statewide results ($2,952). This is consistent with the differences between NCEI and VDOF discussed in Jurisdictional Risk for the statewide annualized loss totals. The NCEI damages are for only crop and property while the VDOF loss includes all damages caused by the incident.

Table 3-123 - Local Plan Annualized Loss reported post-2016-2021

PDC/Jurisdiction	Annualized Wildfire Loss from Local Hazard Mitigation Plan
Hampton Roads PDC	$36,860
Rappahannock-Rapidan RC	$42,522
Richmond Crater	$231,896
West Piedmont	$400,352

3.8.16.9 Local Plan Comparison

Overall, 19 out of the 20 local plans ranked wildfire. Two local plans ranked wildfire as a high hazard, George Washington Regional Commission and Lenowisco PDC. Thirteen of the 20 regional plans ranked wildfire as a medium hazard, and four ranked as low. The average ranking of the local plans for wildfire was medium. For comparison the State HMP ranking for wildfire is medium-low.

3.8.16.10 Changes in Development

Most 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. One plan, West Piedmont, estimated $400,352 in land use development at risk for wildfire. The West Piedmont Hazard Mitigation Plan also discusses future land use plans and impacts on wildfire vulnerability. Growth expectations within the region are expected to have little impact on the amount of agricultural or forested lands. No significant changes in the size of areas vulnerable to drought and wildfires are likely.[13] Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes.

Table 3-124 - Wildfire Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Low	Low	Low	Low	Low
Albemarle	Medium-High	Medium	Low	Low	Low	Low	Medium	Medium-Low
Alexandria, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Alleghany	Low	Low	Low	Low	Low	Low	Low	Low
Amelia	Low	Low	Low	Low	Low	Low	Low	Low
Amherst	Medium	Medium	Low	Low	Low	Low	Low	Low
Appomattox	Low	Low	Low	Low	Low	Low	Low	Low
Arlington	High	High	Low	Low	Low	Low	Low	Medium-Low
Augusta	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Bath	Low	Low	Low	Low	Low	Low	Low	Low
Bedford	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Bland	Low	Low	Low	Low	Low	Low	Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Low	Low	Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Brunswick	Medium	Low	Low	Low	Low	Low	Low	Low
Buchanan	Medium	Low	Low	Low	Low	Low	Low	Low
Buckingham	Low	Low	Low	Low	Low	Low	Low	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Campbell	Medium	Medium	Low	Low	Low	Low	Low	Low
Caroline	Medium	Low	Low	Low	Low	Low	Low	Low
Carroll	Medium	Medium	Low	Low	Low	Low	Low	Low
Charles City	Low	Low	Low	Low	Low	Low	Low	Low
Charlotte	Low	Low	Low	Low	Low	Low	Low	Low
Charlottesville, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Chesapeake, City of	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Chesterfield	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Clarke	Low	Medium	Low	Low	Low	Low	Medium	Low
Colonial Heights, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Covington, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Craig	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Culpeper	Medium	Medium	Low	Low	Low	Low	Low	Low
Cumberland	Low	Low	Low	Low	Low	Low	Low	Low
Danville, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Dickenson	Low	Low	Low	Low	Low	Low	Low	Low
Dinwiddie	Medium	Low	Low	Low	Low	Low	Low	Low
Emporia	Low	Medium-High	Low	Low	Low	Low	Low	Low
Essex	Low	Low	Low	Low	Low	Low	Low	Low
Fairfax	High	High	Low	Low	Low	Low	Low	Medium-Low
Fairfax, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Falls Church, City of	Low	High	Low	Low	Low	Low	Low	Low
Fauquier	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Floyd	Low	Low	Low	Low	Low	Low	Low	Low
Fluvanna	Medium	Medium	Low	Low	Low	Low	Low	Low
Franklin	Medium	Medium	Low	Low	Low	Low	Low	Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Frederick	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Fredericksburg,	Medium	High	Low	Low	Low	Low	Low	Medium-Low
City of								Low
Galax, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Giles	Low	Low	Low	Low	Low	Low	Low	Low
Gloucester	Medium	Medium	Low	Low	Low	Low	Low	Low
Goochland	Medium	Medium	Low	Low	Low	Low	Low	Low
Grayson	Low	Low	Low	Low	Low	Low	Low	Low
Greene	Medium	Medium	Low	Low	Low	Low	Low	Low
Greensville	Low	Low	Low	Low	Low	Low	Low	Low
Halifax	Medium	Low	Low	Low	Low	Low	Low	Low
Hampton, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Hanover	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Harrisonburg, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Henrico	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Henry	Medium	Medium	Low	Low	Low	Low	Low	Low
Highland	Low	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Hopewell, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Isle of Wight	Medium	Medium	Low	Low	Low	Low	Low	Low
James City	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
King and Queen	Low	Low	Low	Low	Low	Low	Low	Low
King George	Medium	Medium	Low	Low	Low	Low	Low	Low
King William	Low	Low	Low	Low	Low	Low	Low	Low
Lancaster	Low	Medium	Low	Low	Low	Low	Low	Low
Lee	Medium	Low	Low	Low	Low	Low	Low	Low
Lexington, City of	Low	High	Low	Low	Low	Low	Low	Low
Loudoun	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Louisa	Medium	Medium	Low	Low	Low	Low	Low	Low
Lunenburg	Low	Low	Low	Low	Low	Low	Low	Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Madison	Low	Low	Low	Low	Low	Low	Low	Low
Manassas, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Manassas Park, City of	Low	High	Low	Low	Low	Low	Low	Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Mathews	Low	Medium	Low	Low	Low	Low	Low	Low
Mecklenburg	Medium	Low	Low	Low	Low	Low	Low	Low
Middlesex	Low	Medium	Low	Low	Low	Low	Low	Low
Montgomery	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Nelson	Low	Low	Low	Low	Low	Low	Low	Low
New Kent	Low	Medium	Low	Low	Low	Low	Low	Low
Newport News, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Norfolk, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Northampton	Low	Medium	Low	Low	Low	Low	Low	Low
Northumberland	Low	Low	Low	Low	Low	Low	Low	Low
Norton	Low	Medium-High	Low	Low	Low	Low	Low	Low
Nottoway	Low	Low	Low	Low	Low	Low	Low	Low
Orange	Medium	Medium	Low	Low	Low	Low	Low	Low
Page	Medium	Medium	Low	Low	Low	Low	Low	Low
Patrick	Medium	Low	Low	Low	Low	Low	Low	Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Petersburg, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Pittsylvania	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Poquoson	Low	Medium-High	Low	Low	Low	Low	Low	Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Powhatan	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince Edward	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince George	Medium	Medium	Low	Low	Low	Low	Low	Low
Prince William	High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Pulaski	Medium	Medium	Low	Low	Low	Low	Low	Low
Radford, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Rappahannock	Low	Low	Low	Low	Low	Low	Low	Low
Richmond	Low	Low	Low	Low	Low	Low	Low	Low
Richmond, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Roanoke	Medium-High	Medium-High	Low	Low	Low	Low	Medium	Medium-Low
Roanoke, City of	Medium-High	High	Low	Low	Low	Low	Low	Medium-Low
Rockbridge	Medium	Low	Low	Low	Low	Low	Low	Low
Rockingham	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Russell	Medium	Low	Low	Low	Low	Low	Low	Low
Salem, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Scott	Medium	Low	Low	Low	Low	Low	Low	Low
Shenandoah	Medium	Medium	Low	Low	Low	Low	Low	Low
Smyth	Medium	Medium	Low	Low	Low	Low	Low	Low
Southampton	Low	Low	Low	Low	Low	Low	Low	Low
Spotsylvania	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Stafford	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Staunton, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Suffolk	Medium-High	Medium	Low	Low	Low	Low	Low	Medium-Low
Surry	Low	Low	Low	Low	Low	Low	Low	Low
Sussex	Low	Low	Low	Low	Low	Low	Low	Low
Tazewell	Medium	Medium	Low	Low	Low	Low	Low	Low
Virginia Beach, City of	High	High	Low	Low	Low	Low	Low	Medium-Low
Warren	Medium	Medium	Low	Low	Low	Low	Medium	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Washington	Medium	Medium	Low	Low	Low	Low	Low	Low
Waynesboro, City of	Medium	Medium-High	Low	Low	Low	Low	Low	Medium-Low
Westmoreland	Low	Medium	Low	Low	Low	Low	Low	Low
Williamsburg, City of	Low	Medium-High	Low	Low	Low	Low	Low	Low
Winchester, City of	Medium	High	Low	Low	Low	Low	Low	Medium-Low
Wise	Medium	Medium	Low	Low	Low	Low	Low	Low
Wythe	Medium	Medium	Low	Low	Low	Low	Low	Low
York	Medium-High	Medium-High	Low	Low	Low	Low	Low	Medium-Low

The 2023 statewide analysis ranked wildfire as medium-low. Potential detrimental impacts associated with the hazard are included in Table 3-125.

Table 3-125 - Emergency management accreditation program analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized impacts are expected to be severe for the event area, and moderate for the outlying areas including smoke inhalation.
Health and Safety of Response Personnel	Localized impacts could be serious as local responders are working within the impacted area, if they live within the impacted area then they may be displaced for an extended period.
Continuity of Operations	Damage to facilities/personnel around 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 around the event could be severe.
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 impacts expected to be severe for the impacted areas, soil stability impacted, area likely to be vulnerable to landslides. Possible smoke and HAZMAT remediation needed.
Economic and Financial Condition	Local economic and financial conditions may be impacted for a long period depending on duration and geographical area of the event, as well as investigations around the cause of the fire.
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

Community Lifelines Impacted by Wildfire

Based on the hazard analysis and description of vulnerability and impacts of wildfire in Virginia, wildfire impacts the following community lifelines:

- Health and Medical
- Food, Water, Shelter
- Energy
- Safety and Security
- Transportation

3.8.17 Winter Weather

3.8.17.1 Background

Winter weather events are typically regional in nature and therefore impacts are felt throughout large sections and sometimes the entire state of Virginia. The winter season in Virginia generally consists of cold temperatures, snow or ice accumulations and the potential for strong winds. Winter weather can adversely impact roadways, utilities, usual business activities, cause health risks (i.e., frost bite and freezing conditions) and even in some cases loss of life.

Virginia has a long history of significant hazardous winter weather, which occurs in many different forms whether independently (i.e., such as snow, freezing rain, ice conditions, wind, etc.) or can occur in combination. The National Weather Service (NWS), NOAA defines winter weather event as a “winter weather phenomenon (such as snow, sleet, ice, wind chill) that impacts public safety, transportation, and/or commerce. It typically occurs during the climatological winter season between October 15 and April 15."

During winter weather events, communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians. The image below shows a recent winter weather event (January 3, 2022) that paralyzed motorists overnight along I-95 in Virginia.

This image provided by the Virginia Department of Transportation shows a closed section of Interstate 95 near Fredericksburg, Va., Monday Jan. 3, 2022. Both northbound and southbound sections of the highway were closed due to snow and ice. (Source: VDOT via Associated Press)

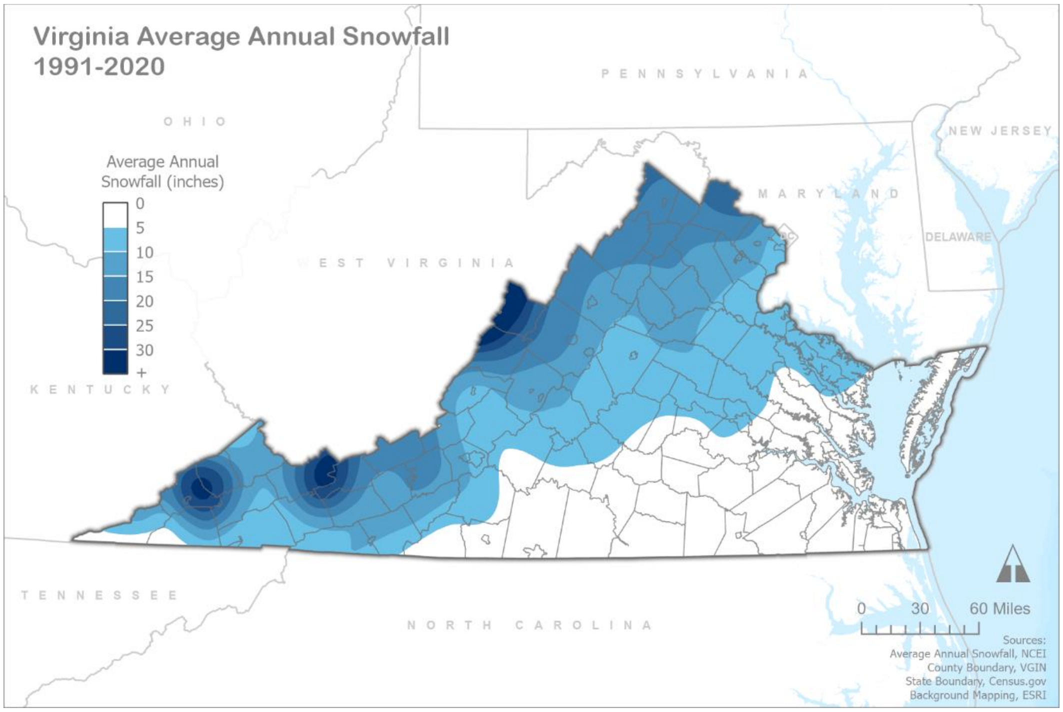
Virginia's biggest winter weather threat comes from a storm pattern known as a Nor'easter. The NWS defines a Nor'easter as "a storm along the East Coast of North America, so called because the winds over the coastal area are typically from the northeast. These storms may occur at any time of year but are most frequent and most violent between September and April." Further the NWS states that Nor'easters usually "develop in the latitudes between Georgia and New Jersey, within 100 miles east or west of the East Coast." These storms progress generally northeastward and nearly always bring precipitation in the form of heavy rain or snow, as well as winds of gale force, rough seas, and, occasionally, coastal flooding and erosion to the affected regions. The combination of heavy frozen precipitation and strong winds is destructive and often damaging to trees and utility lines. Nor'easters may occur from September through April, but are usually at their worst in January, February, and March in Virginia.

Regardless of precipitation, excessively cold temperatures also pose occasional threats to the Commonwealth. A freeze is weather marked by low temperatures, but definitions of extreme cold can vary dramatically across the state and country. While wind chill advisories are issued nearly every year, life-threatening excessive cold is a rare occurrence, and the impact of such events depends on the preparedness of individual households and heating fuel/energy providers. House fires and carbon monoxide poisoning are possible as people use supplemental heating devices (wood, kerosene, etc.) and fuel burning lanterns or candles for emergency lighting.

3.8.17.2 Location and Spatial Extent

Winter weather events are regular occurrences in Virginia and can occur throughout the state. The average annual snowfall in Virginia is greatest in the northern and western portions of the state. Average annual snowfall across Virginia ranges from 5 inches or less inches in the southeast to over 30 inches along localized sections along the western Virginia border of the state (Figure 3-141).

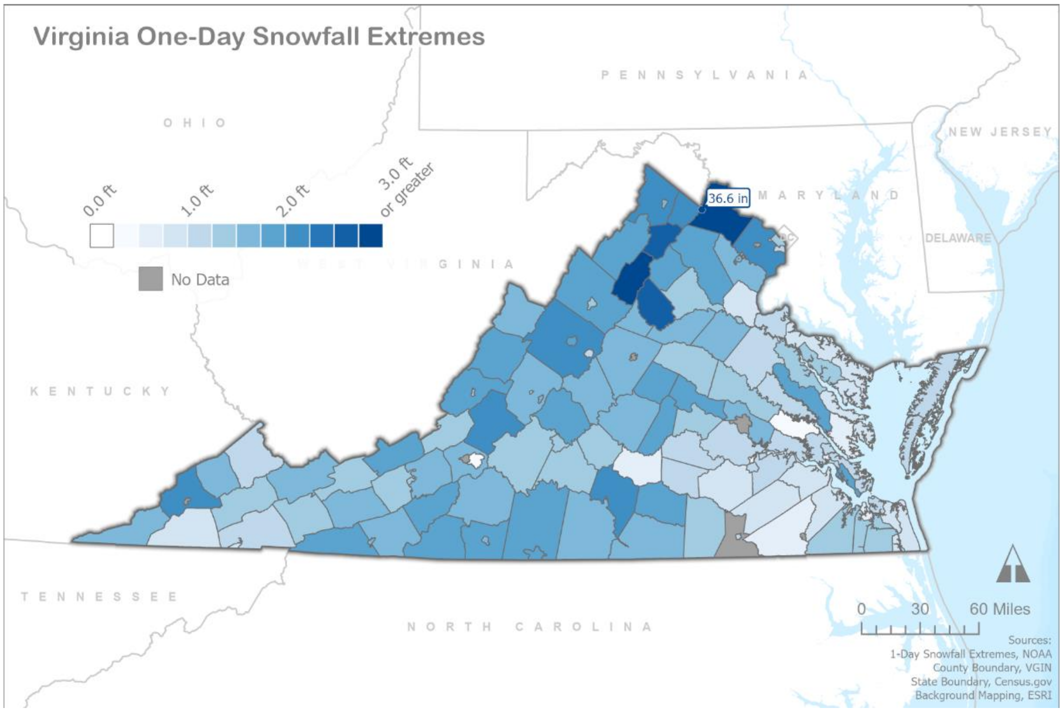
Figure 3-141 - Map of Average Annual Snowfall across Virginia



Source: Southeast Regional Climate Center

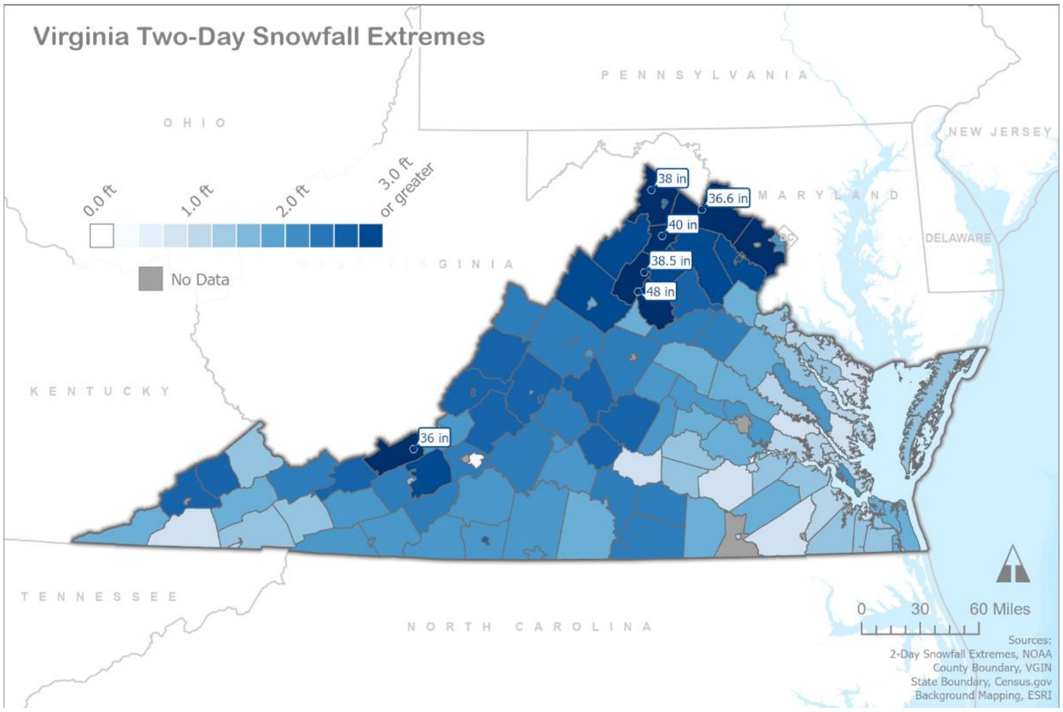
In Virginia, the western and northern parts of the state experience increased maximums in terms of snowfall events according to NOAA NCEI climate monitoring snowfall extreme data from 1895-2021. This is highlighted in Figure 3-141 through Figure 3-144. The figures show the 1-, 2- and 3-day maximums of snowfall events across Virginia. Note that the northern and western portions of the state result in greater snowfall maximums under all three conditions. Areas along the east and southeastern portions of the state generally see lower snowfall maximums.

Figure 3-142 - Map of 1-day snowfall maximums from each County in Virginia



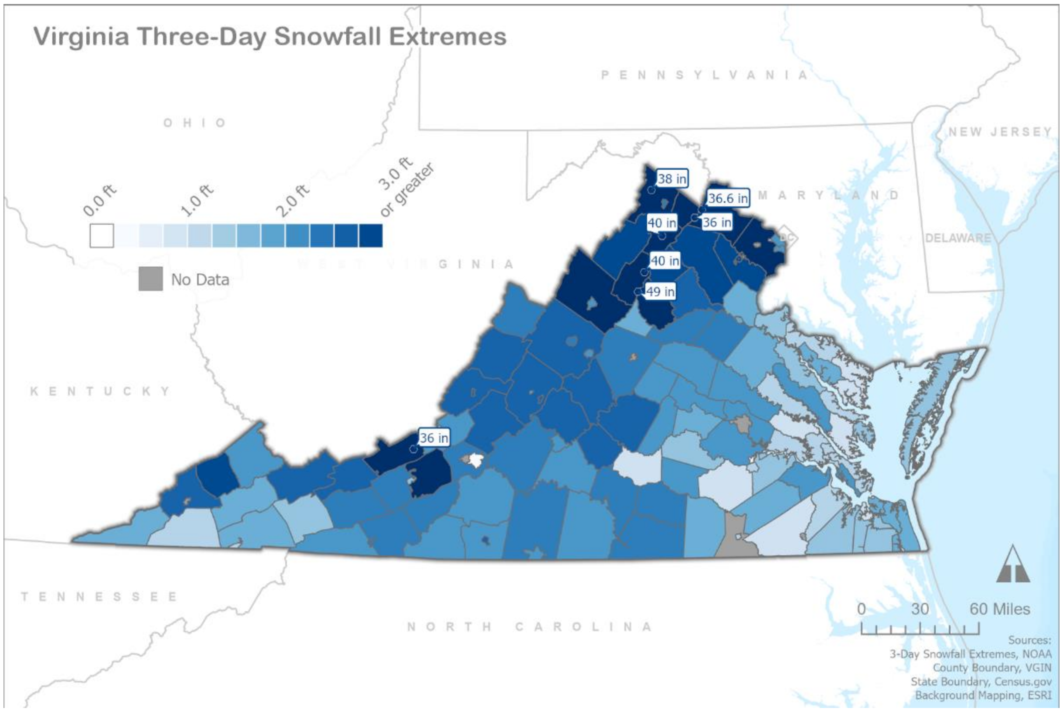
Source: NOAA NCEI Climate Monitoring Snowfall Extremes. Data were last updated on January 11, 2022, to accommodate data through June 30, 2021.

Figure 3-143 - Map of 2-day snowfall maximums from each County in Virginia



Source: NOAA NCEI Climate Monitoring Snowfall Extremes. Data were last updated on January 11, 2022, to accommodate data through June 30, 2021.

Figure 3-144 - Map of 3-day snowfall maximums from each County in Virginia



Source: NOAA NCEI Climate Monitoring Snowfall Extremes. Data were last updated on January 11, 2022, to accommodate data through June 30, 2021.

3.8.17.3 Significant Historical Events

The Regional Snowfall Index (RSI) provides a useful methodology for classifying snowstorms based on societal impact. The RSI is an evolution of the Northeast Snowfall Impact Scale (NESIS) which the NCEI began producing in 2005. NESIS focuses on the impact of storms in the Northeast, while the RSI divides the US into six easternmost climate regions (Northern Rockies and Plains, Upper Midwest, South, Ohio Valley, Northeast, and Southeast) and develops a separate index for each of those regions based on region-specific parameters and population impact considerations[1]. Virginia is part of the Southeast region. The RSI differs from other indices because it includes population, which ties the index to societal impacts. Currently, the index uses population based on the 2020 Census.

The RSI values range from 1 to 18+ or 'notable' to 'extreme'[2]. It is possible for Virginia to experience the entire range of the scale. Researchers at the NCEI have calculated the scores for high-impact storms dating back to the 1900s and therefore the index puts a particular event into a century scale historical perspective (Table 3-126). A Category 5 snowstorm is a very rare event while Category 0 and 1 snowstorm are quite typical.

Table 3-126 - Regional snowfall index (RSI)

Category	RSI Raw Score	Approximate Percent of Storms	Description
5	>18	1%	Extreme
4	10-18	2%	Crippling
3	6-10	5%	Major

Category	RSI Raw Score	Approximate Percent of Storms	Description
2	3-6	13%	Significant
1	1-3	25%	Notable

Source: NCEI, 2021

The most noteworthy and significant winter storms affecting Virginia in recent decades include the following:

- **January 23-26, 2000:** This Nor'easter brought snowfalls between 5 and 20 inches to the eastern half of Virginia, which does not frequently receive such snow depths. Heavy winds created blizzard conditions and created snowdrifts between 4 and 5 feet in some areas. Significant flooding and erosion affected coastal areas including the Grandview area of Hampton. This event was rated a 7.229 on the southeast region RSI scale, or major. A subsequent storm with significant ice accumulations occurred on January 30, leading Governor Gilmore to declare a state of emergency. (FEMA DR-1318).
- **February 13-17, 2003:** The most significant storm of the 2003-04 winter season impacted most of the state. Three rounds of precipitation resulted in 20 to 36 inches of snow across far northern Virginia. This decreased to between 7 and 12 inches of snow and sleet in the central part of the state and to several inches of sleet and/or 1/4 to 1/2 inch of ice accretion in the south. A 24-hour snowfall of 16.7 inches at Ronald Reagan National Airport was the fifth highest on record. Flooding and mudslides occurred in Southwest and Northern Virginia because of this storm. This event scored a 5.933 on the southeast region RSI scale, described as significant. (FEMA DR-1458)
- **February 11-12, 2004:** A winter storm brought significant snow across to northern and central Virginia; accumulations in most of the state ranged from 5 to 8 inches. Northern Virginia and Washington DC received 10 to 15 inches. Nearly 300,000 customers in northern Virginia were without power due to downed trees and power lines.
- **December 26, 2004:** The Day after Christmas Ice and Winter Storm brought a narrow band of snowfall to Virginia's Eastern Shore and southeast Virginia. Snow depths of up to a foot accumulated in York County, Accomack County, Northampton County, Isle of Wight County, Newport News, and Poquoson.
- **December 18-21, 2009:** A nor'easter that formed over the Gulf of Mexico developed into a winter storm affecting much of the East Coast. This event was rated a 12.776 on the southeast region RSI scale, or crippling. This snowstorm resulted in a federal disaster declaration. Buchanan, Virginia reported 27 inches of snow on December 19, 2009. (FEMA DR-1874)
- **February 4-7, 2010:** A nor'easter affecting northern Virginia was rated an 8.103 on the southeast region RSI scale, or major. February 6th was the greatest recorded 1-day snowfall of 34 inches at the Lincoln weather station near Purcellville, Virginia. This snowstorm was a federally declared disaster.
- **January 22-24, 2016:** A severe winter storm and snowstorm, rated 7.66 on the RSI scale, or crippling. The storm is fifth on the list of historic storms ranked on the NESIS scale. This storm resulted in a federal disaster declaration. (FEMA DR-4262)

- **February 11-13, 2021:** Mixtures of snow, sleet, and freezing rain resulted in widespread power outages and some of the worst icing impacts in over two decades. This storm resulted in a federal disaster declaration. (FEMA DR-4602)
- **January 3, 2022:** Winter storm, rated 3.4 (significant) on the RSI scale. The heaviest snow fell across the Virginia Piedmont around the Fredericksburg Metropolitan area. Snowfall totaled up to 1 to 3 inches across extreme northern Virginia, 3 to 6 inches around the Washington Metropolitan area, and 6 to 12 inches across central Virginia into the Virginia Piedmont, including the Fredericksburg Metropolitan area. There were localized amounts just over 12 inches in portions of the Fredericksburg Metropolitan area. (FEMA DR-4644)

3.8.17.4 Probability of Future Occurrence

The probability of future winter weather events is usually determined empirically based on the historical frequency of occurrence of such events. The NCEI *Storm Events Database* records winter weather events and damages dating back to 1996, but it does not systematically document the magnitude or intensity of each event. Long-term weather station observation data provides more detailed information on event magnitude (as measured by snowfall depth, precipitation types, and temperature) but does not provide any information regarding historical impacts. Other sources of information relating to winter weather climatology include the Southeast Regional Climate Center, the Oregon State University's PRISM Group, as well as a variety of other national, regional, and local organizations.

Rather than using existing climatology information, independent analyses of weather station data were performed to estimate the probability of specific winter weather occurrences. While some of the ready-to-use data sources may be sufficient for planning purposes, they are typically limited to certain standard climate normal products. In this plan, independent analyses were used to illustrate the usage of the raw weather station data and to stimulate interest in using weather station data for other purposes.

Using daily weather station data involves decisions about which weather stations to include in the analysis and how to handle data gaps. In deciding which weather stations to use, the location, period of record, and data variables reported are the key factors. Virginia stations with substantially complete data from 1960 through 2000 were chosen for this analysis. Small interruptions or gaps exist in these stations' data records, which may indicate periods when the station was not operational. Entire years with no data were removed from consideration when conducting the analyses in this report, but smaller data gaps were ignored.

As a result, the statistics generated from this data may slightly underestimate the frequency or intensity of winter weather phenomena. More involved techniques may improve this area of the analysis, if desired. To assess the probability and intensity of winter storm events, weather station data were downloaded from the NCEI archives.[3] A selection of cooperative (COOP) weather stations operating between 1960 and 2000 was loaded into a Microsoft Access database to determine the annual frequency of occurrence of certain conditions. The daily station data variables relevant to this investigation include 24-hour snowfall depth, minimum temperature, and daily weather type codes.

In addition to the frequency and depth of snowfall, the effects of winter weather on Virginia's residents are particularly severe when winter storms bring freezing rain, sleet, and ice/snow mixtures. The broad network of COOP weather stations used to estimate snowfall frequency and depth does not provide sufficient information to identify these different types of precipitation. Precipitation type classifications have been recorded by a smaller set of weather stations for many years, which are located primarily at major airports around the state. These classifications, reported on an hourly and/or daily basis, can be used to identify the dominant type of precipitation during the period of observation.

Precipitation type data (DSI-3200 element DYSW) were downloaded and processed in a manner like the snowfall and temperature data. Many specific weather types were aggregated into simpler categories during this process. Only a few stations with substantially complete monitoring from 1984 through 2007 were considered for this investigation. The spatial distribution of the selected weather stations is not broad enough to depict the dominant weather types on a state-wide level. As noted previously in this section, these analyses are subject to some errors due to incomplete reporting; more thorough handling of gaps in the period of record could produce results that are more reliable. However, this simple analysis is sufficient for depicting the general nature of winter weather in Virginia. A more detailed analysis could also be performed using hourly precipitation type codes; but as with the daily codes, not all stations report this data.

Based on this analysis – which remains accurate in this plan update – winter weather will continue to be highly probable throughout Virginia. The northern and western parts of the state will receive winter weather almost annually, while the southern and southeastern portions will receive significant winter weather approximately once a decade.

Impact and Vulnerability

Winter weather vulnerability is a factor of individual, property, and societal elements. At the individual level, the potential for exposure to extreme cold, falling on ice-covered walkways, and automobile accidents is heightened during winter weather events. Potential personal property damage due to winter storms includes tree damage, water pipe breakage, structural failure due to snow loads, and injury to livestock and other animals.

Societal damages include disruption of utility distribution networks and transportation systems, as well as lost business and decreased productivity. The vulnerability to these individual, property, and societal damages varies based on specific factors; for example, proactive measures such as tree maintenance and utility system winterization can minimize property vulnerability. Localities experiencing winter storms on a regular basis are typically less vulnerable than localities that rarely experience winter weather, as they are typically better prepared and more experienced in managing the event and the response to it, as are the residents of the area.

The impacts of winter storms are primarily measured in terms of the financial cost associated with managing and recovering from them. The relationship between winter storm event magnitude and actual financial impact is difficult to model. Factors such as event timing and human perception complicate the relationship between overall magnitude and subsequent impact.

Winter storms involving ice formation or accumulation are typically much more damaging than events consisting purely of snow.

The primary source of data providing some measurement of winter storm impacts is the NCEI *Storm Events Database*. This data dates to 1996 and is not always complete or consistent. A comprehensive analysis of weather station data, NCEI damages, and other relevant GIS data could possibly produce an intensity-damage relationship between winter weather occurrences and resultant damages. However, given the complexity of such an analysis, and the relatively short period for which NCEI has recorded winter storm damage estimates, this type of analysis has not been undertaken as part of this plan.

To make the winter weather vulnerability analysis more robust the NCEI data was supplemented with additional winter weather information that was collected by Virginia Modeling, Analysis & Simulation Center (VMASC) at Old Dominion University. To summarize damages caused by winter weather events over the past 10 years data was reviewed from VMASC and is summarized in Table 3-127 from 2012-2022.

Table 3-127 - Summary of Winter Weather Events and Damages, 2012-2022

Year	Event Type	Total Damage	Description
2012	Heavy Snow	$1,210,000	With the aid of increasing moisture supplied by the remnants of Hurricane Sandy, combined with a strong upslope wind, heavy snow was reported during a 4-day period. The heaviest snow was recorded in the higher elevation where up to 30 inches was reported breaking records for total snowfall. The northern valley was blanketed with 1 to 4 inches of snow.
2013	Heavy Snow	$35,000	As the low became the dominant feature a large swath of moderate to heavy snow developed and persisted especially north of I-64 with embedded banding bringing 1-2 per hour rates in spots. Snowfall in some of the mountains north of Roanoke ranged up to 6 to 12 inches with isolated higher amounts but with considerably less fell at lower elevations and further south. There were several reports of tree and power line damage reported from the heavy wet snow in the northern counties.
2013	Winter Weather	$20,000	Early morning snowfall ranging from a dusting to 0.2 inches contributed to several accidents on I-81 causing major delays. Snowfall may have contributed to an accident on I-81 in Pulaski County.
2014	Heavy Snow	$787,500	During the day on Thursday, February 13, 2014, the axis of heaviest snowfall to be centered along parts of the New River and upper Roanoke valleys.||Snowfall totals averaged 6 to 10 inches along and east of a Martinsville to Lynchburg line, 10 to 14 inches across the Mountain Empire part of southwest Virginia, 12 to 16 inches just east of the crest of the Blue Ridge and north into the southern Shenandoah valley, with 16 to 26 inches in an area between Covington Virginia south into the Blacksburg to Roanoke region and farther south to near Galax. The highest end of this range was centered over Floyd County. ||Sleet amounts were generally less than an inch between Martinsville and Danville. Freezing rain occurred mainly along and east of a line from Martinsville to Buckingham. Amounts ranged from around one tenth of an inch to one quarter of an inch.
	Winter Storm	$590,000	Tuesday, February 11, 2014. During the day on Thursday, February 13, 2014, the axis of heaviest snowfall to be centered along parts of the New River and upper Roanoke valleys.||Snowfall totals averaged 6 to 10 inches along and east of a Martinsville to Lynchburg line, 10 to 14 inches across the Mountain Empire part of southwest Virginia, 12 to 16 inches just east of the crest of the Blue Ridge and north into the southern Shenandoah valley, with 16 to 26 inches in an area between Covington Virginia south into the Blacksburg to Roanoke region and farther south to near Galax. The highest end of this range was centered over Floyd County. ||Sleet amounts were generally less than an inch between Martinsville and Danville. Freezing rain occurred mainly along and east of a line from Martinsville to Buckingham. Amounts ranged from around one tenth of an inch to one quarter of an inch.

Year	Event Type	Total Damage	Description
	Winter Weather	$168,000	Numerous auto accidents were reported across the Piedmont of Virginia into the New River Valley as a weak wedge of high pressure allowed temperatures across much of the area to fall into the low 30s and upper 20s.
2015	Winter Storm	$45,000	Snow, sleet, and freezing rain overspread far western Virginia around 0300E on the 21st. After 1 to 2 inches of wet snow in the river valleys, the snow changed to freezing rain for 3 to 4 hours during the morning. Ice accumulations reached a maximum of a quarter of an inch. The freezing rain became mostly rain by midday for these low elevations. However, in the higher terrain of eastern Buchanan and eastern Dickenson Counties, wet snow continued into the afternoon before ending as drizzle that evening. Clintwood observed 4 to 5 inches of snow. One spotter from the Sandy Ridge area, near the Wise County border, reported 18 inches of snow.
2016	Winter Weather	$130,000	A severe winter storm and snowstorm resulted in a federal disaster declaration. (FEMA DR-4262). An upper-level disturbance brought light snow to areas along and near the Interstate 81 corridor between Pulaski and Botetourt Counties. While snowfall amounts were generally less than one inch for most areas, motor vehicle accidents occurred and caused traffic delays on major arteries in the area.
2017	Winter Storm	$95,000	A winter storm produced 8 to as much as 12 inches of snow across southcentral and southeast Virginia. Some specific higher snow totals included: City of Hampton 12", Prince George in Prince George County 11-12", Skippers in Greensville County 12", Dinwiddie in Dinwiddie County 11", Lunenburg in Lunenburg County 11", City of Norfolk 7-9", and Lawrenceville in Brunswick County 11". Local law enforcement agencies reported numerous accidents.
	Winter Weather	$6,000	Low pressure moved from North Carolina to the Delmarva Peninsula on the 5th of January. This storm produced accumulating snowfall across the entire region as it moved by. Across the Central Piedmont and Fredericksburg area, freezing rain and sleet was mixed in with the snow. The snow and sleet accumulations ranged from 4 to 6 inches in this area. Along the Blue Ridge Mountains and the Central Shenandoah Valley, snowfall accumulations ranged from 5 to 7 inches. Across the Northern Shenandoah Valley and Northern Virginia, snowfall totals between 5 and 8 inches were reported.
2018	Winter Storm	$200,000	Strong low pressure tracking northward just off the East Coast produced between three inches and fourteen inches of snow across Eastern Virginia.
2019	Winter Weather	$500,000	Moisture from the Atlantic Ocean overran surface colder air in place, resulting in some freezing drizzle and light freezing rain. Ice amounts ranged from a trace to a couple hundredths of an inch over the Blue Ridge Mountains into portions of the Shenandoah Valley in Virginia.
	Winter Storm	$75,000	A complex winter storm scenario where precipitation types where observed alternating at times between snow, sleet and freezing rain. In addition to numerous power outages, the wintry mix resulted in hazardous road conditions, where the Virginia State Police responded to nearly 60 traffic crashes and roughly 35 disabled vehicles. One person was killed on Interstate 81 due to an automobile accident.
2020	N/A	N/A	
2021	Ice Storm	$1,870,000	Significant ice accretion between 0.25 inch and 0.50 inch due to freezing rain across much of central and south-central Virginia, and the Virginia northern neck. Numerous trees and power lines were downed, with widespread power outages reported due to the ice accretion. Mixtures of snow, sleet, and freezing rain resulted in widespread power outages and some of the worst icing impacts in over two decades. This storm resulted in a federal disaster declaration. (FEMA DR-4602)
	Winter Storm	$970,000	Precipitation fell in the form of freezing rain and sleet across central and south-central Virginia, and the Virginia Northern Neck, as a couple of weak low-pressure areas tracked northeast along and off the Southeast and Mid Atlantic Coasts. There were two distinct waves of precipitation that moved across the area. One that occurred during the early morning-midday on the 18th, and a second wave of light to moderate precipitation that moved across the region during the early to mid-morning on the 19th. This resulted in significant ice accretion between 0.20 inch and 0.40 inch, along with sleet accumulations between 0.5 inch and 1.5 inches. Several trees and power lines were downed, with numerous power outages reported.
	Winter Weather	$235,000	The combination of Arctic high pressure ridging into the Mid-Atlantic region, and weak low-pressure areas tracking across the Carolinas and off the Mid Atlantic coast, resulted in minor ice accretion between a trace and 0.20 inch due to light freezing rain or freezing drizzle across portions of southeast Virginia.

Year	Event Type	Total Damage	Description
2022	Winter Storm	$63,500	On January 3rd, low pressure tracked along a cold front and intensified while doing so, bringing a period of snow to most of northern and central Virginia. The heaviest snow fell across the Virginia Piedmont around the Fredericksburg Metropolitan area. Snowfall totaled up to 1 to 3 inches across extreme northern Virginia, 3 to 6 inches around the Washington Metropolitan area, and 6 to 12 inches across central Virginia into the Virginia Piedmont, including the Fredericksburg Metropolitan area. There were localized amounts just over 12 inches in portions of the Fredericksburg Metropolitan area.

Data from the above table is from Virginia Modeling, Analysis & Simulation Center (VMASC).

The Southeast Regional Climate Center released a technical paper from the University of Virginia Climatology Office in May of 1993 titled Frequency of Weather-Related Tree Damage in Virginia. This report analyzed tree damage reported in NOAA's Storm Data publication from 1959-1991, noting damages due to a variety of weather events, including severe winter weather. Among other findings, the analysis found that while more snow events occurred in western and northern jurisdictions, tree damages were reported throughout the state[4]. It was noted in an article titled "Severe Weather Preparedness" by Joel Koci (Urban Forestry Higher Education Seat – Trees Virginia Board Member), November 12, 2019, that due to the increased population density in urban areas that there was a greater risk of a disruption of our daily life from extreme weather events even during storms defined as having "normal wind events or precipitation events". The article further mentioned that, with increased amount of precipitation events more preparation is needed to reduce property damage and monetary loss due to tree damage.

The state and local agencies most often affected by winter storms include VDOT, and in some cases, local public works departments. Roadway treatment operations often commence prior to the actual onset of a winter storm and continue for as long as necessary in a prioritized manner. Theoretically, a database of historical response costs could provide some insight into winter storm impacts. However, since the public demand for roadway treatment and response is almost never fully met, such data on historical roadway treatment operations in response to winter storms may be more indicative of budget constraints than of relative storm magnitude.

Risk

For the State 2023 HMP, the overall hazard ranking for winter weather is medium-low.

While the annual probability of winter weather conditions can be estimated, data on the total financial impact of these events is not complete. Risk, strictly defined as probability multiplied by impact, cannot be fully estimated for winter storm due to the lack of accepted intensity-damage models for winter storm events. Therefore, projected annualized dollar losses cannot be estimated. However, a rough estimate of financial impact can be developed based on the NCEI Storm Events database, although such an estimate is subject to the biases and inconsistencies present in those data. In the 20 years from 1996 through 2016, NCEI reports a statewide annual average of approximately $5.4 million per year. However, the available historic winter storm descriptions indicate that the total societal cost of these storms is much higher, as these estimates do not include road-clearing costs, lost productivity, energy costs, and others.

The winter weather frequency data show a strong trend toward more winter weather occurring in areas at higher latitudes and at higher elevations. The mountainous western portion of the state and the furthest northern portions of the state experience winter weather more often and with greater severity. However, all portions of the state are subject to winter weather events. While the magnitude of damages from winter storm are perhaps not typically as great as extreme flooding or a severe earthquake, winter storms occur much more frequently and usually over broader areas. In addition, storm events with relatively low intensity can nevertheless cause significant impacts, especially in areas unaccustomed to such events.

Winter weather hazard zones were developed from the snowfall frequency results discussed above. This scoring system, as shown in Table 3-128, is used to identify facilities at risk, and to identify the jurisdictions exposed to the greatest winter weather hazards.

Table 3-128 - Winter Weather Parameters

Winter Weather Hazard Zone	Average Annual Number of Days with at least 3 inches of snow
Low	<1.5 days
Medium-Low	1.5-2 days
Medium-High	2-3 days
High	>3

3.8.17.5 State Facility Risk

State facilities were intersected with the GIS layer indicating average annual number of days with at least three inches of snowfall. Annualized loss was not calculated due to the lack of established winter weather probabilities and lack of building specific data (including valuation).

The total number of facilities located in the potential damage zones is summarized in Table 3-129. Approximately 22-percent of the state facilitates are in an area with a high winter weather hazard.

Table 3-129 - State Facilities at risk for winter weather

Winter Weather Hazard Zone	Number of State Facilities
Low	4,099
Medium-Low	2,304
Medium-High	3,637
High	2,763
Total	**12,803**

The results of this analysis indicate 2,763 buildings are in a high hazard zone for winter weather. Those 2,763 buildings can be divided between 78 different agencies in Virginia. The top five of those agencies have been listed in Table 3-130. The agencies listed represent approximately 8-percent of the buildings owned by the Commonwealth, almost 38-percent of the buildings that are within a high hazard zone.

Table 3-130 - Top Five Agencies in a High Hazard Zone for Winter Weather

Agency	Number of Buildings in High Hazard Zone

Virginia Polytechnic Institute and State University	749
James Madison University	191
University of Virginia at Wise	51
Woodrow Wilson Rehabilitation Center	38
Western State Hospital	20
Total	**1,049**

3.8.17.6 Critical Facility Risk

Risk for critical facilities was determined by the same parameters used above in state facilities; these results are presented in Table 3-131[4]. Annualized loss was not calculated due to the lack of established winter weather probabilities and lack of building specific data (including valuation).

Table 3-131 - Critical facilities at risk for Winter Weather

Winter Weather Risk	Law Enforcement	Transportation	Public Health	Emergency Response	Education	Total
Low	241	22	434	937	1,121	**2,755**
Medium-Low	81	9	77	372	239	**778**
Medium-High	172	12	365	902	1,192	**2,643**
High	166	13	195	620	484	**1,478**
Total	**660**	**56**	**1,071**	**2,832**	**3,036**	**7,655**

3.8.17.7 Winter Weather Risk to Energy Pipelines

Winter weather may impact pipelines in one of two ways. First, ground motion due to frost heave can put pressure on brittle pipelines possibly resulting in breakage. Second, snow and ice accumulations may damage the control mechanisms that support pipeline operations or may damage regional power or telecommunication systems necessary for routine pipeline operations.

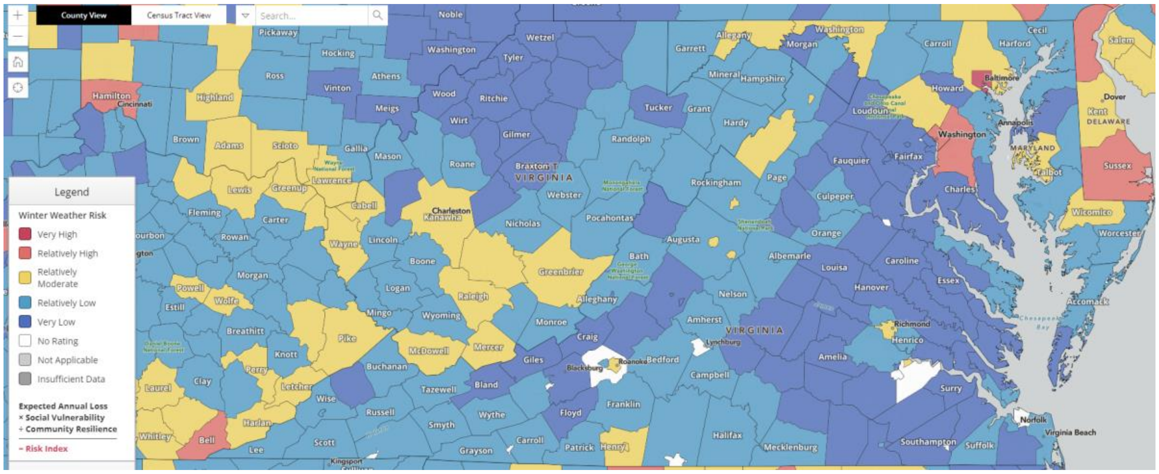
3.8.17.8 National Risk Index

The National Risk Index (NRI) includes three components: a *natural hazards component* (**Expected Annual Loss**), a *consequence enhancing component* (**Social Vulnerability**), and a *consequence reduction component* (**Community Resilience**). Using these three components, a composite Risk Index score and hazard type Risk Index scores are calculated for each community (county and Census tract) included in the Index.

For the purposes of this SHMP/HIRA update the qualitative summary for winter weather are reviewed for each community (county tract).

As shown in Figure 3-145, the greatest risk rating for winter weather is identified as relatively moderate within the cities of Richmond, Staunton, Harrisburg, Martinsville, and Hopewell as well as Henry County. The remainder of the state varies from relatively low to very low, with the bulk of very low risk rating in the eastern part of the state.

Figure 3-145 - National Rating Map – Winter Weather



As discussed previously, these measurements are calculated using average past conditions, but they cannot be used to predict future outcomes for a community. The National Risk Index is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies.

Future Conditions

Recent studies in Virginia address documented trends in average temperature and precipitation during winter. Analyses of temperature change by climate division in Virginia show the largest maximum and minimum temperature anomalies – departures from long term average – during the winter season. In all climate divisions, these anomalies are in the positive direction, indicating an overall warming trend[5]. The largest winter warming trends in both minimum and maximum temperature are in Northern Virginia. However, these warming trends are statistically significant for the eastern 5 of Virginia's 6 climate divisions for maximum temperature, and significant in Tidewater, Eastern Piedmont, and Northern Virginia for minimum temperature. Additionally, NOAA NCEI defines the annual number of very cold nights as nights when the minimum temperature reaches 0°F or lower. Since the 1990s, the overall number of very cold nights has been below the long-term average[6]. Overall, there has been little significant trend in the average amount of winter precipitation, which remains highly variable[5].

Most projections of climate change focus on temperature and precipitation, with few studies available that explicitly explore projections of winter weather precipitation type in Virginia. Snowfall is already relatively infrequent in some winter months and in the southeastern portions of Virginia, making projections challenging. The frequency of snowfall occurrence will probably decrease up to 25%, mostly in interior Virginia during December, January, and February, due to projected increases in winter temperatures given continued warming under both the RCP 4.5 and RCP 8.5 scenarios[7]. Broadly, the rain-snow transition zone in the eastern United States is shifting northward[8]. Some theoretical studies show it is possible that as temperatures warm storms that would previously have been snow could produce freezing rain or ice instead[9], but studies could not be located for this assessment that quantify projections of this likelihood for Virginia.

Global ocean surface temperatures have increased at a rate of +.18ºF each decade since 1950. Some research has shown that increasing ocean surface temperature and reductions in Arctic Sea ice may produce atmospheric circulation patterns that are favorable for winter storm development in the eastern US. Notably, a greater prevalence of high-pressure blocking patterns over the North Atlantic that result in cold outbreaks in the eastern US, along with slow moving systems can further exacerbate the longevity and severity of a snowstorm.

Studies have shown that natural variability associated with El Nino conditions has a strong relationship and influence on the incidence of severe snowstorms in the eastern US. An analysis of 100 storms in six regions east of the Rocky Mountains found that severe snowstorms are approximately twice as likely to occur in the eastern US – north and south – during years when a moderate to strong El Nino is present as compared to years when more neutral conditions are present[10].

Jurisdictional Risk

The hazard ranking for winter weather is based on damages reported in the NCEI *Storm Events Database* and a generalized geographic extent rating developed from the weather station data. Annualized crop and property damages received a low (1) ranking due to the small or infrequent amounts of damages as compared to the other hazards; injuries and fatalities were also ranked as low (1). These parameters in the winter weather risk assessment are detailed in Table 3-133, along with the total ranking. In general, the trends in low temperatures, snowfall, and other winter precipitation types all tend to indicate the same geographic areas experiencing more frequent winter weather. The highest winter weather risk is in western and northern Virginia, with generally decreasing risk towards the southeast.

The jurisdictions with higher winter weather risk are listed below.

- Clarke County
- Augusta County
- Frederick County
- Loudoun County
- Rockingham County
- Warren County
- City of Harrisonburg
- Highland County
- Page County
- Shenandoah County
- Fauquier County
- Rappahannock County
- Greene County
- City of Waynesboro
- City of Staunton
- City of Winchester
- Washington County
- Prince William County
- Fairfax County
- City of Roanoke
- City of Alexandria
- Arlington County
- Montgomery County
- Carroll County
- Wise County
- City of Norton
- Pulaski County
- Smyth County
- City of Galax
- Tazewell County
- City of Radford
- Craig County
- Wythe County

3.8.17.9 Local Plan Risk Assessment

Local hazard mitigation plans were reviewed for spatial data sources used, historical occurrences, hazard probabilities, vulnerability, loss estimations, and land use and development trends. When available, this information supplements the text and figures of each of the sections in this revision.

Nineteen of the 20 local plans assigned winter weather a hazard rank and gave a general description of winter weather and impacts for their region. Two plans discussed roadways with very steep slopes and increased transportation risk during periods of winter storms and the impact on roads and infrastructure. Some plans developed relative risk hazard zones for snowfall and ice potential. Five plans summarized NCEI data that was used to derive annualized loss values (Table 3-132). The annualized loss values used by the local plans are like the summarized data used in the statewide ranking.

Table 3-132 - Local plan winter weather annualized loss reported post-2016

PDC/Jurisdiction	Winter Weather Annualized Loss
Richmond - Crater PDC	$40,411
Commonwealth RC	$5,590
Rappahannock-Rapidan RC	$135,425
Hampton Roads	$805,800
West Piedmont PDC	$214,958

3.8.17.10 Local Plan Comparison

Overall, 19 out of the 20 the local and regional plans ranked winter weather. Out of the 19 that provided a ranking 12 ranked winter weather as a high hazard, 6 ranked as a medium hazard, and 1 ranked as a low hazard (Northern Neck PDC). The overall hazard ranking for winter weather for the 19 local and regional plans that reported was high. For comparison, the 2023 State HMP ranked winter weather as a high hazard.

3.8.17.11 Changes in Development

Most 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. Sixteen of the 20 local plans cite their comprehensive plans for current and future land use changes. Although winter weather was considered high for more than half of the local plans no information was given to reflect changes in development in the hazard prone areas.

Table 3-133 - Winter Weather Hazard Ranking Parameters

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Accomack	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Albemarle	Medium-High	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Alexandria, City of	Medium-High	High	Low	Low	Low	High	High	Medium
Alleghany	Low	Low	Low	Low	Low	Medium	Medium	Low
Amelia	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Amherst	Medium	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Appomattox	Low	Low	Low	Low	Low	Medium	Medium	Low
Arlington	High	High	Low	Low	Low	High	High	Medium
Augusta	Medium-High	Medium	Low	Low	Low	High	High	Medium
Bath	Low	Low	Low	Low	Low	Medium	Medium	Low
Bedford	Medium-High	Medium	Low	Low	Low	Medium-High	Medium-High	Medium
Bland	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Botetourt	Medium	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Bristol, City of	Low	Medium-High	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Brunswick	Medium	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Buchanan	Medium	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Buckingham	Low	Low	Low	Low	Low	Medium	Medium	Low
Buena Vista, City of	Low	Medium-High	Low	Low	Low	Medium	Medium	Medium-Low
Campbell	Medium	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Caroline	Medium	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Carroll	Medium	Medium	Low	Low	Low	High	High	Medium
Charles City	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Charlotte	Low	Low	Low	Low	Low	Medium	Medium	Low
Charlottesville, City of	Medium	High	Low	Low	Low	Medium	Medium	Medium-Low
Chesapeake, City of	High	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Chesterfield	High	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Clarke	Low	Medium	Low	Low	Low	High	High	Medium-Low
Colonial Heights, City of	Medium	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Covington, City of	Low	Medium-High	Low	Low	Low	Medium	Medium	Medium-Low
Craig	Low	Low	Low	Low	Low	High	High	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Culpeper	Medium	Medium	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Cumberland	Low	Low	Low	Low	Low	Medium	Medium	Low
Danville, City of	Medium	Medium-High	Low	Low	Low	Medium	Medium	Medium-Low
Dickenson	Low	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Dinwiddie	Medium	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Emporia	Low	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Essex	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Fairfax	High	High	Low	Low	Low	High	High	Medium
Fairfax, City of	Medium	High	Low	Low	Low	Medium-High	Medium-High	Medium
Falls Church, City	Low	High	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Fauquier	Medium-High	Medium	Low	Low	Low	High	High	Medium
Floyd	Low	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Fluvanna	Medium	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Franklin	Medium	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Franklin, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Frederick	Medium-High	Medium	Low	Low	Low	High	High	Medium
Fredericksburg City of,	Medium	High	Low	Low	Low	Medium-High	Medium-High	Medium
Galax, City of	Low	Medium-High	Low	Low	Low	High	High	Medium
Giles	Low	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Gloucester	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Goochland	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Grayson	Low	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Greene	Medium	Medium	Low	Low	Low	High	High	Medium
Greensville	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Halifax	Medium	Low	Low	Low	Low	Medium	Medium	Medium-Low
Hampton, City of	Medium-High	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Hanover	Medium-High	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Harrisonburg, City of	Medium	High	Low	Low	Low	High	High	Medium
Henrico	High	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Henry	Medium	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Highland	Low	Low	Low	Low	Low	High	High	Medium-Low
Hopewell, City of	Medium	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Isle of Wight	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
James City	Medium-High	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
King and Queen	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
King George	Medium	Medium	Low	Low	Low	Medium-High	Medium-High	Medium-Low
King William	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Lancaster	Low	Medium	Low	Low	Low	Medium-Low	Medium-Low	Low
Lee	Medium	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Lexington, City of	Low	High	Low	Low	Low	Medium	Medium	Medium-Low
Loudoun	High	Medium-High	Low	Low	Low	High	High	Medium
Louisa	Medium	Medium	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Lunenburg	Low	Low	Low	Low	Low	Medium	Medium	Low
Lynchburg, City of	Low	Medium-High	Low	Low	Low	Medium	Medium	Medium-Low
Madison	Low	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Manassas, City of	Medium	High	Low	Low	Low	Medium-High	Medium-High	Medium
Manassas Park, City of	Low	High	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Martinsville, City of	Low	Medium-High	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Mathews	Low	Medium	Low	Low	Low	Medium-Low	Medium-Low	Low
Mecklenburg	Medium	Low	Low	Low	Low	Medium	Medium	Medium-Low
Middlesex	Low	Medium	Low	Low	Low	Medium-Low	Medium-Low	Low
Montgomery	Medium-High	Medium	Low	Low	Low	High	High	Medium
Nelson	Low	Low	Low	Low	Low	Medium	Medium	Low
New Kent	Low	Medium	Low	Low	Low	Medium-Low	Medium-Low	Low
Newport News, City of	High	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Norfolk, City of	High	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Northampton	Low	Medium	Low	Low	Low	Medium-Low	Medium-Low	Low
Northumberland	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Norton	Low	Medium-High	Low	Low	Low	High	High	Medium
Nottoway	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Orange	Medium	Medium	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Page	Medium	Medium	Low	Low	Low	High	High	Medium
Patrick	Medium	Low	Low	Low	Low	Medium	Medium	Medium-Low
Petersburg, City of	Medium	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Pittsylvania	Medium-High	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Poquoson	Low	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Portsmouth, City of	Medium-High	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Powhatan	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Prince Edward	Medium	Medium	Low	Low	Low	Medium	Medium	Medium-Low
Prince George	Medium	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Prince William	High	Medium-High	Low	Low	Low	High	High	Medium
Pulaski	Medium	Medium	Low	Low	Low	High	High	Medium
Radford, City of	Low	Medium-High	Low	Low	Low	High	High	Medium
Rappahannock	Low	Low	Low	Low	Low	High	High	Medium-Low
Richmond	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Richmond, City of	High	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Roanoke	Medium-High	Medium-High	Low	Low	Low	Medium	Medium	Medium-Low
Roanoke, City of	Medium-High	High	Low	Low	Low	High	High	Medium
Rockbridge	Medium	Low	Low	Low	Low	Medium	Medium	Medium-Low
Rockingham	Medium-High	Medium	Low	Low	Low	High	High	Medium
Russell	Medium	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Salem, City of	Medium	High	Low	Low	Low	Medium	Medium	Medium-Low
Scott	Medium	Low	Low	Low	Low	Medium-High	Medium-High	Medium-Low
Shenandoah	Medium	Medium	Low	Low	Low	High	High	Medium
Smyth	Medium	Medium	Low	Low	Low	High	High	Medium
Southampton	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Spotsylvania	Medium-High	Medium	Low	Low	Low	Medium-High	Medium-High	Medium
Stafford	Medium-High	Medium-High	Low	Low	Low	Medium-High	Medium-High	Medium
Staunton, City of	Medium	Medium-High	Low	Low	Low	High	High	Medium
Suffolk	Medium-High	Medium	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Surry	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Sussex	Low	Low	Low	Low	Low	Medium-Low	Medium-Low	Low
Tazewell	Medium	Medium	Low	Low	Low	High	High	Medium
Virginia Beach, City of	High	High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Warren	Medium	Medium	Low	Low	Low	High	High	Medium
Washington	Medium	Medium	Low	Low	Low	High	High	Medium

Jurisdiction Name	Population Vulnerability	Population Density	Injuries and Fatalities	Property Damage	Crop Damage	Events	Geographic Extent	Total Risk Ranking
Waynesboro, City of	Medium	Medium-High	Low	Low	Low	High	High	Medium
Westmoreland	Low	Medium	Low	Low	Low	Medium-Low	Medium-Low	Low
Williamsburg, City of	Low	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low
Winchester, City of	Medium	High	Low	Low	Low	High	High	Medium
Wise	Medium	Medium	Low	Low	Low	High	High	Medium
Wythe	Medium	Medium	Low	Low	Low	High	High	Medium
York	Medium-High	Medium-High	Low	Low	Low	Medium-Low	Medium-Low	Medium-Low

For the 2023 plan, the overall hazard ranking for winter weather is high. Potential detrimental impacts associated with the hazard are included in Table 3-134.

Table 3-134 - Emergency Management Accreditation Program Analysis

Subject	Detrimental Impacts
Health and Safety of Public	Localized and expansive impact expected to be severe to extensive for event areas. Power outages may cause health risks to residents to cold temperatures during these events.
Health and Safety of Response Personnel	Localized impacts expected to be minor unless the response personnel encounter transportation hazards or live within the impacted area.
Continuity of Operations	Damage to or inability to get to the 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 impacts expected to be moderate, including downed trees or limbs.
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.

Community Lifelines Impacted by Winter Weather

Based on the hazard analysis and description of vulnerability and impacts of winter weather in Virginia, winter weather impacts the following community lifelines:

- Health and Medical
- Food, Water, Shelter
- Energy
- Safety and Security
- Communications
- Transportation

Endnotes

1 National Oceanic and Atmospheric Administration (NOAA). Regional Snowfall Index (RSI). Retrieved 04.11.17 from https://www.ncdc.noaa.gov/snow-and-ice/rsi/

2 National Oceanic and Atmospheric Administration (NOAA). Regional Snowfall Index (RSI). Retrieved 04.11.17 from https://www.ncdc.noaa.gov/snow-and-ice/rsi/

3 Currently hosted at: http://hurricane.ncdc.noaa.gov/CDO/cdo

4 University of Virginia Climatology Office. "Frequency of Weather Related Tree Damage in the State of Virginia." Southeast Regional Climate Center Technical Paper Series, May 1993. Copy obtained from the University of Virginia Climatology Office. Print.

5 National Centers for Environmental Information. "Climate change and extreme snow in the US." Retrieved 05.04.17 from https://www.ncdc.noaa.gov/news/climate-change-and-extreme-snow-us

3.9 Summary/Conclusions

3.9.1 Overall Ranking Results

As previously discussed, the local plan ranking compares agreeably to the new ranking that was developed for this report. Hazards that were considered negligible were included as textual descriptions within the above hazard sections. This includes erosion, extreme heat, and extreme cold. Analysis was not completed on human caused and hazardous materials since VDEM has separate plans that address these hazards in detail. Table 3-135 shows the overall ranking results of this plan.

To determine the overall hazard ranking, the total ranking values (RS value) for each of the hazards were separately averaged to determine what hazards should be considered the most significant in Virginia.

Table 3-135 - Overall hazard ranking for the Commonwealth of Virginia

High	Medium-High	Medium	Medium-Low	Low	Negligible
Flood Hurricane Winter Weather	Tornado Non- Tornadic Wind Extreme Heat	Drought Extreme Cold	Pandemic Earthquake Wildfire	Impoundment failure Karst (sinkholes) Landslide Erosion	Land Subsidence Space Weather

The individual hazard sections provide information and analysis tables for which jurisdictions are considered high risk areas. As stated, multiple times in this section, this analysis is only representative of the NCEI data that were used. It is known that the time period of this data is short in comparison to the known historical events. For example, Hurricane Camille in 1969 is before the period of record kept on flooding and landslide, although both were experienced during that event.

Following the development and review of the HIRA, the Committee began developing mitigation actions for Virginia. Several local hazard mitigation plans had very recently added Radon Exposure as a relevant hazard, and the topic of radon was again discussed among Working Committee members in relation to mitigation action development. Planners determined that Radon Exposure was worthy of a brief discussion in the HIRA because at least one mitigation action project was developed to address the hazard.

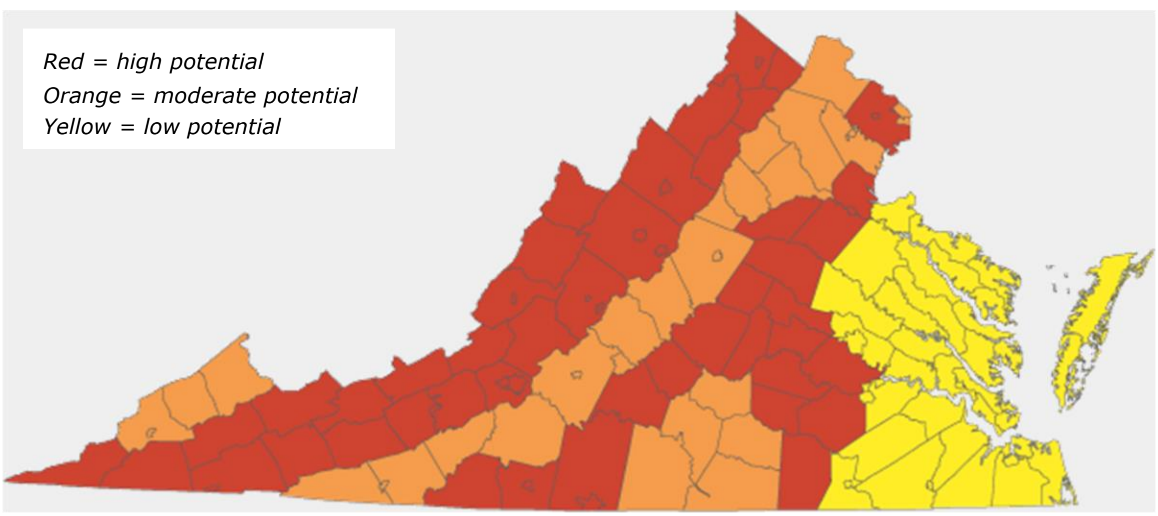
The following brief description of Radon Exposure is excerpted from the *2022 Richmond Crater Hazard Mitigation Plan* where additional information on this hazard may be located:

Radon is a colorless, odorless naturally occurring gas that forms by the radioactive decay of uranium, thorium, or radium, found in certain types of rocks, soil, and groundwater. Radon is found naturally in the atmosphere in trace amounts, where it disperses rapidly and is generally not a health issue. Radon exposure becomes dangerous in confined areas, where the gas can accumulate, and the inert gas can be inhaled into the lungs where it adheres to lung tissue. Under the earth’s surface, radon may be transported as a soil gas or dissolved in ground water. It can enter a building via cracks in solid floors, construction joints, cracks in walls, gaps in suspended floors, gaps around service pipes and drains, cavities inside walls or through the water supply.

The concentration of radon in buildings is highly variable and is based on the underlying rocks or sediments, weather and construction methods. The amount of radon emitted by a particular soil is controlled by the underlying rock type, the concentration of uranium, thorium, or radium in the rock or sediment, and the permeability of the rock, sediment and soil. The EPA recommends taking action to reduce radon in homes, schools or other buildings that have a radon level at or above 4 picocuries per liter (pCi/L) of air (a "picocurie" is a common unit for measuring the amount of radioactivity).

Radon exposure from ground sources happens over a long period of time, often remaining undetected, thus historical "events" are rarely quantifiable. Section 307 and 209 of the 1988 Indoor Radon Abatement Act directed the EPA to identify areas of the United States that have the potential to produce elevated levels of radon. As part of this study, two very limited data sources were analyzed in Virginia: 1) indoor radon data from 1,156 random homes were sampled in the winter of 1991-1992; and 2) non-random commercial data compiled by EPA Region 3. The resulting map of radon zones for Virginia (Figure 3-147) is based on an assessment of five factors that are known to be important indicators of radon potential: indoor radon measurements, geology, aerial radioactivity, soil parameters and foundation types. Virginia Code at Section 15.2-2280 currently provides all red zone counties and cities the option of requiring passive radon resistant construction features.

Figure 3-146 - EPA Map of Radon Zones, Virginia, 1993



3.9.1.1 Overall Social Vulnerability for the Commonwealth of Virginia

As defined within hazard sections Flooding, Hurricane, and Tornado social vulnerability measures the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. Only the highest-risk communities in Virginia are shown in Figure 3-147. Each community in the Commonwealth of Virginia's social vulnerability depends on individual communities' ability to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions while keeping their expected annual losses low. These hazards were summarized and discussed within the individual hazard sections in this HIRA. The summary ratings shown below in Figure 3-147 and in Table 3-136 give us a general sense of which communities are better prepared to withstand the impact of any of the natural hazards defined by FEMA's NRI.

Figure 3-147 - Summary Map of Social Vulnerability for all Hazards

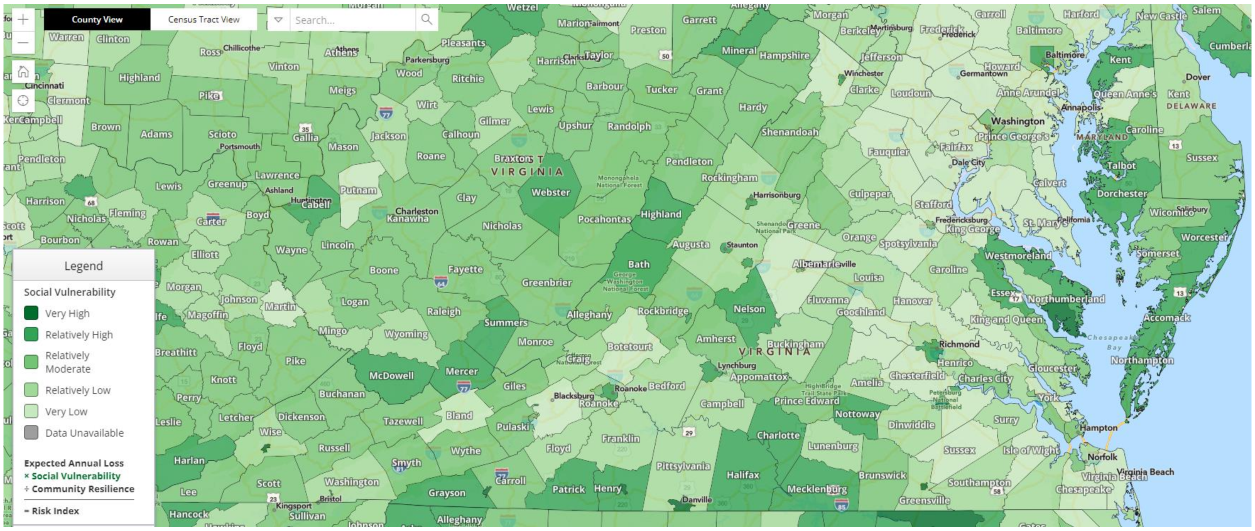


Table 3-136 - Commonwealth of Virginia - Highest Social Vulnerability Ratings

County/City	SVI Rating
Petersburg City	Very High
Lancaster County	Very High
Northampton County	Relatively High
Bath County	Relatively High
Roanoke City	Relatively High
Northumberland County	Relatively High
Mecklenburg County	Relatively High
Halifax County	Relatively High
Nottoway	Relatively High
Richmond City	Relatively High
Essex County	Relatively High
Accomack County	Relatively High

3.9.1.2 Estimating Potential Losses

The local hazard mitigation plans were reviewed to determine if the local plan loss estimates could be summarized to create statewide loss estimates. During the review it was noticed that some plans did not include complete loss estimates and others were highly variable in the methodology used. A summary of the local plan loss estimates for hurricane and flood is provided under Flooding and Hurricane "Probability of Future Occurrence". The variability in the local loss estimates limits the ability to integrate them into a statewide vulnerability and loss estimate.

Rough estimates of annualized losses can be generated based on the NCEI Storm Events Database, which documents the damages associated with the various hazards. Supplemental annualized loss values for flooding, hurricane winds, and earthquake have also been derived from the other sources as described in each individual hazard section. NCEI did not include any historical information about damages due to any geologic hazard and is not included in the loss estimates. Impoundment failure was not included as part of the hazard ranking due to lack of data. See the Impoundment Failure for more details.

Based on information from the NCEI database, the Commonwealth of Virginia can expect approximately $138,671,522 in annualized damages due to all the hazards that impact Virginia. As discussed in Section 3.5 these data have limitations due to the period of record and reporting methodology for significant events.

Table 3-137 below illustrates the number of years of record for each hazard, total damages reported in 2022 dollars, and annualized loss values. Flooding and non-rotational wind make up approximately two-thirds of annualized damages. The estimates given for annualized loss are only based on the hazard categories that were determined to be significant types in Virginia. It includes the NCEI categories that make up each of the established HIRA hazard types used in this analysis.

Annualized Loss by Jurisdiction

The NCEI information was also used as parameters in the hazard ranking. The hazard specific section includes information regarding annualized loss by jurisdiction. The ranking and risk parameter maps show the annualized property and crop damages, injuries and deaths, and events as established using NCEI data. The hazards that used an established method for calculating annualized loss (flood, non-rotational winds, and earthquake) are explained in detail in those sections.

Annualized loss from VDOF is included in this table but was not used as the final annualized loss value for the Commonwealth.

Hazus loss estimates are significantly higher than the NCEI estimates. This is to be expected as the Hazus results consider total direct economic losses including damage to structural, non-structural, building contents, inventory loss, relocation, income loss, rental loss and wage loss. NCEI loss estimates are solely based on the *reported* crop and property damage of past events. Although the numbers are different, each version of the annualized loss has hurricane winds as the highest loss hazard in the Commonwealth followed directly by flooding.

Table 3-137 - Annualized loss values from NCEI and additional sources

Hazard Type	Timeframe	Years of Record	Number of Events	Property Damage	Crop Damage
Drought	1996-2021	20	2,252	$0	$628,619,080
Earthquake					
Erosion					
Flood	1996-2021	20	5,419	$980,609,886	$84,344,132
Hurricane					
Impoundment Failure					
Karst (Sinkholes)					
Landslide	1998-2021	18	4	$178,800	$0
Land Subsidence					
Non-Tornadic Wind	1950-2021	60	15,081	$1,810,217,911	$206,307,329
Pandemic					
Tornado	1951-2021	65	848	$556,135,086	$3,130,788
Space Weather					
Wildfire	1996-2021	20	46	$15,867,904	$1,891,704
Winter Storm	1996-2021	20	9,817	$73,129,081	$57,461,552
Totals				**$3,436,019,467**	**$981,754,585**
Annualized Totals		**$138,674,522**		**$108,297,409**	**$30,817,409**

3.9.1.3 Comparison with Local Ranking

The Local Plan Incorporation section shows the average ranking for the local plans and statewide analysis. Several of the hazard categories that were addressed in the local plans were not considered in the main body of the state plan; these include hazardous materials, terrorism, and biological/radiological incidents. The COVEOP has separate plans that address human caused, radiological incidents, and hazardous materials incidents. Erosion, extreme heat, and extreme cold do not include a detailed hazard analysis and risk assessment but are included as part of this HIRA as their own section. Hazards such as thunderstorm, lightning, and hail have been included as textual descriptions within major hazard sections. Of the hazards considered, the average rankings in local and state analysis are analogous.

Minor differences in the local and statewide ranking were observed. Tornado received a medium ranking for the local plans but was elevated to a medium-high risk in the state plan. Winter weather received a ranking of high in the local plans but was reduced to a medium ranking for the state plan. Earthquake and landslide received a local plan average ranking of low and the statewide analysis resulted in a medium-low ranking. As discussed previously, a detailed analysis was not completed for erosion, extreme heat, and extreme cold.

3.9.1.4 Evaluation of Changing Land Use, Development and Population on Vulnerability

General land use and population trends in Virginia over the last decade were previously summarized. Figure 3-148 summarizes population change from 2010 to 2020, showing population growth in Northern Virginia and Hampton Roads communities. Four of the nine hazards were considered high risk in Northern Virginia communities, a region simultaneously experiencing a large surge in population and development.

South-central and southwest Virginia have relatively lower development pressure, and in some extreme cases, are seeing population decline which decreases development pressure. While many hazards could potentially impact these areas, low population and thus lower exposure, results in a lower risk ranking for many hazards.

Local hazard mitigation plans could be strengthened with improved information about land use and future development planning, perhaps using information from comprehensive plans. Generalized information about land use planning has been made at the State level but really should be evaluated locally. Land use planning, completed at the local level, can reduce risk to the population and infrastructure by addressing the hazards that impact the jurisdiction. It is necessary for this to be done at the jurisdictional level since this is where planning, regulation, and taxation happen. For example, jurisdictions in the Ridge and Valley region could evaluate karst risk and the possibility of enacting zoning ordinances to limit development or population growth in areas known to have sinkhole development. Currently, revisions and updates to land use data are dependent on the sophistication of the local government and the need or ability to update the data.

Figure 3-149 summarizes more recent changes in population (from 2016 to 2021) further highlighting areas of population increases in urban and suburban communities in the Northern Virginia, Richmond, and Hampton Roads areas. Figure 3-150 summarizes changes in residential development patterns based on the number of residential construction permits issued. Growth in the number of permits over the period from 2016 to 2021 indicate a combination of increases in the housing stock through the addition of new residential buildings and gentrification or redevelopment with new buildings replacing older housing stock. Increases in the housing stock suggests that more housing units, and associated infrastructure like utilities, will be vulnerable to damages from hazards, while gentrification and redevelopment suggests that more higher valued residential assets will be vulnerable to damages from hazards.

Figure 3-148 - Recent Population Change in the Commonwealth of Virginia, 2016-2021

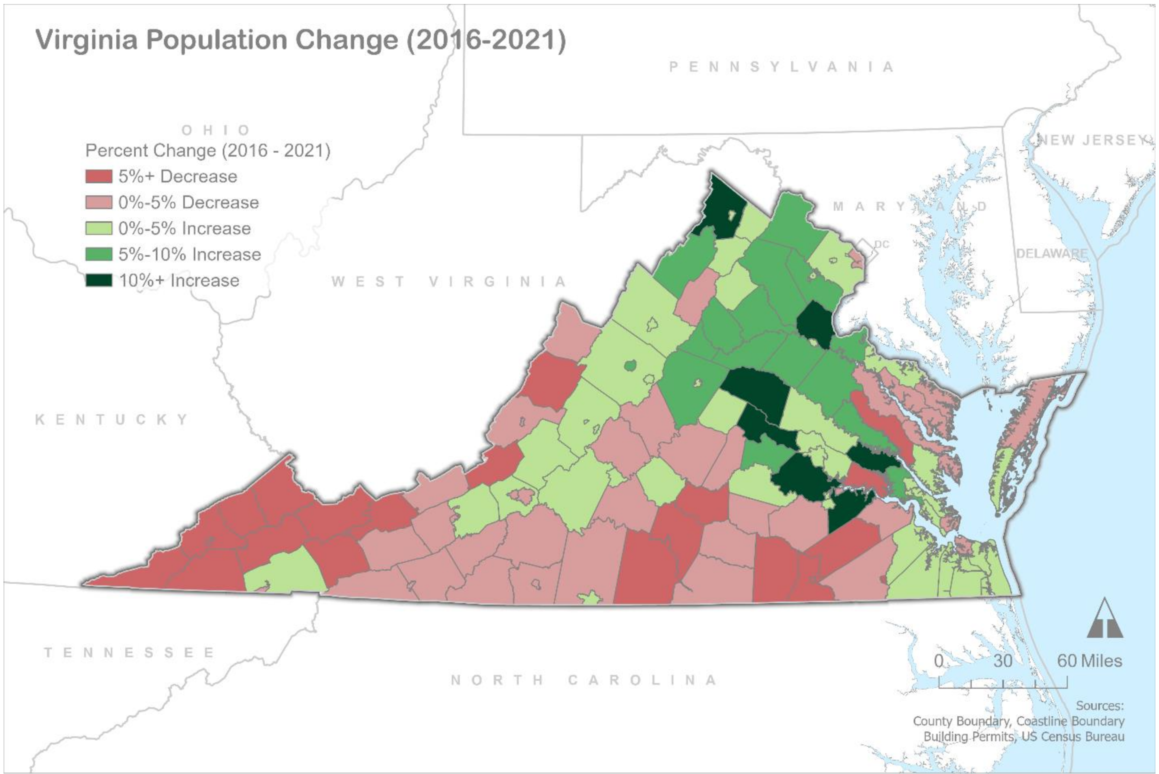
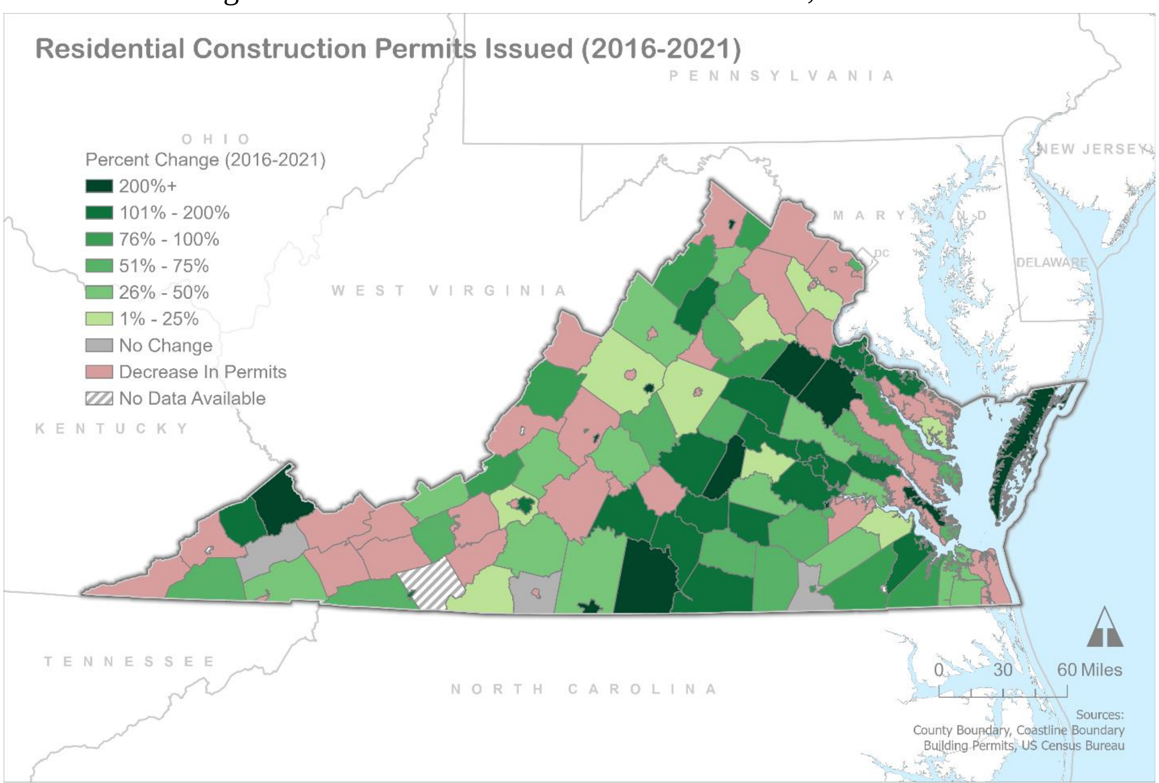


Figure 3-149 - Change in Residential Construction Permits Issued, 2016-2021



A combination of population growth and increases in the number or value of the housing stock points to areas with the most development pressure and expected land use changes in the near future. Population growth and development are often accompanied by increases in state facilities and infrastructure to better serve the population. While state investment in new state facilities and infrastructure has been minimal over the last five years, these changes in population and development patterns might factor into location decisions of future state assets, in turn affecting the vulnerability of these assets.

Figure 3-150 shows the combined changes in population and building permits from 2016 to 2021. Notable areas with growth in both the population and the housing stock include Spotsylvania County, Caroline County, Louisa County, Goochland County, Chesterfield County, New Kent County, and King George County. None of the nine hazards were considered high risk in these jurisdictions as summarized in the current analysis and identified in local hazard mitigation plans. Across these jurisdictions, the highest hazard risk was Medium-High for tornados for Chesterfield County. Spotsylvania County was identified as Medium risk for flooding, hurricane, and winter weather.

Given the moderate population vulnerability and density in five of these more rural jurisdictions (Caroline County, Louisa County, Goochland County, New Kent County, and King George County), coupled with low social vulnerability, development pressures are expected to contribute to modest growth in the number of citizens, homes, businesses and infrastructure at risk to hazards in general. In terms of future hazards, changes in population and development are not expected to significantly increase the number of injuries and fatalities, property or crop damage, and geographic extent of the different hazards in the future.

For the more densely populated jurisdictions with a greater number of residents (Chesterfield County, Spotsylvania County), the population growth and increase in the number of homes or the value of homes may increase the risk of damage from hazards such as tornados, hurricanes, earthquakes, flooding, and winter weather. For these jurisdictions, developmental pressures may increase the number of injuries and fatalities, property damage, and the geographic extent of these hazards in the future. Increases in population density may increase the injuries and fatalities associated with a future pandemic.

In contrast, several communities – particularly in Northern Virginia - saw significant population increases without significant increases in the housing stock, which suggests changes in development may be needed in the near future to accommodate the population growth. This rapid development may also have an impact on investment in and location of state assets, with implications for future vulnerability.

Demographic analyses by the Weldon Cooper Center for Public Service (https://demographics.coopercenter.org/virginia-population-projections) show that population growth and development are not uniform across the state. Many rural communities such as in the southwestern and south central parts of the state have experienced a population decline, which is projected to continue over the future decades. The composition of the population has also changed, with the share of youth (under 19 years) and working-age adults (20 to 64 years) declining and expected to continue to shrink. In contrast, the share of older residents (65 years and older) has increased, and the trend is expected to increase into the next decade, from 12% of the overall state population in 2010 to 15% in 2020 and an expected 18% in 2030. Rural parts of the state are seeing more pronounced decrease in population and increase in the elderly population due to outmigration of the working age population. For example, Lancaster County experienced a decline in its population – 37% of residents in the county are over the age of 65 years. These demographic changes will have implications in terms of social vulnerability and may influence locational decisions of state assets needed to serve an aging population, such as health and transportation infrastructure. With an increasing elderly population comes decreases in financial resources, mobility and ability to prepare for and respond to hazards. This population would be particularly vulnerable to hazards such as extreme heat, extreme cold, pandemic, hurricane, flooding, and winter weather.

Figure 3-150 - Changes in Population and Residential Building Permits, 2016-2021

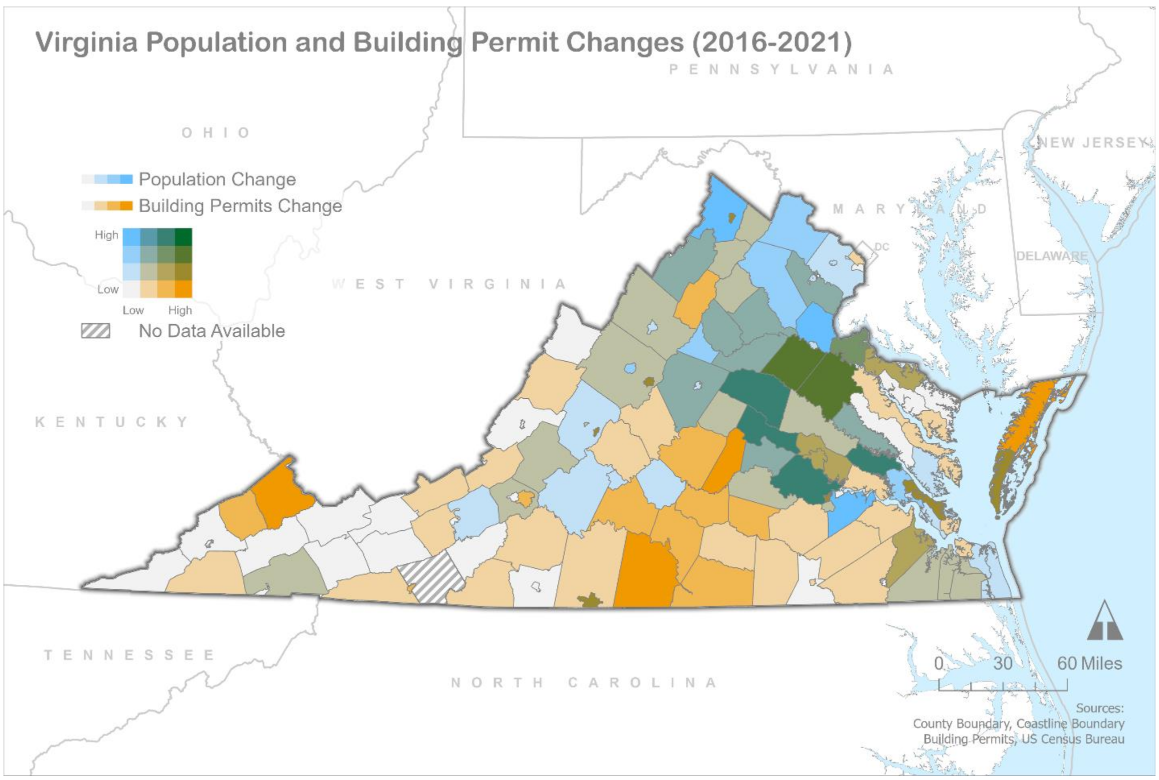


Table 3-138 summarizes the characteristics of jurisdictions experiencing development pressure and how future characteristics may impact future vulnerability to hazards, in general.

Table 3-138 - Characteristics of jurisdictions experiencing development pressure

Hazard Type	Suburban and Developing Localities		Rural and Developing Localities				
	Chesterfield County	Spotsylvania County	Louisa County	Goochland County	King George County	Caroline County	New Kent County
Population vulnerability	High	Medium-High	Medium	Medium	Medium	Medium	Low
Population density	Medium-High	Medium	Medium	Medium	Medium	Low	Medium
Social vulnerability	Very Low	Very Low	Relatively Low	Very Low	Very Low	Relatively Low	Very Low
% of population over 65 years in 2020	16%	15%	21%	23%	14%	17%	18%
Number of state assets in locality	364	66	47	224	35	74	23
Value of state assets in locality	$924,421,450	$98,007,874	$21,364,090	$348,223,662	$30,434,872	$26,018,971	$6,750,957

Table 3-139 provides more specific information about how the demographic and development characteristics stated above impact state assets for each specific hazard in the jurisdictions experiencing development pressure.

Table 3-139 - Impacts to state assets in jurisdictions experiencing development pressure

Hazard	Suburban and Developing Localities	Rural and Developing Localities
Drought	Drought impacts are negligible on structures; however, Pocahontas State Park and Lake Anna State Park, and other natural resources may be more vulnerable to drought, especially if development pressure causes changes in ground cover, tree cover, habitat and other natural features.	Drought impacts are negligible on structures; however, state parks and other natural resources may be impacted by drought, especially if development pressure is increasing vulnerability.
Earthquake	New roads, bridges and state-owned buildings in Chesterfield County add vulnerability due to location near seismic zone.	Potential vulnerability increase with new roads, bridges and state-owned buildings.
Erosion	Vulnerability slightly increases as more people reside in the areas, and private and public assets are sited in areas vulnerable to erosion.	Development may impact natural areas and water resources of the Commonwealth, which may further downstream erosion or cause sediment/water quality problems.
Extreme Cold	Vulnerability increases as more people will be vulnerable to disruptions to state assets (such as the transportation network) and utilities.	Impacts will increase as more people will be vulnerable to disruptions to state assets (such as the transportation network) and utilities.
Extreme Heat	Vulnerability increases as more people will be vulnerable to disruptions to state assets and utilities. Increases in urban heat island effect caused by rooftops, roadways, and other pavement areas worsens the hazard.	Impacts will increase as more people will be vulnerable to disruptions to state assets and utilities. Reduction in tree cover may worsen the hazard.
Flooding	Impacts will increase as flood vulnerability increases with more development and reductions in permeable surfaces. Urban and stormwater flood risk to existing development increases and state resources may be needed to support revised flood mapping. Risk to existing infrastructure (dams, bridges, culverts, etc) if design conditions change.	Changes in land cover, tree cover, and other geomorphologic features impacts stream hydrology. State resources may be needed to support revised flood mapping. Risk to existing infrastructure (dams, bridges, culverts, etc) if design conditions change.

Hazard	Suburban and Developing Localities	Rural and Developing Localities
Hurricane	Vulnerability increases as more people, private property, and state assets will be vulnerable to hurricanes. Additional state recovery resources may be needed in post-disaster scenario for recovery of transportation routes and debris management.	As New Kent County develops, state assets therein may become more vulnerable to wind and storm surge. Changes in land cover can impact wind fetch, tree health and soil stability during a hurricane.
Impoundment Failure	If flood vulnerability increases as a result of urbanization, the risk of impoundment failure and impacts to state assets downstream may increase if dams are not in good condition or designs do not adequately account for increased flow. Known High Hazard dams in Chesterfield County are all in Satisfactory condition, except Wake Lake (not rated), Margaret (Fair) and Lake Crystal (not rated).	If flood vulnerability increases as a result of urbanization, the risk of impoundment failure and impacts to state assets downstream may increase if dams are not in good condition or designs do not adequately account for increased flow.
Karst (Sinkholes)	The risk is currently low. Increased development may bring increased risk of infrastructure-related sinkholes (e.g., broken water main), but causes little to no increased natural sinkhole risk.	The risk is currently low. Increased development may bring increased risk of infrastructure-related sinkholes (e.g., broken water main), but causes little to no increased natural sinkhole risk.
Landslide	Vulnerable assets at risk may slightly increase as more public assets are sited in at-risk areas.	Vulnerable assets at risk may slightly increase as more public assets are sited in at-risk areas.
Land Subsidence	Increased aquifer withdrawals to provide more drinking water may slightly increase risk to existing assets, but the risk is very low to existing state assets, and impacts are minimal.	Increased aquifer withdrawals to provide more drinking water may slightly increase risk to existing assets, but the risk is very low to existing state assets, and impacts are minimal.
Non-Tornadic Wind	Decreased tree cover around state assets may increase fetch for straight-line winds.	Decreased tree cover around state assets may increase fetch for straight-line winds.
Pandemic	State assets are not directly vulnerable to pandemic.	State assets are not directly vulnerable to pandemic.
Tornado	Additional state resources may be needed for recovery services in heavily populated areas, and for the rebuilding of impacted state assets.	Additional state resources may be needed for recovery services in heavily populated areas, and for the rebuilding of impacted state assets.
Space Weather	New airports, utilities and communications systems in developing areas add new vulnerabilities for state assets.	New airports, utilities and communications systems in developing areas add new vulnerabilities for state assets.
Wildfire	As these counties continue to urbanize, the risk of wildfire associated with state assets there decreases. Natural areas tend to be pocketed between urbanized areas and have less risk, and urban areas have different fire risks. However, Pocahontas State Park and Lake Anna State Park are large parks.	As rural areas become more suburban, wildfire risks to state assets may increase, although the risk is relatively low in the counties indicated. Wildland urban interfaces increase, and more structures are built in areas that remain vulnerable to wildfire. Risk to state assets such as roads, historic structures, and utilities increases.
Winter Weather	Vulnerability increases as more people will be vulnerable to disruptions to state assets (such as the transportation network) and utilities.	Impacts will increase as more people will be vulnerable to disruptions to state assets (such as the transportation network) and utilities.

3.10 Endnotes

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Contents

4.1 2023 Updates

This section was reviewed, revised, and validated by both the COV SHMP Advisory Committee and the Working Group. Changes in local, state, and Federal capabilities were addressed, including new Executive Orders, new laws, new programs and new databases related to hazards identified in Section 3. Updated information from local hazard mitigation plans has also been incorporated through review of the most recent plans; however, additional source data addressing local capabilities with regard to mitigation were included, as well. This section has been updated based on feedback from reviews by Committee members, discussions during the Committee meetings, as well as in person meetings conducted with several agencies toward the end of the planning process.

4.2 Introduction

The purpose of conducting a capability assessment is to confirm that a state's final mitigation strategy is based on the principles found in (or missing from) existing authorities, policies, programs, and resources, and based on the state's ability to expand

and improve these existing tools. This planning process strives to establish goals, objectives, and related mitigation actions that are feasible based on an understanding of the organizational capacity of the agencies tasked with their implementation. A capability assessment helps to determine which mitigation actions are practical and likely to be implemented over time given a governmental unit's planning and regulatory framework, level of administrative and technical support, and level of fiscal resources.

Careful examination of capabilities helps detect existing gaps, shortfalls, or weaknesses within ongoing government activities that could hinder proposed mitigation activities or exacerbate hazard vulnerability. A capability assessment highlights positive mitigation measures already in place or being implemented at various levels of government, which should continue to be supported and enhanced through future mitigation efforts.

In order to inventory and analyze Virginia's capabilities, VDEM compiled information on a variety of "capability indicators" such as existing plans, policies, programs, and regulations that may reduce, or in some circumstances, increase the community's hazard vulnerability. The matrix of capability indicators at the end of this section has been built over several years of plan updates and gathering capability information, and on review of numerous documents relating to factors that impact state capability. Identified gaps, weaknesses, or conflicts can be recast as opportunities to implement specific mitigation actions. As such, this assessment includes a brief review of other state mitigation plan actions and online programs to highlight mitigation programs that are successful elsewhere (Appendix F). These ideas were shared with the Committees during the final Working Group Workshop in July 2022 in which members developed the Mitigation Action Plan for 2023.

In Virginia, hazards are addressed at all levels of government. Programs are often linked or accumulative, with programs at the local and State level funded through State or Federal programs. In many cases, programs promulgated by State statute are implemented locally.

4.3 Local Capabilities in Virginia

Local jurisdictions in Virginia address some hazards in the planning and development process, primarily through the building code. Local building codes include provisions requiring new buildings and structures to be designed to resist certain flood, wind, snow and seismic loads. The Uniform Statewide Building Code has specific provisions addressing fire hazards and the safety of occupants.

In the preparation of a local comprehensive plan, the planning commission is required to survey and study such matters as the use and preservation of land, characteristics and conditions of existing development, natural resources, surface water, geologic factors, environmental and economic factors, existing public facilities, drainage, flood control and flood damage prevention measures, among others. (§15.2-2224, *Code of Virginia*)

In addition, comprehensive plans and ordinances for zoning and subdivisions must explicitly address flood hazards and geologic information (§15.2-2223 *et seq.*, *Code of Virginia*). Cities and counties in the coastal zone also must address coastal management issues such as erosion.

4.3.1 Local Planning and Development

With respect to addressing natural hazards, local jurisdictions control land use through plans, ordinances, and codes. These programs are enabled through state law and regulation and, like the many state programs described later in this section, contribute significantly to mitigation of natural hazards.

Comprehensive Plans

Comprehensive address the physical development of land within a jurisdiction's boundaries. The comprehensive plan "shall be made with the purpose of guiding and accomplishing a coordinated, adjusted and harmonious development of the territory which will, in accordance with present and probable future needs and resources, best promote the health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants" (§15.2-2223, *Code of Virginia*). Most plans evaluate and provide guidance for both land uses and the environment; areas of consideration include residential, business, industrial, agricultural, parks and open space, public land, floodplains, transportation corridors, community facilities, historical districts and areas targeted for redevelopment. Also included are demographic trends such as population densities and information on age and quality of housing stock.

Zoning Ordinances

Zoning is for general purposes of promoting health, safety, or general welfare of the public. Consideration to the following should be given within each zoning district established by local ordinance:

- adequate light, air, convenience of access, and safety from fire, flood, crime and other dangers;
- provision of adequate police and fire protection, disaster evacuation,
- water, sewerage, flood protection, and other public requirements; and
- protection against loss of life, health, or property from fire, flood, panic and other dangers. (§15.2-2283, *Code of Virginia*)

Land Subdivision and Development Ordinances

These specialty ordinances are prescribed by statute and provide restrictions for plats, utilities, and streets, and address flood control, drainage, and other regulations that control the density and use of the land. (§15.2-2241, *Code of Virginia*). The ordinances are limited by State statute, but promulgated, administered and enforced by Virginia's cities and counties.

Virginia Uniform Statewide Building Code (USBC)

The USBC includes provisions related to wind hazards, snow loads, seismic risk, flood hazards, and structural fire hazards. Building codes regulate design and construction standards for new construction and some building alterations. Local governments use building departments, Certified Building Officials, and Certified Inspectors to issue permits and inspect work to ensure compliance with the USBC. Permitting and inspection processes both before and after a disaster can affect the level of hazard risk faced by a community. In Virginia, the State Building Code Office provides technical assistance and interpretation of regulations to local governments.

The USBC, based on the model codes established by the International Code Council (ICC), is promulgated by the Board of Housing and Community Development (BHCD) and regularly updated (§36-98, *Code of Virginia*). Use of the USBC is mandatory for all new construction as well as substantial improvements within all Commonwealth cities, counties, and towns.

Effective July 1, 2021, Virginia adopted the 2018 I-codes as referenced in the Virginia Construction Code Part 1, the 2018 Statewide Fire Prevention Code; and the 2017 National Electrical Code. Significant natural hazard-related code changes in the 2018 code cycle update included:

- Several building energy resilience measures that could lessen impacts of extreme heat and winter weather, such as energy certificate requirements, increases to minimum ceiling insulation requirements, multiple provisions for reroofing, roof replacement, roof recovering, and reinstallation of roofing materials
- **Flooding** - requiring specific engineering details when dry floodproofing is provided;
- **Flooding** - requiring documentation of the elevation of the lowest floor being submitted to the building official for buildings and structures in flood hazard areas;
- **Wind** - updating the components and cladding values, wind maps and wind zones;
- **Flooding** – many updates to buildings constructed in flood hazard areas; and,
- **Fire** – over 1000 edits were made to increase fire protection to buildings.

The 2021 code update cycle kicked off in October 2021 with the publication of the Notices of Intended Regulatory Action. This action alerts the public that the BHCD intends to consider amending the regulations outlined in the code. Three separate study groups began meeting in December to discuss In-Building Emergency Communications Systems, Townhouse Sprinklers and Active Shooter Barricade Devices in public buildings.

The ICC model codes have been cross-walked with NFIP regulations by FEMA and are generally consistent with requirements for local floodplain management ordinances. However, the model codes do not include all administrative provisions required for participation in the NFIP without adoption of a specific appendix.

Floodplain Management

In addition to the provisions of the USBC, floodplain management is typically addressed in a stand-alone ordinance adopted for voluntary participation in the National Flood Insurance Program (NFIP). In Virginia communities, floodplains are typically adopted and regulated as a zoning overlay in the local zoning ordinance. According to FEMA's Community Status Book in June 2022, Virginia has 291 communities currently participating in the NFIP. Seven of those participating communities have no special flood hazard area identified. There are 19 communities for which FEMA has identified Special Flood Hazard Areas (SFHA) that are not participating.

An additional indicator of local floodplain management capability is participation in the Community Rating System (CRS). The CRS is a voluntary incentive program that encourages communities to undertake defined flood mitigation activities that exceed the minimum requirements of the NFIP by extra local measures. The creditable CRS mitigation activities are assigned a range of point values. As points are accumulated and identified thresholds are reached, communities can apply for an improved CRS class rating. Class ratings, which run from 10 to 1, are tied to flood insurance premium reductions. As class ratings improve (decrease), so do the flood insurance premiums for NFIP policy holders. Every 500 points accumulated is equal to a 5% reduction in flood insurance premiums in the SFHA; premium discounts are typically limited to 5% outside the SFHA. Any community that is in full compliance with the rules and regulations of the NFIP may apply to FEMA for a CRS classification better than class 10.

As of June 2022, there are 27 CRS participating communities in Virginia:

- Two Class 9
- Ten Class 8
- Eight Class 7
- Five Class 6

- Two Class 5 (Norfolk and James City County)

4.3.2 Local Emergency Response and Recovery

Hazard mitigation is one of five mission areas of emergency management. The four other mission areas include prevention, protection, response, and recovery. Each mission area is interconnected with hazard mitigation. Opportunities to reduce potential losses through mitigation practices are ideally implemented before a disaster strikes. Examples include the acquisition or elevation of flood-prone structures or the enforcement of regulatory policies that limit or prevent construction in known hazard areas. The post-disaster environment provides an important "window of opportunity" to implement hazard mitigation projects and policies. During this time period, State and Federal disaster assistance, such as the Hazard Mitigation Grant Program (HMGP), may be available. In addition, elected officials and disaster victims may be more willing to implement mitigation measures in order to avoid similar events in the future.

In Virginia, response to natural hazard events is coordinated through local emergency management agencies. Most local agencies are responsible for preparing for and training to respond to disasters, whether natural or technological in origin. Recovery, especially from major events, may involve other local agencies, such as the building department, water/wastewater utilities, and parks and recreation. Several types of plans support this local capability.

Hazard Mitigation Plan

A hazard mitigation plan represents a community's blueprint for how it intends to reduce the impact of natural and human-caused hazards on people and the built environment. The essential elements of a hazard mitigation plan include a risk assessment, capability assessment and mitigation strategy. In Virginia, plans are generally aligned by Planning District Commission regions, with multi-regional hazard mitigation plans coordinated and led by committees composed of local and regional agencies, utilities and other stakeholders. VDEM assists regions with the planning process, and provides preliminary review of each plan prior to submittal to FEMA.

Please refer to Table 4-1 which provides a summary of the current communities, status, and plan expiration dates for each of the 20 regional hazard mitigation plans in Virginia as of July 2022.

Table 4-1 - Status of Regional Mitigation Plans in Virginia

Planning District Commission (PDC)	Localities Included in PDC Geographic Area	Plan Expiration Date	Comments
Central Virginia	**Counties** (4): Amherst, Appomattox, Bedford, Campbell. **Cities** (2):Lynchburg. **Towns** (5): Altavista, Amherst, Appomattox, Brookneal, Pamplin City, Bedford.	**2/8/2026**	**Plan is Approved**
Southside PDC	**Counties** (3): Brunswick, Halifax, Mecklenburg. **Cities** (0). **Towns** (12): Alberta, Boydton, Brodnax, Chase City, Clarksville, Halifax, La Crosse, Lawrenceville, Scottsburg, South Boston, South Hill, Virgilina.	**9/1/2025**	**Plan is Approved**
Cumberland Plateau PDC	**Counties** (4): Buchanan, Dickenson, Russell, Tazewell. **Cities** (0). **Towns** (12): Bluefield, Cedar Bluff, Cleveland, Clinchco, Clintwood, Grundy, Haysi, Honaker, Lebanon, Pocahontas, Richlands, Tazewell.	**2/12/2025**	**Plan is Approved**
LENOWISCO PDC	**Counties** (3): Lee, Scott, Wise. **Cities** (1): Norton. **Towns** (15): Appalachia, Big Stone Gap, Clinchport, Coeburn, Duffield, Dungannon, Gate City, Jonesville, Nickelsville, Pennington Gap, Pound, St. Charles, St. Paul, Weber City, Wise	**5/17/2026**	**Plan is Approved**
Roanoke Valley-Allegheny PDC	**Counties** (4): Allegheny, Botetourt, Craig, Roanoke. **Cities** (3): Covington, Roanoke, Salem. **Towns** (7): Buchanan, Clifton Forge, Fincastle, Iron Gate, New Castle, Troutville, Vinton.	**9/3/2024**	**Plan is Approved**
Central Shenandoah PDC	**Counties** (5): Augusta, Bath, Highland, Rockbridge, Rockingham. **Cities** (5): Buena Vista, Harrisonburg, Lexington, Staunton, Waynesboro. **Towns** (11): Bridgewater, Broadway, Craigsville, Dayton, Elkton, Glasgow, Goshen, Grottoes, Monterey, Mount Crawford, Timberville	**5/3/2026**	**Plan is Approved**
Middle Peninsula PDC	**Counties** (6): Essex, Gloucester, King and Queen, King William, Mathews, Middlesex. **Cities** (0). **Towns** (3): Tappahannock, Urbanna, West Point. Tribes (3): Pamunkey, Upper Mattaponi, Rappahannock	**2/1/2022**	**Plan is Approved/Update in progress**
West Piedmont PDC	**Counties** (4): Franklin, Henry, Patrick, Pittsylvania. **Cities** (2): Danville, Martinsville. **Towns** (7): Boones Mill, Chatham, Gretna, Hurt, Ridgeway, Rocky Mount, Stuart.	**2/9/2022**	**Plan is Approved/Plan update in progress**

Planning District Commission (PDC)	Localities Included in PDC Geographic Area	Plan Expiration Date	Comments
Northern Virginia RC	**Counties** (4): Arlington, Fairfax, Loudoun, Prince William. **Cities** (5): Alexandria, Fairfax, Falls Church, Manassas, Manassas Park. **Towns** (13): Clifton, Dumfries, Hamilton, Haymarket, Herndon, Hillsboro, Leesburg, Lovettsville, Middleburg, Occoquan, Purcellville, Quantico, Vienna	**3/26/2022**	**Plan is Expired/Plan update in progress**
Accomack-Northampton PDC	**Counties** (2): Accomack, Northampton. **Cities** (0). **Towns** (19): Accomac, Belle Haven, Bloxom, Cape Charles, Cheriton, Chincoteague, Eastville, Exmore, Hallwood, Keller, Melfa, Nassawadox, Onancock, Onley, Painter, Parksley, Saxis, Tangier, Wachapreague.	**4/9/2022**	**Plan is Expired/Update in progress**
Hampton Roads PDC	**Counties** (10)): James City, York, Southampton, Surry, Isle of Wight. **Cities** (3): Hampton, Poquoson, Newport News, Williamsburg, Chesapeake, Franklin, Norfolk, Virginia Beach, Portsmouth, Suffolk. **Towns** (4): Smithfield, Windsor, Claremont and Dendron	**6/7/2027**	**Plan is FEMA Approved Pending Adoption**
PlanRVA and Crater PDCs	**Counties** (6): Charles City, Goochland, Hanover, Henrico, New Kent, Powhatan. **Cities** (1): Richmond. **Towns** (1): Ashland.	**8/9/2027**	**Plan is FEMA Approved Pending Adoption**
	Counties (6): Chesterfield, Dinwiddie, Greensville, Prince George, Sussex, Surry. **Cities** (4): Colonial Heights, Emporia, Hopewell, Petersburg. **Towns** (8): Jarratt, McKenney, Stony Creek, Surry, Wakefield, Waverly.		
George Washington Regional Commission	**Counties** (4): Caroline, King George, Spotsylvania, Stafford. **Cities** (1): Fredericksburg. **Towns** (2): Bowling Green, Port Royal.	**10/4/2022**	**Plan is Approved/BRIC 2020 Funding**
New River Valley PD	**Counties** (4): Floyd, Giles, Montgomery, Pulaski. **Cities** (1): Radford. **Towns** (10): Blacksburg, Christiansburg, Dublin, Floyd, Glen Lyn, Narrows, Pearisburg, Pembroke, Pulaski, Rich Creek.	**11/27/2022**	**Plan is Approved/BRIC 2020 Funding**
Commonwealth Regional Council	**Counties** (6): Buckingham, Charlotte, Cumberland, Lunenburg, Nottoway, Prince Edward. **Cities** (0). **Towns** (11): Blackstone, Burkeville, Charlotte Court House, Crewe, Dillwyn, Drakes Branch, Farmville, Kenbridge, Keysville, Phenix, Victoria.	**12/13/2022**	**Plan is Approved/Update in progress**

Planning District Commission (PDC)	Localities Included in PDC Geographic Area	Plan Expiration Date	Comments
Northern Neck PDC	**Counties** (4): Lancaster, Northumberland, Richmond, Westmoreland. **Cities** (0). **Towns** (6): Colonial Beach, Irvington, Kilmarnock, Montross, Warsaw, White Stone.	**2/7/2023**	**Plan is Approved/BRIC 2020 Funding**
Thomas Jefferson PDC	**Counties** (5): Albemarle, Fluvanna, Greene, Louisa, Nelson. **Cities** (1): Charlottesville. **Towns** (5): Columbia, Louisa, Mineral, Scottsville, Stanardsville.	**3/19/2023**	**Plan is Approved/Update in progress**
Northern Shenandoah Valley PDC	**Counties** (5): Clarke, Frederick, Page, Shenandoah, Warren. **Cities** (1): Winchester. **Towns** (14): Berryville, Boyce, Edinburg, Front Royal, Luray, Middletown, Mount Jackson, New Market, Shenandoah, Stanley, Stephens City, Strasburg, Toms Brook, Woodstock	**8/7/2023**	**Plan is Approved**
Rappahannock-Rapidan RC	**Counties** (5): Culpeper, Fauquier, Madison, Orange, Rappahannock. **Cities** (0). **Towns** (8): Culpeper, Gordonsville, Madison, Orange, Remington, The Plains, Warrenton, Washington.	**12/10/2023**	**Plan is Approved**
Mount Rogers PDC	**Counties** (6): Bland, Carroll, Grayson, Smyth, Washington, Wythe. **Cities** (2): Bristol, Galax. **Towns** (12): Abingdon, Chilhowie, Damascus, Fries, Glade Spring, Hillsville, Independence, Marion, Rural Retreat, Saltville, Troutdale, Wytheville	**2/26/2024**	**Plan is Approved**

Emergency Operations Plan (EOP)

A local emergency operations plan required in accordance with *Code of Virginia* §44-146.19, must outline responsibilities and the means by which resources are deployed during and following an emergency or disaster. VDEM directs local governments in plan development and revisions by conducting a plan review, facilitating plan review meetings, and developing plan templates through collaboration with local partners.

Continuity of Operations Plan (COOP)

A continuity of operations plan establishes a clear chain of command, line of succession, and plans for backup or alternate emergency facilities in case of a disaster or disruption. Adherence to an established COOP varies across Virginia's counties and municipalities. Not all communities have COOP.

4.3.3 Effectiveness of Local Capabilities

By assessing the effectiveness of capabilities, local governments as a whole can identify gaps and other programmatic deficiencies and develop mitigation actions. Mitigation actions address identified gaps as well as mitigation goals and objectives. By highlighting local gaps, state agency officials and other stakeholders may observe areas where State action could improve local capability.

The 2018 version of this plan solicited local capability gap information and identified the following overarching concerns:

1. Coordination of Post-Disaster Assistance – While there are numerous opportunities to tap into Federal and State funds to reduce future risk, coordination between local and State partners is challenging. State planners indicated that they believed the proposal to undertake a statewide recovery plan would assist agencies with recovery/mitigation responsibilities in this regard. Note: Virginia updated the *Commonwealth of Virginia Recovery Plan: State and Local Fiscal Recovery Funds* on April 8, 2022. It is available online at: https://www.doa.virginia.gov/reports/AmericanRescue/Virginia-Recovery-Plan-Performance-Report-revised-4.8.22.pdf
2. Cost Effectiveness - The emphasis on community-wide flood mitigation projects is laudable; however, determining cost effectiveness for larger projects is not always as straightforward as with single-family, residential projects. More training and tools to specifically address community-wide projects would be useful.
3. Non-Federal Match - There are open hazard mitigation projects in which property owners end up dropping out due to their inability to come up with the non-Federal and non-State share of the project. Impacted local governments are trying to identify more private investment opportunities to address this deficiency.

Pursuant to *Code of Virginia* §44-146.19(F), all political subdivisions provide an annual emergency management assessment to the Commonwealth. VDEM facilitates this process through a standardized Local Capabilities Assessment for Readiness (LCAR) survey. For 2021, stakeholder engagement occurred through a series of virtual workshops with representation from state, regional, and local emergency management (including Diversity, Equity, and Inclusion), as well as behavioral health, law enforcement, public health, social services, and transportation stakeholders. The final survey tool was a result of collaboration between workshop participants and VDEM executive leadership that focused on vulnerable populations. Data captured with this tool can be used by local and state partners to identify both strengths and gap areas through the five mission areas of emergency management.

The mitigation section of the LCAR specifically provides information on jurisdictional capabilities to implement hazard mitigation projects, and includes the highest priority mitigation project for each jurisdiction. Localized flood risk reduction projects were most commonly reported (37%), followed by planning related activities (17%) and generators (16%). Significantly, 42% of jurisdictions need assistance in the area of mitigation, primarily on grant topics; this represents a 13% increase since the 2020 LCAR. The 2021 LCAR included a recommendation that state agencies prioritize grant assistance in high vulnerability jurisdictions as rates of assistance needs are significantly higher than the state average in these areas. Other key findings of the LCAR with regard to hazard mitigation capability include:

- Significant change occurred in staffing sufficiency. When asked whether or not the current staffing was sufficient for the emergency management program only 43% responded "Yes" compared to 53% in 2020;
- Jurisdictions indicated the largest portion of time spent, 33%, was in the area of response, followed by Prevention (20%), Protection (16%), Mitigation (16%), and Recovery (15%);
- Across mission areas, mitigation and recovery were rated as the lowest percentages of capability and confidence and the largest percentage of assistance needs.

VDEM has undertaken an outreach strategy to local governments that will target vulnerable populations within coastal or riverine flood zones. Each City/County in Virginia was analyzed based on criteria that included race, income, health, transportation, and age. This information was then overlayed with the FEMA flood maps and vulnerable areas were identified down to the census tract level. A vulnerability percentage was assigned to each locality and VDEM then ranked them based on the highest vulnerability. The first phase of outreach included reaching out to the 41 highest percentage localities and holding workshops with multiple departments within each locality. Intended audiences include local staff from local/regional planning and zoning, engineering, first responders, public works/utilities, transportation, floodplain managers, environmental/historic compliance officers, Building Officials, risk managers, stormwater, social services, economic development, and volunteer/faith-based organizations. VDEM Grants, VDEM Office of Diversity, Opportunity, and Inclusion (ODOI), DCR, DHCD, and VMASC worked together to host workshops that addressed current hazards, problem areas, and mitigation solutions within these identified vulnerable areas.

The second phase of this project included hiring an outside contractor to begin working with these communities on developing potential mitigation applications for these 41 communities. This part of the project is currently underway as of September 2022. These project applications are expected to become awarded projects under various mitigation funding opportunities.

4.4 State and Regional Capabilities

State programs that most directly address hazards and mitigation range from regional planning commissions that provide guidance and funding to support mitigation planning and projects at the local level to the Coastal Zone Management Program that uses Federal funding to support specific coastal initiatives. These programs tackle mitigation through a variety of methods that have gradually developed over many years.

4.4.1 State Agencies

These brief profiles provide a summary of the program foundations for mitigation by agency; highlights include innovative or newly developed programs that combine to create an additional layer of hazard knowledge and protection for citizens.

Virginia Department of Emergency Management (VDEM)

VDEM's mission is to lead Virginia's prevention, protection, mitigation, response, and recovery efforts to save lives and protect all Virginians, prioritizing under-resourced communities and embracing equity. The responsibility of VDEM is to ensure a comprehensive, efficient and effective response to emergencies and disasters throughout Virginia, including provision of assistance in the absence of events for which federal aid is made available.

VDEM is charged with supporting mitigation planning and administers Hazard Mitigation Assistance (HMA) programs that provide grants to eligible entities to implement cost effective
mitigation projects in the pre-disaster and post-disaster periods. VDEM also leads the state and federal Public Assistance Programs, which provide disaster assistance to state agencies, local jurisdictions, and certain private nonprofit entities to repair and restore damaged facilities. Damaged facilities must be repaired in a manner that is compliant with existing codes and
standards. VDEM manages the National Weather Service's Integrated Flood Observing and Warning System (IFLOWS) in several western and southwestern counties. IFLOWS improves local flash flood warnings through a linked wide area monitoring and communications network. Although the IFLOWS is not currently extensive in the central part of the state east of Lynchburg, there is local interest in tying into the system to improve local flood warning capability.

The VDEM Mitigation Grants staff currently has a staff of one State Hazard Mitigation Officer (SHMO), one Deputy State Hazard Mitigation Officer (DSHMO), and three

Grants Administrators (GA). There are currently two vacant GA positions and one vacant Technical Assistance Coordinator (TAC) position. A shortage in staff is an identified challenge for soliciting applications from localities. As soon as the TAC position is filled, their main goal will be to work with higher education institutions and other mitigation/resilience focused groups to promote mitigation and grant opportunities. Our current GA job duties include managing awarded grant projects and application development for annual Flood Mitigation Assistance, Building Resilient Infrastructure and Communities, Legislative Pre-Disaster Mitigation Grant, and State Shelter Upgrade Fund.

Due to the staffing shortages, VDEM contracts out support for one-on-one solicitation of applications from our vulnerable communities and benefit cost analysis for application development. In addition, the stakeholder engagement, loss avoidance studies, and open space reporting is also contracted out to ensure completion on a timely basis. Ideally in the future, existing staff would be trained and able to complete these contracted items. VDEM Mitigation does a very good job of implementing and monitoring projects once they are awarded. Reimbursements, quarterly reporting, and site visits are prioritized and successfully completed in a timely fashion; however, extra support with benefit cost analysis, environmental review, and application development do not get the support they need due to staffing shortages. The GAs have worked successfully with the Regional Planners and other regional staff to support project application development, but additional direct support to each locality in need is a goal. Additional collaboration with the regional staff is necessary to ensure localities' needs are being met.

In September 2018, VDEM and FEMA announced development of a FEMA Integration Team (FIT) to coordinate program implementation, hazard risk reduction, and operational planning. The team was officially adopted by Memorandum of Agreement. Under the agreement, the FIT will enhance the capabilities of FEMA Region III staff already assigned to VDEM by increasing FEMA's ability to provide on-site technical assistance and rapid delivery of FEMA's programs within the Commonwealth of Virginia.

Goals for the Mitigation Grant Program include:

1. Develop a widely used program/application to support and develop future mitigation applications for localities;
2. Increase staffing to be able to offer more comprehensive training and technical assistance in project development;
3. Increase mitigation knowledge with the Recovery and Mitigation Specialists (RAMS) to be able to utilize their expertise more;
4. Work towards Enhanced Status of the COV Hazard Mitigation Plan;
5. Fill vacant positions; and,
6. Utilize the FEMA FIT Team in all aspects of mitigation.

In partnership with other state agencies and local jurisdictions, VDEM also coordinates hurricane evacuations. The revised *Virginia Hurricane Evacuation Guide*, published during the Covid-19 pandemic, is the public-facing outreach element that provides mitigation and evacuation information to citizens. The guide includes summary information regarding the Commonwealth's "Know Your Zone" initiative that applies to roughly 1.25 million residents in 23 localities along coastal Virginia; the program also benefits individual businesses and visitors in the region. Tiered evacuation zones were developed in close coordination with local emergency managers throughout Hampton Roads, the Northern Neck, the Middle Peninsula and the Eastern Shore based on the most up-to-date Virginia Hurricane Evacuation Study (VA HES).

VDEM administers the Emergency Shelters Upgrade Assistance Grant Fund per Chapter 3.2 of Title 44, *Code of Virginia* §44-146.29:3, also known as the "Shelter Upgrade Fund." This code became active July 1, 2020. Moneys in the fund (state share $2,500,000) are to be used solely for the purposes of providing matching funds to localities to install, maintain, or repair infrastructure related to backup energy generation for emergency shelters, including solar energy generators, and to improve the hazard-specific structural integrity (wind retrofit) of local shelter facilities.

VDEM has developed many tools to address human-caused hazard mitigation, as well. Since 2010, the Commonwealth has developed and/or revised the Radiological Emergency, Hazardous Materials, Earthquake Response, Terrorism Consequence, Pandemic Influenza, Cyber Attack, Energy Assurance and Technological Hazard plans, which are all part of the *Commonwealth of Virginia Emergency Operations Plan*, which was updated October 2021. The VDEM Planning Division, in collaboration with the Virginia State Police, supports the Virginia Fusion Center (VFC), which is the state's multi-disciplinary Intelligence Center. The center was created to provide operational and strategic counter terrorism/criminal information and intelligence to law enforcement, military, public safety, governmental, and private sector decision-makers, as well as to the public. VDEM provides personnel to the VFC who assist with intelligence gathering and product development on existing and emerging threats that may affect prevention, protection, response, recovery, and mitigation efforts before, during, and after events and emergencies. VDEM also collaborates with the Northern Virginia Regional Intelligence Center (NVRIC) which is a regional Fusion Center. VDEM provides funding to the NVIRC for a Critical Infrastructure Cybersecurity Analyst.

The GIS unit of the Planning Division supports steady state and disaster operations with geographic information system products for situational awareness, response operations, grants projects distribution, and recovery efforts for individual assistance. The GIS unit collects, manages, analyzes, and displays information geospatially to visualize incident and contextual data in a common operating picture. GIS also helps

VDEM focus response, recovery and mitigation efforts using the location and density of vulnerable populations, as well as daily tracking of VDEM-engaged incidents to include hazardous materials, medical flights, and search and rescue missions.

Code of Virginia §44-146.30 and 44-146.34, Hazardous Material Emergency Response Program, ensures training, regional teams state-wide and regional Hazardous Materials officers as VDEM staff in all 7 VDEM regions. *Code of Virginia* §44-146.38 requires all political subdivision to appoint a hazardous materials coordinator.

VDEM works with agency partners to prepare outreach materials on various hazards. For example, VDEM publishes an online Earthquake Preparedness Guide, which is promoted via press releases and social media. The guide includes information on how individuals can prepare their home before an earthquake and recover should one occur.

The Virginia Emergency Operations Center (VEOC) hosts the Virginia Emergency Support Team (VEST), which responds to calls for assistance from local governments throughout the Commonwealth. Representatives from state, federal, private, and nonprofit groups work together at the VEOC to form the VEST. As the statewide emergency management coordination and support mechanism, the VEST utilizes a National Incident Management System (NIMS) based framework to facilitate command and coordination, resource management, communications, and information management. The Emergency Support Function structure facilitates a multidisciplinary approach to fulfilling requests for support and technical expertise within each of the critical response and recovery components, such as public safety, mass care, or public works and engineering. The integration of both well-established models maximizes internal and external VEST coordination activities.

VDEM assumes a lead role in monitoring which functions of government and utilities are most critical for both normal electric power grid operation and recovery operations, and then determines which components are essential to ensuring those functions will survive. The Virginia Energy Security Plan was being prepared by VDEM in accordance with U.S. Department of Energy guidance concurrent with this hazard mitigation planning process; a draft was not available for review. The guidance indicates that the plan will address all energy sources and regulated and unregulated energy providers, provide a State energy profile, address potential hazards to each energy sector or system, provide a risk assessment of energy infrastructure and cross-sector interdependencies, provide a risk mitigation approach to enhance reliability and end-use resilience, and address:

- multi-State and regional coordination, planning, and response; and
- coordination with Indian Tribes with respect to planning and response; and

- to the extent practicable, encourage mutual assistance in cyber and physical response
- plans.

Dominion Energy released a report in 2015 outlining how the organization mitigates geomagnetic disturbances. Solar-event situational awareness is a program which utilizes the National Oceanic and Atmospheric Administration geomagnetic disturbance (GMD) forecast. System operators receive the GMD forecast through an online portal and via email. The GMD forecast includes information on the timing and severity of incoming disturbances. The utility then translates GMD forecasts into potential impacts to the power grid. Dominion Energy also employs real-time Geomagnetic Induced Current (GIC) monitoring. GIC monitors are deployed at critical locations throughout the system and measure dc current magnitude at transformer neutral grounds. The utility has hardened transformers and capacitor banks to reduce the impacts of GMDs, and performs geoelectric scenario studies and modeling. Studies include assessments of the utility's geoelectric field characteristics and a scenario analysis of the impacts of a 100-year geoelectric field event.

In 2021, VDEM created and staffed an Office of Diversity, Opportunity, and Inclusion (ODOI) to thread diversity, inclusion, and accessibility principles into communications, interactions and other interfaces with vulnerable communities that are disproportionately impacted during disasters, including tribes. The ODOI serves two functions within the agency: 1) assist VDEM regions and localities in providing access and resources to every individual, regardless of possible barriers to access or ability; and 2) internally assist the agency to build diversity, inclusion, and accessibility principles throughout every function of the agency.

Department of Conservation & Recreation (DCR)

DCR works with Virginians to conserve, protect, and enhance their lands and improve the quality of the Chesapeake Bay and our rivers and streams, promotes the stewardship and enjoyment of natural, cultural and outdoor recreational resources, ensures the safety of Virginia's dams, and serves as the coordinator of all flood protection programs and activities in the Commonwealth. DCR is the State Coordinating Office for NFIP activities, administers the dam safety program, and participates in interagency initiatives concerning coastal erosion.

Virginia's General Assembly enacted the Virginia Flood Damage Reduction Act of 1989. This legislation was the result of several disastrous floods or coastal storms that hit the state between 1969 and 1985. To improve Virginia's flood protection programs and place related programs in one agency, responsibility for coordination of all state floodplain programs was transferred in 1987 from the Water Control Board to the Department of Conservation and Recreation (DCR). DCR was named manager of the state's floodplain program and designated coordinating agency of the NFIP under the act, §10.1-602 and a governor's memorandum released in July 1997. The DCR Floodplain Management Program was specifically created to manage Virginia's flood hazards. In particular, it aims to prevent loss of life, reduce property damage, and conserve natural and beneficial values of state rivers and coastal floodplains. To achieve these goals, DCR promotes NFIP compliance and participation, offers technical assistance and community education, coordinates with other state and federal agencies, and helps manage funding through the Dam Safety, Flood Prevention and Protection Assistance Fund.

In their role of overseeing local and state participation in the NFIP, Floodplain Management Program staff use annual Federal Community Assistance Program – State Support Services Element (CAP-SSSE) funding to support their engagement with localities on a regular basis to establish and enforce floodplain management regulations. They work closely with local floodplain administrators to review communities' floodplain management programs, including floodplain management ordinances, permit review processes, and flood maps and mitigation projects. DCR uses CAP-SSSE funding to provide workshops and one-on-one training to communities on various topics such as floodplain management principles, permitting development in the floodplain, using the Virginia Flood Risk Information System, joining CRS, understanding Elevation Certificates and incorporating floodplain management into community planning efforts.

In addition to helping communities, program managers help individuals learn about floodplain regulations and flood insurance. The CAP-SSSE funding supports assistance to property owners, engineers, consultants, developers, realtors and insurance agents with questions on flood zones and mapping, construction methods and ordinance interpretation. Also, special training is provided to professional groups.

DCR works closely with FEMA to ensure that Virginia's floodplain managers are up-to-date on current FEMA policies and guidance. They share this information with localities in the state, serving as a liaison between Virginia communities and FEMA to help local officials continue proper implementation of floodplain programs. DCR also works with the USACE, which reviews joint permit applications for development in inland waterways, conducts floodplain studies, and funds cost-share projects with localities. DCR works with NWS, USGS and the Natural Resources Conservation Service staff that work on flood-related projects in Virginia.

DCR works closely with VDEM, which manages the state's HMA projects, infrastructure protection measures and updates to regional hazard mitigation plans. DCR and VDEM meet regularly to coordinate flood management goals for the state and share information on flood events. DCR also coordinates with other state agencies including DEQ, DHCD, and VDOT. Some of these relationships have been formalized by participation in the Virginia Silver Jackets, an interagency team dedicated to reducing flood hazards in the state. DCR also supports the Virginia Floodplain Management Association (VFMA), a local chapter of the Association of State Floodplain Managers. VFMA provides additional professional training and conference-based opportunities for floodplain managers statewide to expand their knowledge and acquire or hone new skills in the field.

Effective January 1, 2022, a new flood disclosure regulation (§55.1-708.2), requires that an owner of residential real property who knows that the dwelling unit is a repetitive risk loss structure must disclose such fact to the purchaser. A "repetitive risk loss structure" is defined as a property for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978. The law further requires that the owner of a property subject to the disclosure requirement must provide notification to the purchaser of any disclosure before the ratification of a contract.

DCR, in collaboration with the Virginia Institute of Marine Science's Center for Coastal Resources Management, created Virginia Flood Risk Information System (VFRIS) to best inform communities and property owners of their flood risk. VFRIS is a compilation of information available primarily from FEMA and Virginia Geographic Information Network (VGIN), that helps communities, real estate agents, property buyers, property owners, and others discern an area's flood risk and avoid hazardous situations. VFRIS can improve the quality of analysis included in local comprehensive plans and preparedness postures for property owners.

The Dam Safety Program ensures proper design, construction, operation and maintenance of dams to protect public safety within the Commonwealth of Virginia. The program requires all dams of regulatory size to apply for an Operation and Maintenance Certificate. To receive a Regular Operation and Maintenance Certificate, the owner must include an assessment of the dam by a licensed Professional Engineer and an Emergency Action Plan. If a dam has a deficiency but does not pose imminent danger to public safety, a Conditional Operation and Maintenance Certificate may be issued to allow the owner time to correct the deficiency. Dams are classified with a hazard potential; hazard potential describes the downstream losses anticipated in event of failure and is unrelated to the structural integrity of a dam. Dams are classified into three categories based on hazard potential, with each requiring inspection by a professional engineer. High hazard potential dams must be inspected every two years and significant hazard potential dams must be inspected every three years. Low hazard potential dams must be inspected every six years unless the dam would only cause damage to the property of the owner of the dam.

In September 2017, Virginia DSFPM implemented the online Dam Safety Inventory System " (DSIS) for all of its dam related information. DSIS is an inventory system designed to house all of VA DSFPM dam related data and regulatory documents for every known dam in the Commonwealth. The system allows users to apply for and submit regulatory documents and certifications and also provides for online feedback and approvals. This centralized inventory system allows DSFPM to easily review and share data needed for emergency situations, including but not limited to:

- Emergency Plan Documents
- System Queryable Emergency Plan Details
- Dam Drainage Areas
- Dam Points
- Dam Inundation Studies
- Dam Inundation Zones

Aside from spatial data and emergency plans, users can access data and documents related to inundation studies, inspections, permits, certificates, and PMP studies. DSIS also includes an emergency dashboard that provide both past and forecasted precipitation amounts for all dams using NWS data for 6, 12, and 24 hours. When precipitation estimates exceed rainfall triggers, the dams affected are flagged and reported out on the emergency dashboard. VA DSFPM Regional Engineers use this as a tool to determine immediate communication needs. All available dam data is accessible to make decisions for emergency preparations and response.

All information collected during the application and regulatory submittal process is accessible in read only format to DSIS users. Effective May 1, 2021, 4VAC50-20-20. General provisions, F., was modified to include the following: The owner shall ensure all information required to be submitted under this chapter be provided to the department via the electronic Dam Safety System (DSIS), unless prior approval for an alternative method of submission is granted by the department.

Disaster recovery programs within Virginia DSFPM include assistance to dam owners and local officials in assessing the condition of dams following a flood disaster and assuring the repairs and reconstruction of damaged structures are in compliance with the Virginia Impounding Structure Regulations and the National Flood Insurance Program (NFIP) regulations.

As stated in Chapter 3, any application for an Operation and Maintenance Certificate for a regulated dam must include an assessment of condition of the dam by a licensed Virginia Professional Engineer and an Emergency Action Plan (EAP) or an Emergency Preparedness Plan. An executed copy of the EAP must be filed with the appropriate local emergency management official and VDEM[i]. The EAP must be updated by the dam owner during the term of the six-year certificate if any relative information has changed, including conditions downstream.

The EAP is a formal document that recognizes potential impounding structure emergency conditions and specifies preplanned actions to be followed to minimize loss of life and property damage. The plan specifies actions the owner must take to minimize or alleviate emergency conditions at the impounding structure. It contains procedures and information to assist the owner in issuing early warning and notification messages to responsible emergency management authorities as well as dam specific criteria for staging the emergency.

The EAP must also contain dam break inundation zone maps as required to show emergency management authorities the critical areas for action in case of emergency. The maps are developed at a scale sufficient to graphically display timing of impact to downstream inhabited areas and structures, roads, public utilities, and other pertinent structures within the identified inundation area. This information is critical for timely notification and evacuations. In coordination with the local organization for emergency management, a list of downstream inundation zone property owners and occupants, including telephone numbers may be plotted on the map or may be provided with the map for reference during an emergency. EAPs are maintained in hardcopy format with the VDEM Situational Awareness Unit to ensure access to information during events where data access has been interrupted. VA DSFPM provides dam focused education and training to help dam owners and private engineers understand dam related regulatory / maintenance responsibilities as required by the Virginia Impounding Structure Regulations.

To aid in the implementation of mitigation actions and activities for state regulated dams, especially high hazard dams that pose an unacceptable risk to the public, the Commonwealth of Virginia has a Virginia Dam Safety, Flood Prevention and Protection Assistance Fund available to local governments and private entities for specified dam safety and floodplain management issues[ii]. The fund was established to provide matching grants to local governments, including local Soil and Water Conservation Districts, and to private entities owning regulated dams to improve dam safety. This includes matching grants to local governments for orphan-type dams that are within their jurisdiction. State-owned and federally owned dams, or dams not regulated pursuant to the Virginia Dam Safety Act[iii] are ineligible. The fund also provides matching grants to any local government for the purposes of assisting the local government with improvements to flood prevention or protection. Grants are awarded through a competitive application process, as spelled out in a yearly issued Grant Manual[iv] and awards are approved by the Virginia SWCB. High hazard potential classification dams with unacceptable risks to the public are prioritized. This includes but is not limited to those high hazard potential classified dams with confirmed spillway deficiencies, large dams with no hazard classification determinations, dams with high numbers of residential units within the dam's probable dam break/inundation zone, and proposed grant projects which focus on critical dam safety program elements such as hazard potential classification analysis, dam break/inundation zone analysis or mapping and digitization, probable maximum precipitation (PMP) impact analysis and certification, and EAP development.

Total past grant awards from the Dam Safety, Flood Prevention and Protection Assistance Fund are listed in Table 4-2. Since 2017, the program has awarded $12.4 million to support projects with a total cost of over $52.7 million. The largest awards were: $1.05 million for Spillway Repair and Dam Rehabilitation of the Upper North River #77 Dam in Augusta County; $5 million for College Lake Dam in Lynchburg; and $2.94 million for rehabilitation of Mountain Run Dams #11 and #50 in Culpeper County.

Table 4-2 – Grant Awards for Dam Safety, Flood Prevention and Protection Assistance Fund

Grant Year	Floodplain	High	Significant	Low	Low, Special	Unknown	Grand Total
2017	$75,000	$4,295,213	$218,230	$113,808		$30,000	$4,732,251
2018	$166,876	$762,186	$61,112	$1,500		$95,083	$1,086,767
2019	$233,173	$5,257,960	$54,730	$33,038	$12,400	$77,313	$5,668,615
2020	$10,515	$76,895	$59,008	$18,505	$17,000	$24,175	$206,098
2021	$70,000	$496,682	$40,276	$17,175	$21,205	$80,700	$726,039
Grand Total	$555,563	$10,888,936	$433,367	$184,027	$50,605	$307,272	$12,419,771

Through partnership with FEMA, DCR has helped administer $341,000 in High Hazard Potential Dam funding for structural analysis, plans and specifications, and permitting oversight and record reports for improvements to Harwood's Mill Dam in Newport News. DCR also provides Dam Safety Education resources, including Dam Safety Awareness Day, the Dam Owner Academy (a series of videos on dam safety management), and Dams 101 (a factsheet with dam safety tips).

The Virginia Community Flood Preparedness Fund (CFPF) was established in *Code of Virginia* Chapter 13, Title 10.1, Article 4, Section 10.1-603.24 and Section 10.1-603-25 and the provisions of §10.1-1330, Clean Energy and Community Flood Preparedness Fund, which was passed during the 2020 session of the General Assembly. Money in the fund comes from the auction of carbon allowances through the Regional Greenhouse Gas Initiative (RGGI).The CFPF is a statewide program administered by DCR that provides a permanent funding stream to finance flooding resilience projects, studies, and capacity-building initiatives and prioritizes low-income communities. The RGGI is a program made up of 11 states that aims to reduce greenhouse gas emissions. In the first round of funding in 2021, CFPF provided $7.74 million in funds to support almost $11.9 million in project costs. Round 2 grants for 2021 provided $24.7 million to support over $33.5 million in project costs. Projects included planning and capacity building in low-income communities, flood prevention and protection studies, and projects to support hybrid or nature-based solutions.

Some easement and other programs that may be used to support floodplain acquisition projects include the Scenic Rivers Program, Virginia Outdoors Fund, Conservation Reserve and Enhancement Program, and Best Management Practices implemented with Water Quality Improvement grants.

DCR also coordinates a Shoreline Erosion Advisory Service, which provides free services such as technical assistance, site investigations, written reports, plan reviews, construction inspections and other information to private landowners with respect to erosion. This program coordinates with the Virginia Institute of Marine Science at the College of William and Mary, which researches shoreline management and erosion control through the Shoreline Studies Program. This program focuses on shoreline management, shoreline evolution, beaches and dunes, and regional sediment management.

The Virginia Cave Board, a division of DCR, identifies and analyzes caves and karsts across the state. Their investigators assess the site across several factors, including terrain, soil, drainage, structural analysis, and bedrock assessment. These investigations determine if a site is eligible for new buildings or enhancements or is threatened by sinkholes. The Virginia Agricultural Cost Share Program, administered by DCR, adopted a Sinkhole Protection Best Management Practice. The program will cost match or offer tax breaks for eligible sinkhole-related projects. These include the removal of debris from sinkholes, the creation of structural or agronomic measures to provide adequate vegetation for filtering and sediment trapping of surface run off, or the addition of fencing to protect livestock and for personal safety. The Virginia Sinkhole Protection BMP can pay up to 75% of the cost for a sinkhole cleanout, with a maximum contribution of $2,500.

The purpose of the DCR Virginia Natural Heritage Karst Program is to protect natural karst and caves in the state. For over a quarter century, the program has worked to study, protect, and educate Virginia citizens and stakeholders about the biologically rich and environmentally sensitive karst landscapes formed on and within the Commonwealth's extensive exposures of limestone and dolomite, which are common west of the Blue Ridge. Initially funded by a grant to the Virginia Natural Heritage Program from the Environmental Protection Agency under the Clean Water Act, the Karst Program today is supported through limited state general funds and heavily supplemented by grants and contracts from private, federal, and state partners like the Cave Conservancy of the Virginias, the Virginia Cave Board, The Nature Conservancy, the US Fish and Wildlife Service, the US Forest Service, the Virginia Department of

Wildlife Resources, the Virginia Department of Transportation, Dominion Energy and the National Speleological Society.

Department of Housing & Community Development (DHCD)

In addition to the building code responsibilities outlined in the Local Capabilities section above, DHCD collaborates with communities to assist them in fully developing their economic potential, and creating a healthy, safe and affordable living environment. The agency has the following focus areas relevant to mitigation for vulnerable populations impacted by natural hazards:

- Housing Assistance
  - Repair and energy efficiency
  - Tax credit programs
  - Housing searches
  - Eviction Reduction Program
- Housing Development and Rehabilitation
  - Resources for housing rehabilitation and multifamily housing
  - Housing Innovations in Energy Efficiency
- Homeless Assistance and Prevention
  - Virginia Homeless Solutions Program and Homeless and Special Needs Housing funding;
  - Homeless Reduction Grants.

After catastrophic disasters of regional proportions, DHCD assists VDEM's Virginia Emergency Support Team (VEST) Bureau in coordinating local Long-Term Disaster Recovery Task Forces. These task forces are critical to coordination of various economic assistance and redevelopment programs, volunteer efforts, donations and redevelopment. Local recovery task forces have supported disaster recovery in: Southwest Virginia (multiple flooding and severe weather events); City of Franklin (Hurricane Floyd, 1999); the City of Poquoson (Hurricane Isabel, 2003); Pulaski County & the Town of Pulaski (tornado, 2011); the Town of Strasburg (Superstorm Sandy, 2012); and Appomattox County & Essex County (tornadoes, 2016). The VEST was activated for or supported eight times in 2020 for the following events:

- COVID-19 – 356 days
- First Amendment Events – 62 days
- Hurricane Isaias – 4 days
- Election Day – 1 day
- US Capitol Invasion/DC Emergency Management Assistance Compact (EMAC) - 1 day
- US Inauguration – 4 days
- February Severe Weather (snow and ice) – 16 days
- Colonial Pipeline Disruption – 5 days

DHCD offers planning grants through the Federal Community Development Block Grant (CDBG) program to increase housing and commercial revitalization project success and positive impact on vulnerable communities. These grants aid in developing clear strategies for addressing a locality's greatest community development needs following meaningful citizen participation. CDBG funds can be used to support pre-disaster and post-disaster mitigation projects. For example, following Hurricane Isabel, DHCD grant staff coordinated with VDEM hazard mitigation and human service managers to target funds to communities hardest hit by the storm. This effort resulted in more than $5 million in CDGB monies supporting elevations of flood prone properties, increasing the capacity of the designated Isabel HMGP program funds by 25%. Virginia's eligible CDBG Entitlement Communities, which are metropolitan cities with populations of at least 50,000, and certain urban counties with populations of at least 200,000, develop their own CDBG programs and funding priorities. These communities administer their own CDBG funds separately from the Commonwealth's CDBG State Program allocation that awards grants to smaller units of local governments to develop affordable housing, provide services and create jobs.

CDBG has been used to assist after tornadoes in Glade Spring/Washington County (2011), Pulaski County and Town (2012), and Appomattox, Essex and Surry Counties (2016). The program also assisted the Town of Strasburg following Hurricane Sandy (2012). It is expected that CDBG will continue to be a critical funding source for housing mitigation programs, as it can typically be used as the non-federal portion of all HMA programs that require a match.

DHCD's Division of Building and Fire Regulations focuses on the development, promotion and uniform enforcement of regulations that achieve safe, affordable buildings in Virginia. The Jack A. Proctor Virginia Building Code Academy delivers administrative and technical code training programs for mandated certification requirements for over 3,500 statewide professional certifications in various code enforcement disciplines including code official, inspection and plan review. Most of the programs required for certification are multiday and are offered throughout the calendar year in various locations across the state. In addition to the mandated training, the academy periodically offers a number of specialized training events on current issues in the code enforcement industry. In 2021 alone, the academy issued 544 certifications and expended 2,353 subject matter expert and instructor hours. The division also provides technical assistance to local code officials and reviewers, and processes appeals to code requirements and interpretations for Building Officials throughout the Commonwealth.

During the 2018 Code Development Cycle, a Resiliency Sub-Workgroup was convened to focus on this special topic, and a Resiliency Impact Analysis of the codes was conducted. The group met most recently during the 2021 Code Development Cycle to develop proposals for Virginia's codes to increase resiliency, as well as review the resiliency impact of proposals submitted by others throughout the review cycle. Most notably, the group brought forward a code proposal from the 2024 model codes that incorporates considerations for tornado loads on structures and updates the ASCE standard to the most recent standard.

Sub-Workgroups are formed by DHCD to focus on special topics that receive a large number of code change proposals and may require in-depth analysis and discussion. The Sub-workgroups review all code change proposals and may develop new code change proposals for consideration by the General Workgroups. Sub-Workgroups are made up of selected stakeholder groups closely associated or impacted by the subject of the group.

Pursuant to the Regional Cooperation Act (*Title 15.2, Chapter 42 of the Code of Virginia)*, Virginia has 21 planning district commissions (PDCs), voluntary associations of local governments intended to foster intergovernmental cooperation by bringing together local elected and appointed officials and involved citizens to discuss common needs and determine solutions to regional issues. Another purpose of PDCs is to encourage and facilitate local government cooperation in addressing problems of greater than local significance. This is accomplished through the development of a regional strategic plan and various other duties assigned to PDCs in the Regional Cooperation Act. DHCD supports the required duties of the PDCs and distributes state general appropriation funding for each PDC. In Virginia, the PDCs are used to gather regional emergency managers for collaboration of various planning and preparedness and response efforts, to obtain funding for many regional emergency management initiatives, and to obtain funding and direct preparation of regional hazard mitigation plans.

Coastal planning district commissions also offer region-specific resources and programs concerning sea level rise, flooding and resilience. Examples include the Accomack-Northampton Planning District Commission's Climate Adaptation Working Group, the Hampton Roads Planning District Commission's coastal resiliency initiatives, the Middle Peninsula Planning District Commission's Fight the Flood Program, the Northern Neck Planning District Commission's flood hazard mitigation program, and the Northern Virginia Regional Commission's Resiliency Planning Work Group.

In partnership with FEMA's Building Resilient Infrastructure and Communities (BRIC) grant program, DHCD was selected in 2021 to receive funding to provide ICC's "When Disaster Strikes" training to code enforcement personnel throughout the state as a first step toward developing a statewide disaster response network.

DHCD administers the Virginia Weatherization Assistance Program, which reduces household energy use through the installation of cost-effective energy savings measures such as sealing air leaks, adding insulation, and repairing heating and cooling systems. These measures also improve resident health and safety. Income limits ensure that the program focuses on those citizens most in need of assistance. This program is implemented directly through a statewide network of nonprofit organizations coordinated by DHCD.

Department of Forestry (VDOF)

VDOF is responsible for the protection and development of Virginia's 15.7 million acres of forestland, providing protection and management for forest fire, insects, and disease. VDOF is directly responsible for suppression of forest fires, the enforcement of forestry-related laws and supports the state response to natural disasters. The agency maintains an urban forestry strike-team as well as a strong relationship with the logging industry for salvage related harvesting following a natural disaster. Full-time and part-time wildland firefighters are trained and qualified by VDOF in fire control tactics and the Incident Command System. An emergency state and federal interagency response center is located within VDOF's headquarters office in Charlottesville. The agency also maintains mobile command centers that are available for rapid deployment. VDOF produced statewide wildland fire risk assessments that were merged with other southern states; these assessments are available through the Southern Group of State Foresters Wildfire Risk Assessment Portal at: https://www.southernwildfirerisk.com/. VDOF also provide onsite assessments of trees to determine if they are at risk of damage or damaging structures due to high winds of hurricanes. VDF provides storm recovery recommendations and certifies arborists who can safely remove damaged and fallen trees.

VDOF has several awareness programs focused on educating the public on wildfire prevention and safety. VDOF's FireWise Virginia works with homeowners to reduce wildfire threat; the Smokey the Bear program educates youth on fire and campfire safety. The agency also offers FireWise Virginia Community Hazard Mitigation Grant program, encouraging communities to mitigate potential threats from wildfire. VDOF administers approximately $250,000 per year in Federal grant funding for wildfire hazard mitigation. The primary use is for the improvement of defensible space around structures, with approximately 430 structures protected each year. In addition, VDOF completes approximately 120 acres per year of hazardous fuels reduction at an annual total cost of $30,000 on approximately 8 to 10 different sites. Nearly all of this work has been mechanical reduction tied to defensible space creation.

VDOF and the Virginia Department of Fire Programs (VDFP) jointly administer the Dry Hydrant Grant Program to protect against wildfires in rural areas where water mains and conventional hydrants are not available. Program support is available at the request of Virginia fire departments who secure approval from local landowners. The program provides 100% of the funding necessary to cover the expenses of new installations and repairs under the program. This aid to localities provides $100,000 per year used to install approximately 20 to 24 new dry hydrants annually.

VDOF is combating heat islands through urban tree planting programs. The Urban and Community Forestry Grant Program provides funds to state agencies, local and regional governments, tribal communities and organizations, approved non-profit organizations, neighborhood associations, civic groups, public educational institutions, or community tree volunteer groups to plant new trees in urban areas.

VDFP focuses on wildfire suppression, preparation, prevention and management, including prescribed burning. The department provides funding to local fire services through the Aid-to-Localities program as well as other grant programs. It provides training to fire management teams and volunteers in localities across Virginia. The agency manages the Virginia Fire Incident Reporting System and collects data on fire risks across the state. VDFP is a Virginia Emergency Support Team agency and provides operational and technical assistance to communities across several hazard types. VDFP also performs fire prevention inspections with the State Fire Marshal's Office.

Virginia Department of Health (VDH)

The mission of the Virginia Department of Health (VDH) is to promote and protect the health of all Virginians. The VDH Office of Emergency Preparedness has two federal grants through the US Department of Health and Human Services' (HHS) Office of the Assistant Secretary for Preparedness and Response (ASPR) Hospital Preparedness Program (HPP) and Centers for Disease Control and Prevention (CDC) Public Health Emergency Preparedness (PHEP). HPP and PHEP programs implementation activities in Virginia are focused on development of all healthcare and public health capabilities and ensuring that federal preparedness funds are directed to priority areas as identified through strategic planning efforts.

Preparedness activities funded by the PHEP program are targeted specifically for the development of emergency-ready public health departments that are flexible and adaptable. This funding helps health departments build and strengthen their abilities to effectively respond to a range of public health threats, including infectious diseases, natural disasters, and biological, chemical, nuclear, and radiological events.

HPP provides leadership and funding through grants and cooperative agreements to improve surge capacity and enhance community and hospital preparedness for health care emergencies. VDH coordinates across state hospitals to monitor trends in diseases. Virginia uses a passive disease surveillance system as a primary tool for monitoring the health of communities. This system relies on healthcare providers, laboratories, and other entities required by the Code of Virginia to provide information to local health departments for all reportable conditions in the Commonwealth. The pandemic mitigation VDH framework is based upon an early, targeted, layered application of multiple partially effective non-pharmaceutical measures. VDH also initiates education programs through distributing clinical letters and providing brochures to physicians and insurers.

Monitoring foodborne diseases is also managed by VDH through environmental inspections of food service, production, and manufacturing facilities. VDH has the capability to shut down organizations with unsafe food or water. VDH manages the Virginia Behavioral Risk Factor Surveillance System, a federally-funded telephone survey of adult Virginians to collect data on behaviors that may contribute to risks of death and disease.

The agency plays an important role in providing the citizens of Virginia with outreach and information on severe weather preparedness, drinking water safety, extreme heat and heat-related illnesses, flood water safety, food safety, hurricane safety, mold and post-storm cleanup, thunderstorm and lightning safety, tornado safety and winter weather preparedness. VDH has developed a data portal or dashboard to share information related to communicable disease (including COVID-19), and heat related illness, among other databases.

The Department's epidemiologists played an enormous role in executing the Commonwealth's response to the COVID-19 crisis beginning in 2020. Vaccinate Virginia, a web portal that facilitates distribution of COVID-19 vaccines to citizens, was launched once vaccines were available. The vaccination portal made the process of finding vaccination locations and times easier for citizens in order to speed the deployment of vaccines to all.

Virginia Resources Authority (VRA)

The VRA facilitates loans to support local infrastructure for projects concerning environmental quality, public health, transportation, and economic development. Since its inception, VRA has funded more than 875 critical projects across the Commonwealth, exceeding $5 billion of investment in Virginia's communities. Financing solutions draw on VRA's unique ability to provide revolving fund loans to localities at below-market interest rates and to issue bonds backed by the moral obligation of the Commonwealth. The VRA staff offers extensive expertise in a variety of financing options and provides ongoing assistance to localities for public projects.

Department of General Services (DGS)

DGS oversees the design and construction of state-owned buildings, applying the state building code provisions related to wind, seismic, snow, and flood loads. The *Governor's Executive Memorandum 2-97* designates DGS as the responsible agency for ensuring state construction proposed in mapped flood hazard areas complies with the NFIP. All DGS proposals are processed as variances and must be reviewed by DCR.

Virginia Department of Transportation (VDOT)

VDOT is responsible for building, maintaining, and operating the state's roads, bridges and tunnels, including repairs and replacements required after large and small hazard occurrences. In accordance with requirements of the Federal Highway Administration, VDOT routinely factors flood hazards and stormwater management into the planning and design of transportation infrastructure. Seismic provisions are required for highway design in the southwestern portion of the state. As a public safety agency, VDOT responds to various emergencies on the roads through their Safety Service Patrol, coordinates hurricane evacuation preparation with the Hurricane Evacuation Work Group, repairs roads after flooding events, prepares roads/bridges prior to winter storms, and conducts road clearing before and after snow events. VDOT also provides an Online Snowplow Tracker Tool to show the status of snow clearance operations, and a hotline for drivers with questions. VDOT provides travel information and driving tips online, on social media, and on highway signage along major travel routes.

The Virginia Transportation Research Council sponsors research into building models to identify the impacts of flooding on roadways. The VDOT Pathways for Planning web application uses flooding data (including floodplains, impaired waterways, riverine flooding, and coastal waterways) to identify roadways that are impassible or impaired due to flooding; permission is required to access the data.

VDOT created the Office of Transportation Sustainability (OTS) to facilitate sustainability efforts through three programs: (1) Decarbonization; (2) Resilience; and (3) Land Management. Under the Resilience Program, VDOT is developing a framework for the incorporation of resiliency strategies into transportation planning, project development, delivery, operations, maintenance, and asset management. The framework is aimed at identifying resiliency needs and developing specific strategies to anticipate, prepare for and mitigate events that put the transportation network at risk of disruption and deterioration, while ensuring that network improvements do not undermine other climate resilience strategies or put more people at risk.

The November 2022 *VDOT Resilience Plan*[1] formalizes a framework for incorporating resilience into transportation planning, project development, delivery, operations, maintenance and asset management. The plan includes strategies to achieve six primary objectives:

- Promote data-driven decisions;
- Engage and partner with stakeholders;
- Identify at-risk infrastructure and prioritize needs;
- Survey resilience measures (adaptive design criteria, nature-based resilience measures, enhanced operational, maintenance and emergency management measures, etc.);
- Utilize feasibility and cost effectiveness analyses; and,
- Incorporate resilience into current funding policies.

VDOT's establishment of the Resilience Plan is an important step to support the goal of increasing resilience statewide, and in coordination with fellow state transportation agencies, to help increase infrastructure resilience nationally. As the agency works toward the objectives and strategies outlined in the plan in the coming months and years, staff will continue to engage and partner with federal and state agencies, localities, Metropolitan Planning Organizations, industry partners, advocacy groups and other stakeholders to solicit input through coordination meetings, workshops and other avenues. Additionally, VDOT will establish and implement an outreach plan to help leverage existing efforts, maximize benefits and ensure decision-making is coordinated with statewide policy.

Division of Risk Management, Department of Treasury (DRM)

DRM's primary responsibility is to establish and administer various risk management plans as required by state law. DRM maintains the Virginia Property System (VAPS), a database for maintaining insurance values for state-owned buildings and their contents. Non-owned buildings occupied by state agencies are also included. VAPS allows agencies and institutions to modify their own property and location values as well as other property information. DRM maintains a blanket insurance policy, which covers all state buildings. Each agency pays premiums based on their buildings and loss history. Claims are handled by DRM, and can be made for building structural and contents damage.

Virginia Energy

Formerly known as the Department of Mines, Minerals and Energy, Virginia Energy operates six divisions. Four of these divisions regulate the mining and reclamation of

[1] Accessed online 12/5/22 at https://www.virginiadot.org/programs/resources/environmental/VDOT_Resilience_Plan_Nov_2022_FINAL_acc112222.pdf

more than 30 different mineral resources such as coal, gas, oil, and non-petroleum minerals like rock and gravel. The primary goal of these divisions is to provide for safe and environmentally sound mineral and fossil fuel extraction. One objective of the program is to eliminate adverse environmental conditions and public safety hazards associated with extraction sites, such as flood hazards and slope failures.

Virginia law controls the release of mining permits based on the risk of land subsidence; Virginia Energy requires a subsidence control plan as part of the permitting process. The permittee has responsibility for several factors, such as fulfilling any repair requirements, complying with reporting standards, and understanding mining activity limitations.

The Division of Geology and Mineral Resources serves as Virginia's geological survey. Staff perform investigations aimed at reducing risk from geologic hazards such as landslide, and encouraging sustainable development through the wise use of mineral, land, water, and energy resources. In addition to publishing maps and reports, agency scientists maintain repositories of geological and geophysical data, as well as rock, fossil, and core samples. The agency reduces the impact of geologic hazards that pose safety and environmental problems, such as landslides and karst, and provides maps and digital data to local jurisdictions to be included in local plans. Maps of steep slope areas are available for some areas, and the agency has created and continues to populate a statewide landslide map to document historic landslides.

Abandoned, mineral mined lands are those areas disturbed by the mining of all minerals, except coal, which were not required by law to be reclaimed or have not been reclaimed. Virginia's General Assembly enacted reclamation laws in 1968 to minimize the adverse effects of mining on the environment. Recognizing that past mining practices had left many orphaned or unreclaimed mine sites, a commitment was also made to study the extent of orphaned mines in Virginia. The Commonwealth has an estimated 4,000 orphan mines, 69% of which have been inventoried. Once identified, an abandoned mineral mine site is evaluated for potential hazards to the environment and the public health and safety. This evaluation includes soil and water investigations, studies on the feasibility of reclaiming the site, cost analysis, and seeking the landowner's consent to allow reclamation to proceed. Virginia Energy maintains a georeferenced database of abandoned mineral-mined lands online at: https://energy.virginia.gov/webmaps/MineralMining/. The Division of Geology and Mineral Resources also maintains a geospatial database that identifies karst and sinkhole locations throughout the Commonwealth.

Virginia Energy compiles evidence of prehistoric earthquakes and pairs these data with cultural and infrastructure data to improve emergency management practices. These data have been used to develop the GIS fault geodatabase for Virginia, confirm existing fault mapping in the state, identify communities at greatest risk of future earthquake damage, and present data products and outreach materials to planners and emergency management agencies in seismically active areas. The agency collaborates with the Virginia Tech Seismological Observatory, which monitors seismic activity across the Commonwealth.

Virginia Energy is also involved in identifying ways to increase energy savings for the Commonwealth through several programs and policies. The Energy Efficiency Team works to expand clean energy inventory and provide access to clean energy programs to all Virginians through three primary program categories:

1) **Energy Efficiency**, including Energy Savings Performance Contracting, Demand Response programs that pay facilities to reduce energy load during times of grid stress or high energy prices, and the Energy Data Warehouse;
2) **Energy Financing**, including establishing local green banks, Property Assessed Clean Energy, which is a means of financing energy efficiency upgrades, disaster resiliency improvements, water conservation measures and renewable energy installations at a property; and,
3) **Energy Access**, or the distribution of costs and benefits of an energy systems and the accessibility to affordable energy across customers in a region or utility service territory.

As directed by the Virginia General Assembly, every four years Virginia Energy develops a comprehensive Virginia Energy Plan. The governor's vision for the 2022 Plan is to develop a data-driven roadmap that considers all energy sources and is transparent with Virginians about the opportunities and costs each energy source presents while recognizing new information will continue to guide the process and decision making over time. The 2022 Energy Plan, which will replace the Energy Assurance Plan of 2012, will provide energy policy recommendations that aim to balance the current and future needs of all Virginians, environmental goals, economic competitiveness, consumer choice and technology innovation. The plan will focus on achieving four objectives: Lower Cost of Living; Job Creation; Bringing People to Virginia; and an "All-of-the-Above" Approach to Energy Policy. Virginia Energy develops the Virginia Energy Plan in consultation with many stakeholders, including:

- State Corporation Commission;
- Department of Environmental Quality;
- The Clean Energy Advisory Board;
- Representatives from solar, wind, energy efficiency and transportation electrification sectors;
- Natural gas and electric utilities;
- Consumer, environmental, manufacturing, forestry and agricultural organizations; and,
- Virginia Citizens.

Department of Environmental Quality (DEQ)

DEQ is the lead agency for several mitigation programs that address a variety of hazards. The Virginia Coastal Zone Management (CZM) Program is a network of Virginia state agencies and local governments, established by Executive Order in 1986 which administers enforceable laws, regulations and policies that protect coastal resources, strengthen the coastal economy, and foster sustainable development. DEQ serves as the lead agency for Virginia's networked program and administers an annual CZM grant award from NOAA. The Virginia CZM Program helps agencies and localities develop and implement coordinated coastal policies and solve coastal management problems.

The CZM Program's Coastal Policy Team, composed of representatives of all the program's member agencies, facilitates cooperation among the agencies and provides a forum for discussion and resolution of cross-cutting coastal resource management issues. One of the goals of the program is 'to reduce or prevent losses of coastal habitat, life, and property caused by shoreline erosion, storms, and other coastal hazards in a manner that balances environmental and economic considerations. 'The program addresses coastal hazards through several coastal resiliency initiatives. Flood hazard-related land features addressed through the program include tidal and non-tidal wetlands, dunes and beaches, riparian buffers, barrier islands, and highly erodible/high hazard lands. Many Virginia CZM program initiatives have focused on shoreline management and adaptation to sea level rise/ recurrent flooding.

Climate resiliency was selected by the Coastal Policy Team as the next focal area theme to help meet the goals and needs in the statewide resiliency plan. Virginia CZM Program grant projects beginning in October 2020 have addressed increasing technical capacity through use of tools like the Resiliency and Adaptation Feasibility Tool (RAFT) and the CRS. Focal Area projects are promoting ecotourism as a way to derive economic benefit from conserved lands that provide climate resiliency or developing project designs to restore or create climate resilient habitats and identification of high priority habitats. The FY20-FY2023 Climate Resiliency Focal Area continues the progress made under the five-year (2016-2020) Coastal Hazards strategy and the next five-year Coastal Hazards strategy that began in October 2021.

The 1989 Chesapeake Bay Preservation Act, *(Title 10.1, Chapter 21 of the Code of Virginia, as amended)* or "Bay Act," is one of the enforceable programs of Virginia's CZM Program. The Bay Act was intended to improve water quality in the Chesapeake Bay and its tributaries by requiring the use of conservation planning and pollution prevention practices when using and developing environmentally sensitive lands. At the heart of the Bay Act is the concept that land can be used and developed in ways that minimize negative impacts on water quality. The regulations provide the required elements and criteria that local governments must adopt and implement in administering their Bay Act programs. The Bay Act recognizes that local governments have the primary responsibility for land use decisions and expands their authority to manage water quality, and establish a direct relationship between water quality protection and local land use decision-making.

Consequently, localities started implementing the provisions of the Bay Act regulations in the early 1990s by amending their local comprehensive plans, zoning and land use ordinances. These localities have incorporated water quality protection measures consistent with the Bay Act Regulations into their zoning ordinances, subdivision ordinances, and comprehensive plans. The regulations address non-point source pollution by identifying and protecting certain lands called Chesapeake Bay Preservation Areas. The regulations use a resource-based approach that recognizes differences between various landforms and treats them differently.

The Bay Act was modified during the 2020 session of the Virginia General Assembly to include "coastal resilience and adaptation to sea-level rise and climate change" as one of the purposes of the Act. This change triggered new regulations and could provide Virginia localities with a new adaptation tool. DEQ developed new regulations that were adopted by the State Water Control Board in 2021. The program now requires an assessment of climate change impacts anytime an encroachment into the Resource Protection Area (RPA) is proposed. This analysis must be based on the lifespan of the project or 30 years, must consider the loss of the RPA buffer, and adaptation measures that may be required.

DEQ is the lead agency for developing and implementing the Commonwealth's statewide program to protect water quality and quantity from stormwater runoff. The agency issues permits, certifies land disturbances, and offers compliance assistance to local governments who are key partners in the program, administering both stormwater and erosion control programs at the local government level. *Stormwater Management Act (§ 62.1-44.15:24 et seq.)* and *Erosion and Sediment Control Law (§62.1-44.15:51 et seq.)* set forth regulations regarding land development activities to prevent water pollution, stream channel erosion, depletion of groundwater resources, and more frequent localized flooding, in order to protect property values and natural resources. Stormwater management programs address adverse impacts and comprehensively manage the quality and quantity of stormwater runoff on a watershed-wide basis.

DEQ monitors and evaluates hydrologic and water supply conditions and assesses drought conditions following guidance in the *Virginia Drought Assessment and Response Plan*.
Through its Drought Monitoring Task Force, DEQ compiles Drought Status Reports using information gathered from several state and federal agencies. The reports, distributed by VDEM, contain sections relating to current climatological conditions and

situation reports regarding water supplies, water quality, wildfire risks and agriculture and crop reports. DEQ may convene a Virginia Drought Monitoring Task Force (DMTF) when drought indicators show that significant drought conditions are likely to occur. The DEQ and DMTF may declare one of several Drought Stages, enabling the state and local governments to restrict water use. The DEQ divides drought responses into three stages: Drought Watch, Drought Warning, and Drought Emergency.

DEQ also has responsibility for the environmental consequences of accidents and disasters that could impact the State's air, water and land resources. The agency plays a major role in hazardous materials containment, testing and abatement. The Virginia Water Protection Program administers state regulations in accordance with federal guidelines under the Federal Clean Water Act of 1972. State law requires that a VWP permit be obtained before disturbing a wetland or stream by clearing, filling, excavating, draining or ditching. Landowners make applications through the Joint Permit Application process, which covers both federal and state reviews. The Virginia Marine Resources Commission (VMRC) and the USACE are also involved in review of the joint permit applications, particularly for coastal wetland and shoreline impacts. As a result of State Bill 776 approved April 7, 2020, living shorelines are the default option for shoreline erosion control, unless an applicant can show that the living shoreline will not work on the specific location, which will increase the use of nature-based shorelines across Virginia. This bill also requires VMRC to update standards for wetlands permits, taking sea level rise and climate change impacts into account on each wetland permit application. The regulations were further clarified in 2022 to define the term "other structural and organic materials", a key point that allows cost-effective innovations in living shoreline products to be used in Virginia under an abbreviated General Permit for living shorelines.

Department of Historic Resources (DHR)

The Virginia Department of Historic Resources is the State Historic Preservation Office (SHPO). The department's mission is to foster, encourage, and support the stewardship of Virginia's significant historic architectural, archaeological, and cultural resources. DHR provides information and guidance to private and public historic property owners/managers regarding the protection, preservation, and repair/mitigation of historic buildings, structures, archaeological sites, and other culturally significant assets. DHR reviews and comments on state and federal projects subject to the State Environmental Review Act, Section 106 of the National Historic Preservation Act, and other applicable state and federal laws and regulations. Funding is available for archeological sites endangered by erosion through DHR's Threatened Sites Program.

As a condition of the disaster relief assistance for historic properties funding the department received from the National Park Service after hurricanes Michael and Florence, DHR was required to produce a disaster mitigation plan focused on historic resources in Virginia. During the last storm grant program for Hurricane Sandy, the department issued a locality-specific disaster mitigation plan for historic resources that may be used as a template in other communities. The *Historic Surry Disaster Mitigation Plan*, can be located online at: https://www.dhr.virginia.gov/pdf_files/SandyGrant/Disaster%20Mitigation%20Plan_final%20draft.pdf.

University-Led Initiatives

The Commonwealth Center for Recurrent Flooding Resiliency, a partnership of Old Dominion University (ODU), the College of William & Mary, and the Virginia Institute of Marine Science supports "building resilience to rising waters". The Center performs studies on recurrent flooding and provides findings to the local governments, state agencies, industries, and citizens of Virginia. The Center also provides training and policy guidance to various state agencies and municipal bodies upon request. Examples have included the City of Norfolk (Retain Your Rain Mini-Grant Program), Division of Legislative Services (Chesapeake Bay Restoration Fund Advisory Committee), the City of Virginia Beach (*Flood Protection Program Bon Referendum Analysis,* 2021) and the Secretary of Natural Resources/Special Assistant to the Governor for Coastal Adaptation and Protection (*Recommendations for Freeboard Standards for State-Owned Buildings in the Commonwealth of Virginia*, 2019).

The Institute for Coastal Adaptation and Resilience (ICAR), a national center for the science and practice of coastal resilience at Old Dominion University, launched in 2018 to develop practical solutions to challenges faced by coastal communities. ICAR builds on over eight years of investment and commitment by Old Dominion to leadership in coastal adaptation and resilience. ICAR works collaboratively to develop and support interdisciplinary academic and professional development programs with a focus on resilience broadly, and coastal resilience specifically. These include curricular and extracurricular academic programming, including service learning, experiential and entrepreneurial opportunities. ICAR activities emphasize engagement with the community and collaboration with partners to promote synthesis, integration, knowledge sharing, and coordination of research and education activities. Key research focus areas include:

1. Sea level rise and climate science – improving the understanding of interactions among sea level, coastal ocean circulation, and the larger climate ecosystem;
2. Flooding and the built environment – addressing climate impacts on coastal infrastructure;
3. Social science and policy – analyzing the human dimensions of coastal resilience; and
4. Health dimensions of coastal resilience – assessing the health dimensions and emerging health threats of climate change.

In March 2022, ICAR, together with ODU, Hampton Roads Planning District Commission, and Virginia Sea Grant hosted the Hampton Roads Sea Level Rise/Flooding Adaptation Forum. The Adaptation Forums continue as quarterly meetings to bring together professionals in adaptation including local municipal government staff, scientific experts, private sector engineers, state and federal agency staff, NGOs and other stakeholders to facilitate regional coordination, information exchange and share adaptation best practices. ICAR has participated in the City of Virginia Beach Summer Series on Sea Level Rise (2018), the North Landing River/Albemarle Sound Estuarine Symposium (2018), and created a series of community connection efforts to share sound climate science with Hampton Roads community members. In September 2022, ICAR Seminar Series continued with a presentation on the Projected Impacts of Future Sea Level Rise and Recurrent Flooding in Coastal Virginia. Additionally, ICAR is launching a Coastal Resilience and Adaptation Economy initiative that targets entrepreneurial and business accelerator activities in an emerging economy, meeting an expanding global market for rural, suburban and urban solutions to increased flooding, erosion, coastal hazards, and sea level rise. The project lays the foundation of a resilience innovation ecosystem that produces new, long-term, high-paying jobs and businesses in support of many coastal sectors ranging from housing and waterfront buildings to infrastructure and blue-green environmental assets.

Virginia Sea Grant is a six-university partnership that works to improve coastal ecosystems, coastal communities, and working waterfronts by financially supporting researchers, graduate fellows, extension members, and interns. The six universities include: George Mason University, Old Dominion University, the University of Virginia, Virginia Commonwealth University, Virginia Institute of Marine Science, Virginia Tech and William & Mary. Alongside these universities and a variety of other partners, the program acts as an “honest broker” to spread useful, unbiased, and science-based knowledge to a wide variety of audiences and constituents. Sea Grant supports graduate students through research fellowships and post-graduate students in fellowships in science policy and resource management. The program supports extension agents who conduct and communicate research for coastal communities that can benefit from it. Virginia Sea Grant’s professional post-graduate fellowships offer on-the-job training where fellows can work directly with state and federal agencies on coastal policy and management issues. Virginia Sea Grant supports established collaborations as well as new or emerging collaborations that respond to dynamic challenges in the study of coastal adaptation. Between 2014 and 2020, Virginia Sea Grant supported 293 fellowships and internships, trained 4,192 professionals in safe and sustainable seafood practices, and completed professional development training for 343 people.

The Virginia Coastal Policy Center (VCPC) at William & Mary Law School provides science-based legal and policy analysis of ecological issues affecting the state's coastal resources. These specialists provide education and advice to a host of Virginia government officials, legal scholars, and non-profit or business leaders. VCPC activities are inherently interdisciplinary, drawing on scientific, economic, public policy, sociological, and other expertise. With access to internationally recognized scientists at VIMS, and Virginia Sea Grant's national network of legal and science scholars, and to elected and appointed officials across the nation, VCPC engages in a host of information exchanges and collaborative partnerships.

The Resilience Adaptation Feasibility Tool (RAFT) is an innovative"collective impact collaborative approach to climate resilience that leverages the expertise and resources of multidisciplinary partners and diverse stakeholders to assist coastal localities striving to increase their resilience. This project is a partnership between: The Institute for Engagement & Negotiation at the University of Virginia, The Virginia Coastal Policy Center at William & Mary Law School, and ODU/Virginia Sea Grant Climate Adaptation and Resilience Program.

George Mason University is creating the Virginia Climate Center to bring resources and expertise to bear in the state's efforts to increase resilience to the impacts of climate change. Local municipal leaders will have access to an unprecedented range of observational data, environmental models, and experts in climate science, sustainability and engineering solution through the center. The center will receive just under $2 million in federal funding to provide products and services to Virginia companies and municipalities to help them adopt climate risk prevention and mitigation strategies for sustainable entrepreneurship, enhanced profitability, and wise resource management. The center will offer advice on risk prevention and mitigation strategies, actionable information on current and projected future climate, and assessments of the likely climate change impacts on human health, buildings, infrastructure, transportation, agriculture and natural resources.

The Virginia Modeling, Analysis, and Simulation Center (VMASC) is a multidisciplinary applied research and enterprise research facility of ODU, located in the Tri-Cities Center in Suffolk, Virginia. Staffed by over two dozen research faculty and project scientists, the center provides modeling and simulation, analytic research, and technological support for partners across various industry, government, and community sectors; including, healthcare, cyber security, strategic defense, transportation and infrastructure, usability, and instructional design. VMASC has partnered with VDEM on many emergency management initiatives, including this hazard mitigation plan.

The Center for Risk Management of Engineering Systems (CRMES) brings together faculty from across the University of Virginia, including the School of Engineering and Applied Science, the Darden School of Business, and the College of Arts and Sciences. The focus of CRMES is performing multi-disciplinary studies to investigate risk for government and industry stakeholders. CRMES delivers research to international audiences regarding the risk and resilience of complex sociotechnical systems. CRMES research focuses on a variety of domains, including: reliability modeling and simulation; resilience analytics; cyber-physical defense of civil infrastructure; multimodal transportation planning and safety; supply chain risk management and resilience; energy sustainability; and multi-regional and cross-regional analysis of infrastructure interdependencies.

The Center for Hardware and Embedded systems Security and Trust (CHEST) is a university-based research center of the National Science Foundation, which includes strategic partnerships with the University of Virginia. CHEST supports research into the design, protection, and resilience of electronic hardware and embedded systems, including resilience to supply chain disruptions. The University of Virginia focuses on infrastructure safety and resilience projects to assess threats to the safe manufacture, delivery, and integration of microelectronics for consumer and government products. This research considers fundamental human needs as well as social and environmental factors when assessing infrastructure resilience.

The Commonwealth Center for Advanced Logistics Systems (CCALS) is an applied research collaboration that brings industry, government, and university stakeholders together to deliver enhancements to logistics systems. CCALS has several mitigation initiatives including cyber risk and resilience of infrastructure systems, supply chain disruption analyses, and the impacts of climate change on interconnected social and physical systems. The University of Virginia partners with CCALS on a variety of projects including: the assessment of risk and resilience to supply chains in large industrial regions; the assessment risk policy in corrections centers; and analyses of civil transportation systems and roads.

Virginia Silver Jackets

The Virginia Silver Jackets team brings individuals from different agencies together to collaborate, share data, and leverage resources in order to identify and implement solutions to reduce flood hazards statewide. In addition to the USACE, the Virginia Team currently includes staff from VDEM, DCR, Natural Resources Conservation Service, FEMA, NWS, and USGS. The Virginia Silver Jackets Team first met on June 23, 2010, and the program has been active since its inception.

A project completed in 2016 through Silver Jackets collaboration was the high water mark initiative for the City of Richmond. On the 44th anniversary of the historic flood resulting from precipitation from Hurricane Agnes, the City of Richmond and the Virginia Silver Jackets Team held a ceremony unveiling a high water mark sign in Pony Pasture Rapids Park. The record of flood at the park stands 13 feet above the parking lot. The unveiling event, supported through a FY16 Interagency Silver Jackets

Project Proposal, was the result of an eight month effort and includes two additional signs installed in Great Shiplock Park and Brown's Island. The group selected each location specifically because of high visibility to the public, the opportunity to use public land, and the ability to mount signs to existing structures. The partnership also supported an inundation mapping project along the Blackwater River in Franklin, Virginia, through a partnership with NWS, USGS, DCR and VDEM. Work is expected to be complete in 2022 on a project involving inundation mapping along the Roanoke River in the Upper Roanoke Valley of Virginia.

4.4.2 Related State Plans and Documents

There are several state plans and documents related to mitigation planning and projects in Virginia. Those most pertinent to mitigation for natural hazards include those summarized below.

Virginia Flood Risk Management Standard

Governor Northam signed EO-45 (2019), creating the Virginia Flood Risk Management Standard. A first of its kind for any state, the Virginia Flood Risk Management Standard improves flood protection in coastal areas by discouraging building in floodplains and incorporating sea level rise projections that have been developed based on the best available science and adopted by NOAA. In addition, Executive Order 45 establishes a "freeboard" standard that increases protection of state-owned buildings in both coastal and riverine floodplains by requiring that they be built to elevation standards that will protect them from flooding.

This initiative is the result of EO-24 (2018) to improve resilience and protect people and property from natural catastrophes. EO 24 required the issuance of state-wide or regional freeboard and sea-level rise projections. The Virginia Flood Risk Management Standard satisfies those requirements by setting standards for coastal and riverine flood prone areas. Flood prone areas includes sea level rise inundation areas, as well 100- and 500 year-floodplains mapped by FEMA.

Floodplain Management Plan for the Commonwealth of Virginia (2005), DCR

The Floodplain Management Plan is a comprehensive guidance document for federal, state, and local officials to address floodplain management issues, assess floodplain management needs, and establish strategies, measures, and priorities for meeting those needs. The Plan presents the Commonwealth's strategy for the identification, planning, and mitigation of flood hazards as well as to encourage sound floodplain management. In addition, the Plan provides tools for flood hazard risk identification to enhance the knowledge and skills of local and state officials responsible for floodplain management and to promote the advancement of responsible development in and beneficial uses of floodplains. DCR's Floodplain Management Program is currently updating the Commonwealth's Floodplain Management Plan, with an expected completion date toward the end of 2022.

Executive Memorandum 2-97, Floodplain Management for State Agencies (1997)

Developed in the early 1990s and adopted after Hurricane Fran in 1996, this document clarifies the Governor's intent that all state agencies have some responsibility in managing flood hazards and impacts through avoidance, promotion, and coordination activities. The Executive Memorandum addresses important aspects of state performance:

- DCR is charged as the State Coordinating Office of the NFIP and the technical advisor on the viability of proposed flood mitigation projects;
- All State agencies engaged in construction or land disturbing activities are to comply with locally adopted floodplain management ordinances;
- New state buildings in flood hazard areas must be authorized by a variance obtained from the Director of DGS Division of Engineering and Buildings in consultation with DCR; and
- The SCC determines the adequacy of the Commonwealth's insurance with respect to potential flood damage.

Post Disaster Mitigation Strategy

Prepared by the Commonwealth and FEMA immediately following establishment of a Disaster Field Office to respond to each presidential declared disaster, the Mitigation Strategy focuses mitigation priorities specific to recovery from that disaster. In conjunction with the state's mitigation goals and vision statement, the Mitigation Strategy priorities are determined to support recovery operations for the specific disaster event. These priorities can include education, support of local officials in administration of floodplain ordinance requirements, targeted technical training, or development of specific mitigation messages for affected residents, businesses and local governments. The Strategy also outlines priorities for implementing HMGP funding. Immediate recovery priorities are outlined to guide eligible HMGP applicants.

Commonwealth of Virginia Recovery Plan: State and Local Fiscal Recovery Funds (2022)

As part of the American Rescue Plan Act (ARPA) Coronavirus State and Local Fiscal Recovery Fund (SLFRF), Virginia received an allocation of $4.927 billion in total ARPA funds. The Commonwealth submitted an initial Recovery Plan on August 31, 2021, after the Virginia General Assembly held a special session to appropriate ARPA funds on August 2, 2021. This report stands as an update to the initial report and describes ongoing efforts to respond to the COVID-19 pandemic. Virginia determined to award funds to address five specific needs: help public health, help small businesses, help workers, help public schools, and fully deploy broadband across Virginia. The Commonwealth awarded funds for 115 projects across 37 agencies. Expenditures through the end of 2021 are included in the April 8, 2022, version of this report.

Virginia Coastal Resilience Master Plan (2021)

As a part of EO-24 (2018) , the Commonwealth is charged with developing a Coastal Resilience Master Plan. Generically termed the "Master Plan", this document is to be the guiding document for the state's coastal adaptation and protection efforts. Virginia's Chief Resilience Officer (CRO), along with the Special Assistant to the Governor for Coastal Adaptation and Protection (SACAP), are responsible for the Plan's development and implementation. The Commonwealth intends to develop successive updates of the Master Plan on at least a five-year cycle, managed by DCR in consultation with the Chief Resilience Officer, the Special Assistant to the Governor for Coastal Adaptation and Protection, and the Technical Advisory Committee.

In 2021, the Commonwealth worked with multiple stakeholders to build the *Coastal Resilience Master Plan*. Participants included over 1,300 public survey participants, over 300 local and regional practitioners. This plan documents which land is exposed to coastal flooding hazards now and into the future, as well as the impacts of future flooding scenarios on coastal Virginia's community resources and manmade and natural infrastructure.

The Master Plan concluded that between 2020 and 2080:

- The number of residents living in homes exposed to extreme coastal flooding is projected to grow from approximately 360,000 to 943,000, an increase of 160%;
- The number of residential, public, and commercial buildings exposed to an extreme coastal flood is projected to increase by almost 150%, from 140,000 to 340,000, while annualized flood damages increase by 1,300% from $0.4 to $5.1 billion;
- The number of miles of roadways exposed to chronic coastal flooding is projected to increase from 1,000 to nearly 3,800 miles, an increase of nearly 280%; and
- An estimated 170,000 acres, or 89%, of existing tidal wetlands and 3,800 acres, or 38%, of existing dunes and beaches may be permanently inundated, effectively lost to open water.

The next phase of the Master Plan will aim to address recommendations of the Technical Advisory Committee to broaden the analysis of natural hazards to include rainfall-driven, riverine, and compound flooding in order to better understand the nature of all flood hazards facing coastal communities. This phase will also expand and improve the inventory of resilience projects by continuing efforts with project owners to better understand the benefits of projects.

4.5 Federal Agencies and Programs

After each declared disaster, federal resources that may support recovery are critical to recovery. Some federal programs can be accessed in an ongoing capacity to support local initiatives.

4.5.1 Federal Emergency Management Agency (FEMA)

As the nation's emergency management agency, FEMA programs focus on supporting state and local initiatives that will reduce the impacts of disasters. The programs provide ongoing technical assistance, regulatory standards and financial assistance. A subset of programs is activated only after a disaster is declared. The following programs focus on mitigation for future disasters even if they are normally only administered in a post-disaster scenario.

Commonwealth Sum-Sufficient Match - HMGP

The FEMA Hazard Mitigation Grant Program (HMGP) provides post-disaster funding to state, local, tribal and territorial government efforts to develop hazard mitigation plans and rebuild in a way that reduces, or mitigates, future disaster losses in their communities. This grant funding is available after a presidentially declared disaster and must be requested by an authorized entity. In this program, homeowners and businesses cannot apply for a grant. However, a local community may apply for funding on their behalf.

All state, local, tribal and territorial governments must develop and adopt hazard mitigation plans that are approved by FEMA in order to receive funding for their hazard mitigation projects. The HMGP program allows federal funding of up to 75%. The remaining 25% must be provided by non-federal funds. Historically, the Commonwealth has provided up to 20% of the project costs, when available, resulting in local match requirements of only 5%. Virginia's support of the program has made HMGP available to many local governments who otherwise could not provide the required 25% non-federal cost share. Presently, this funding cannot be used with any other HMA program.

Response & Recovery – Public Assistance (PA)

Immediately following the declaration of a major disaster, FEMA and the state implement procedures to assess damage, estimate the cost of restoration, and allocate funds for recovery. The PA program focuses on restoration of certain non-profit and public buildings, public utilities, and transportation infrastructure that covers a portion of the costs to respond and recover from the event. Under certain circumstances, mitigation measures can be factored into recovery of public buildings and facilities to minimize the potential for future losses from comparable events.

Response & Recovery – Individual Assistance (IA)

Implemented jointly immediately following a major disaster declaration for events which impacts citizens, the IA program provides funds for temporary housing, basic housing repairs, and replacement of essential household items. IA is available directly to citizens who were impacted by the declared event in a declared jurisdiction.

Pre-Disaster Mitigation (PDM)

Authorized by Section 203 of the Stafford Act, 42 USC 5133, the Disaster Mitigation Act of 2000 (DMA2K) amended the Stafford Act by opening the PDM funding stream and requiring state and local hazard mitigation plans. The PDM program assists states, territories, tribal governments, and local communities with implementation of a sustained pre-disaster natural hazard mitigation program to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on federal funding resulting from future disasters. The PDM program funds damage-reduction approaches, based on planning developed with three principles: (1) preventive actions must be decided at the local level; (2) private sector participation is vital; and (3) long-term efforts and investments in prevention measures are essential. Local governments, through the Commonwealth's Planning District Commissions, periodically revise local hazard mitigation plans that enable them to compete for PDM funds once their local plan is approved. The federal share of a project for the PDM program is capped at 75% or $4 million, whichever is less.

Flood Mitigation Assistance (FMA)

Authorized by Section 1366 of the National Flood Insurance Act of 1968, as amended (NFIA), 42 USC 4104c, with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP). This grant program is focused on those properties that, if mitigated, will benefit the National Flood Insurance Fund (NFIF) and NFIP policyholders. For the most part, the projects acquire, elevate, or relocate residential buildings that have a history of repetitive claims against the NFIF. All projects, including measures other than acquisition and elevation, must be cost effective and not have adverse environmental impacts. Localities wishing to apply for these funds must have an approved hazard mitigation plan. The amount of funding available is dependent on annual appropriations. FMA projects focus almost exclusively on Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties. Federal funding is available for up to 75 percent of the eligible activity costs. FEMA may contribute up to

100 percent Federal cost share for SRL properties, and up to 90 percent Federal cost share for RL properties.

Building Resilient Infrastructure and Communities (BRIC)

BRIC aims to shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. BRIC projects demonstrate innovative approaches to partnerships, such as shared funding mechanisms, and/or project design. For example, an innovative project may bring multiple funding sources or in-kind resources from a range of private and public sector partners. Or an innovative project may offer multiple benefits to a community in addition to the benefit of risk reduction. Through BRIC, FEMA continues to invest in a variety of mitigation activities with an added focus on infrastructure projects and Community Lifelines.

Response & Recovery – Hazard Mitigation Grant Program (HMGP)

VDEM manages this program, and project applications are required to be submitted to FEMA within a year of a federal disaster declaration. HMGP can fund planning efforts such as the development/revision of state, local, and university hazard mitigation plans, or it can be used to fund brick and mortar projects with mitigation benefits in excess of project costs. HMGP can fund projects to mitigate risk such as elevations, acquisition and demolitions, acquisition and relocations, minor localized flood control projects, infrastructure retrofits, floodproofing projects, wildfire mitigation, and safe room construction. HMGP can also fund initiative projects such as emergency generator quick connects, emergency generators, warning systems, GIS that supports mitigation, and outreach and education materials.

National Flood Insurance Program (NFIP)

The NFIP offers flood insurance to property owners with insurable assets located in jurisdictions that adopt and enforce certain provisions that will help to minimize future flood losses. The measures apply to all activities proposed within special flood hazard areas that are designated on floodplain maps provided by FEMA. All development must be designed and constructed to withstand damage (from water and wind-related hazards) and must not create any adverse impacts on other properties. The floodplain mapping component of this program is one of the most effective measures for keeping structures out of flood hazard areas, either through avoidance or minimization.

FEMA's Risk MAP program works collaboratively with state, local, and tribal entities to deliver quality floodplain data that increases public awareness and leads to action that reduces risk to life and property. It also fosters informed risk management decisions and actions to mitigate risk through a consistent risk-based approach to assessing potential vulnerability and losses. By analyzing and depicting flood risk, communities and the public can understand their risk and make informed decisions to reduce vulnerability. The agency's Map Modernization program has transformed most of FEMA's flood hazard mapping inventory to 21st century digital technology and restored confidence in the reliability of floodplain boundaries, while making updates to the underlying engineering data.

With over 20,000 communities in the NFIP, maintaining current maps is a daunting task. Map Modernization is a collaborative process that spans all levels of government as well as a multitude of other organizations. This collaborative process results in partnerships among state, regional, and local stakeholders. The Commonwealth participates in the Map Modernization initiative as a Cooperating Technical Partner.

In 2021, FEMA implemented *Risk Rating 2.0: Equity in Action*. The new, individualized approach to risk assessment, built on years of investment in flood hazard information, assesses many factors for individual properties, including: frequency of flooding; multiple flood types (river overflow, storm surge, coastal erosion, heavy rainfall); proximity to flood sources; and building characteristics, such as first floor heights and the cost to rebuild. The approach uses new data, new flooding models and new technologies. In March 2021, FEMA estimated that 45% of Virginia flood insurance customers (46,812 policies) would see immediate decreases in premiums; 48% (50,931 policies) would experience $0 - $10/month increases; 5% (5,093 policies) would experience $10 - $20/month increases; and, 2% of customers (1,949 policies) would see increases of greater than $20/month.[2]

Safeguarding Tomorrow Revolving Loan Fund (RLF) Program

The Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act became law on January 1, 2021 and authorizes FEMA to provide capitalization grants to states, eligible federally recognized tribes, territories and the District of Columbia to establish revolving loan funds that provide hazard mitigation assistance for local governments to reduce risks from natural hazards and disasters. The Act amends the Robert T. Stafford Disaster Relief and Emergency Assistance Act. These low interest loans will allow jurisdictions to reduce vulnerability to natural disasters, foster greater community resilience and reduce disaster suffering. Federally recognized tribes that received a major disaster declaration are eligible to apply.

The priorities of the Safeguarding Tomorrow RLF program are to:

[2] https://www.fema.gov/sites/default/files/documents/fema_virginia-state-profile_03-2021.pdf accessed 2/21/2023.

- Empower Entities. FEMA will collaborate with eligible entities to help them increase their capacity and capability, through focused engagement activities leading up to the application period and providing increased technical assistance during the Year 1 application period.
- Create innovative funding solutions. Applicants can leverage loans for non-federal cost share with other FEMA Hazard Mitigation Assistance programs, helping underserved communities access additional funding resources.
- Deliver equitable investments and increased access. A goal of the Safeguarding Tomorrow RLF program is that 40% of the overall benefits generated by the entity loan funds flow to underserved communities.
- Reduce grant application complexity. The goal of launching this effort is to reduce program complexity by breaking down barriers and increasing access to mitigation funding.
- Maximize administrative flexibility. Throughout the process, identify administrative burdens and reduce them to the greatest extent possible.

VDEM, in coordination with DCR will be reviewing the notice of funding opportunity and the required elements of this program in relation to eligible entities throughout the Commonwealth. To be eligible for Safeguarding Tomorrow RLF, Virginia must have a FEMA-approved Hazard Mitigation Plan.

National Earthquake Hazard Reduction Program (NEHRP)

NEHRP was established by Congress as part of the Earthquake Hazards Reduction Act of 1977, Public Law (PL) 95–124. At the time of its creation, Congress' stated purpose for NEHRP was to reduce the risks of life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program. In establishing NEHRP, Congress recognized that earthquake-related losses could be reduced through improved design and construction methods and practices, land use controls and redevelopment, prediction techniques and early-warning systems, coordinated emergency preparedness plans, and public education and involvement programs.

National Hurricane Program (NHP)

The NHP provides data, resources and technical assistance for hurricane evacuation planning and response for state, local, tribal, territorial and federal government partners. Hurricane evacuation and response planning efforts span from steady-state deliberate planning to operational decision support and crisis planning when hurricanes threaten the United States. In addition to planning efforts, the NHP provides preparedness training, operational tools and risk information to emergency managers to support their hurricane evacuation and response decisions. The National Hurricane

Program is a partnership between FEMA, the U.S. Army Corps of Engineers and the NOAA National Hurricane Center.

Through the NHP, FEMA helps all of the federal government partners establish, enhance and maintain basic levels of preparedness and mitigation capabilities, promote effective mitigation measures, conduct hazard identification and evacuation studies, conduct post-storm analyses of mitigation measures, conduct training, and promote public awareness and education of hurricane safety and preparedness. Virginia's participation is coordinated through the Hurricane Program at VDEM.

The current authorizing language for the NHP can be found in the Stafford Act, as well as Sec. 632 of the Post-Katrina Emergency Management Reform Act (PKEMRA). The latter authorizes and mandates FEMA to 'provide evacuation preparedness technical assistance to state, local, and tribal governments, including the preparation of hurricane evacuation studies and technical assistance in developing evacuation plans, assessing storm surge estimates, evacuation zones, evacuation clearance times, transportation capacity, and shelter capacity.

National Dam Safety Program (NDSP)

FEMA coordinates the NDSP among federal agencies and state partners. In addition to maintaining a dam inventory, encouraging research, and promoting the implementation of state programs, the program also provides training and funds. Virginia's participation is coordinated with the Division of Dam Safety and Floodplain Management at DCR.

Dam Break Early Warning System

This is a statewide system that significantly improves public safety for residents that live downstream of over 600 high and significant hazard dams and has been shown to reduce fatalities from dam failures. The system is a real time, web-based system that monitors live feeds from the NWS, NOAA, NRCS, USGS, compares rainfall and stream data against pre-set thresholds and triggers alerts to notify dam owners and emergency responders of potential dam breaks. This program is coordinated through DCR.

Hazards US (HAZUS)

HAZUS is a modeling program that utilizes a set of GIS-based tools that help estimate losses associated with earthquakes, floods, tsunamis, and wind. Developed in partnership with the National Institutes for Building Safety, HAZUS can be used to model event scenarios useful to compare risks between regions as well as to evaluate effects of certain mitigation measures. Each state receives a copy of the software and certain baseline data. Recent improvements were made in the quality of data that characterize building types and locations, significantly improving analysis results. HAZUS was utilized within this plan update for the hurricane wind and earthquake modules.

4.5.2 US Department of Housing and Urban Development (HUD)

HUD programs are administered through DHCD and local entitlement communities and offer several programs to support local efforts that address hazards and implement mitigation measures.

Community Development Block Grant (CDBG)

The CDBG program works to ensure decent affordable housing, to provide services to the most vulnerable in communities, and to create jobs through the expansion and retention of businesses. CDBG funds are routinely used in disaster-impacted areas for repair, elevation and acquisition/demolition of damaged structures, particularly citizens that qualify for the HMGP program.

Following Hurricane Isabel in 2003, a special CDBG congressional funding allotment was targeted to communities where HMGP funds could not fully address mitigation needs. In Henry County, a drainage improvement project was funded through HMGP with the non-federal cost share paid through CDBG. This is an example of coordination between CDBG and FEMA-VDEM funding to assist disaster recovery. At the state level, DHCD typically retains a limited amount of funding to be used for Urgent Needs funding.

US Department of Commerce, Economic Development Administration (EDA)

EDA supports economic recovery strategies, in part by providing cost-shared funds for planning and technical assistance, emergency infrastructure grants, construction grants and a Revolving Loan Fund to assist communities and quasi-public entities such as local development corporations and public or private non-profit organizations. EDA funds have been used to retrofit or relocate public water supply or wastewater treatment facilities. After disasters, some communities use EDA long-term recovery funding to help businesses move to safer locations.

4.5.3 US Army Corps of Engineers (USACE)

USACE civil works project administration for flood risk management, ecosystem restoration, and navigation activities and support are delegated to USACE districts based on river basin watershed boundaries. The following five USACE District offices, including river basins, can provide assistance in Virginia:

- Baltimore District – Potomac and Shenandoah River Basins
- Huntington District – New and Big Sandy River Basins
- Wilmington District – Roanoke River Basin
- Nashville District – Tennessee River Basin
- Norfolk District – Chowan, James, Rappahannock, and York River Basins, Chesapeake Bay, and small coastal basins

The Norfolk District prepared the Hurricane Evacuation Study and Restudy for the Commonwealth that form the basis of the *Hurricane Evacuation Annex* and planning tool. The Norfolk District oversees regulatory permitting efforts for the entire state, but also coordinates with the other four USACE Districts, as needed. In addition to the main office in Norfolk, regional field offices are located around the state to provide regulatory assistance. The following programs support implementation of multi-hazard mitigation initiatives statewide.

Flood Control and Coastal Emergency Act (PL 84-99)

USACE has authority under Public Law (PL) 84-99, Flood Control and Coastal Emergencies for emergency management activities. The USACE can undertake activities including disaster preparedness, advance measures, emergency operations (Flood Response and Post Flood Response), rehabilitation of flood control works threatened or destroyed by flood, protection or repair of federally authorized shore protective works threatened or damaged by coastal storm, and provisions of emergency water due to drought or contaminated source.

Preparedness: The Flood Control and Coastal Emergency Act established an emergency fund for preparedness for emergency response to natural disasters; for flood fighting and rescue operations; for rehabilitation of flood control and hurricane protection structures. Funding for USACE emergency response under this authority is provided by Congress through the annual Energy and Water Development Appropriation Act. Disaster preparedness activities include coordination, planning, training and conduct of response exercises with Local, State and Federal agencies.

Response: PL 84-99 allows USACE to supplement state and local entities in flood fighting urban and other non-agricultural areas under certain conditions. All flood fight efforts require a Project Cooperation Agreement (PCA) signed by the public sponsor and a requirement for the sponsor to remove all flood fight material after the flood has receded. PL 84-99 also authorizes emergency water support and drought assistance in certain situations and allows for advance measures assistance to prevent or reduce flood damage conditions of imminent threat of unusual flooding.

Rehabilitation: An eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the federal system owner, and at 20% cost to the eligible non-federal system owner. All systems considered eligible for PL 84-99 rehabilitation assistance must be in the Rehabilitation and Inspection Program prior to the flood event. Acceptable operation and maintenance by the public levee sponsor are verified by levee inspections conducted by USACE on a regular basis. USACE has the responsibility to coordinate levee repair issues with interested federal, state, and local agencies following natural disaster events where flood control works are damaged.

Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 5121 et seq.) (The Stafford Act).

In accordance with The Stafford Act and the Federal Response Plan, FEMA may direct federal agencies to use available personnel, supplies, facilities, and other resources to provide assistance in the event of a major disaster or emergency declaration. Under the Federal Response Plan, the Department of Defense (DOD) has responsibility for Emergency Support Function (ESF) #3, Public Works and Engineering. DOD has designated USACE as its operating agent for ESF #3, to include planning, preparedness, and response, with assistance to be provided by other branches of DOD as needed. FEMA may direct USACE to use its available personnel, supplies, facilities and other resources to provide assistance in case of a major disaster or emergency declaration by the President. At any time before a Presidential disaster declaration is made, FEMA may direct USACE to perform any emergency work necessary, with or without reimbursement of agency costs. Typical ESF #3 assistance includes the following:

- Needs Assessments: Participation in damage/needs assessments.
- Temporary Power: Provision of emergency power to public facilities.
- Ice and Water: Management and emergency contracting to support public health and safety, such as providing potable water and ice.
- Debris Management: Emergency debris clearance and removal and disposal management of debris from public property.
- Emergency Infrastructure Assessments: Assessments of damaged streets, bridges, ports, waterways, airfields and other facilities necessary for emergency access to disaster victims.
- Critical Public Facility Restorations: Emergency restoration of critical public facilities (including temporary restoration of water supplies and wastewater treatment systems).
- Demolition/Structural Stabilization: Emergency demolition or stabilization of damaged structures and facilities.
- Technical Assistance: Technical assistance including inspection of private residential structures and commercial structures.

- Participate on interagency Hazard Mitigation Teams.

Department of Defense Directive 3025.1 - Defense Support of Civil Authorities

This directive allows USACE to take immediate action in response to a request for assistance from a civil authority. Under imminently serious conditions and if time does not permit approval from higher authority, USACE may provide an immediate response by temporarily employing the resources under their control, subject to any supplemental direction provided by higher headquarters, to save lives, prevent human suffering, or mitigate great property damage within the US. Support provided under immediate response authority should be provided on a cost-reimbursable basis, where appropriate or legally required, but will not be delayed or denied based on the inability or unwillingness of the requester to make a commitment to reimburse the Department of Defense.

Rivers and Harbors Act of 1899. (Sections 15, 19, and 20, as amended)

USACE has the authority in an emergency to remove sunken vessels or similar obstructions from navigation channels in accordance with current regulations and guidance.

Rehabilitation and Inspection Program

Public Law 84-99 gives USACE the authority for the inspection and rehabilitation of federal and non-federal flood risk management projects. Eligible projects can receive flood-fight assistance during a flood event and rehabilitation/repair assistance after getting damaged from a flood. Rehabilitation of non-federal projects will be cost-shared at 80% federal and 20% from the public sponsor for cost sharable items. Rehabilitation of federal projects will be at 100% federal cost for cost sharable items.

Inspection of Completed Works Program

Provides for the periodic inspection of active federal flood risk management projects to determine if the project is being maintained in accordance with USACE criteria. The primary purposes of these inspections are to prevent loss of life and catastrophic damages; preserve the value of the federal investment; and to encourage non-federal sponsors to bear responsibility for their own protection. This program should assure sponsor compliance with existing agreements that the structures and facilities constructed by the US for flood protection will be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits. In no case does the policy allow for federal expenditures to correct problems caused by lack of adequate local maintenance.

Levee Safety Program / Dam Safety Program

USACE inspects and assesses about 2,500 levee systems nationwide. USACE developed and maintains an online National Levee Database available to the public to help communicate risk. As of 2022, the database included detailed information on more than 15,000 miles of levee systems, many of which are associated with USACE programs. USACE also publishes and maintains an online National Inventory of Dams available to the public to help communicate risk. USACE itself manages approximately 700 dams it operates and maintains, yet the national inventory contains information on approximately 79,000 dams from all 50 states, Puerto Rico, and 18 federal agencies. The database is published every two years. It consists of dams meeting at least one of the following criteria:

1. High hazard classification - loss of one human life is likely if the dam fails;
2. Significant hazard classification - possible loss of human life and likely significant property or environmental destruction;

3. Equal or exceed 25 feet in height and exceed 15 acre-feet in storage; or
4. Equal or exceed 50 acre-feet storage and exceed 6 feet in height.

Flood Plain Management Services Program

Under Section 206 of the 1960 Flood Control Act (PL 86-645) as amended, upon request, technical assistance and general planning guidance can be provided to state and local governments, Native American Indian tribes, and other non-federal public agencies without charge. Program services also are offered to non-water resources federal agencies and to the private sector on a 100% cost recovery basis. Technical assistance typically includes flood hazard evaluations for site specific locations, developing or interpreting flood flows, flood depths or stages; floodwater velocities; and the extent, duration, and frequency of flooding. General planning guidance can include development of special studies, guides, and pamphlets related to water resources.

Planning Assistance to the States Program

Under Section 22 of the Water Resources Development Act of 1974 (Public Law 93-251), as amended, USACE can assist states, Native American Indian tribes, local governments, or other non-federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. Studies are cost-shared 50/50 between the federal government and non-federal sponsor (may include 100% work in kind) up to $500,000 annually. Typically, individual studies, of which there may be more than one per State or tribe per year, generally cost $25,000 to $75,000.

Continuing Authorities Program

Congress has provided USACE with a number of standing authorities to study, design, and construct small scale (less than $10 million) water resource projects for various purposes without additional project specific congressional authorization. The sponsoring agency may be a state, county, city, tribe, or other group and must cost share in the project. Projects can include streambank and shoreline protection, flood risk management, navigation improvements, beneficial uses of dredged material, aquatic ecosystem restoration, and USACE project modifications for improvement to the environment. Cost-sharing for study and project costs can vary by business line.

General Investigations Program

Congress can authorize USACE to study, design, and construct major flood risk management, navigation, and ecosystem restoration projects that may cost more than $10 million. A feasibility study is cost-shared 50/50 between the federal government and non-federal sponsor, where the cost-sharing for other project costs can vary by business line.

4.5.4 US Department of Agriculture, Natural Resources Conservation Service (NRCS)

The NRCS is dedicated to the conservation of soil and water and related resources. Technical assistance is provided to individuals, groups, organizations, and government agencies through conservation districts. Virginia's Departments of Agriculture and Consumer Services and Department of Conservation and Recreation are the state's contacts for NRCS programs:

- Under authority in Public Law 566, numerous flood reduction projects were constructed to address problems in small watersheds. NRCS supports river basin and watershed planning initiatives undertaken by local jurisdictions.
- The Emergency Watershed Protection Program can provide technical and financial assistance to communities to repair and restore clogged and damaged waterways to pre-disaster conditions.
- The Emergency Conservation Program, coordinated with the USDA Farm Services Agency, provides technical assistance to the agricultural community after disasters.
- Wetland Reserve Program provides technical and financial support to help landowners implement wetland restoration, conservation and wildlife practices.

NRCS frequently works with disaster recovery and mitigation in a post-disaster setting in the Commonwealth addressing stream and river flooding issues through the EWP program. This has been used extensively in western mountain flood events since the early 1990s.

4.5.5 US Department of Agriculture

USDA has several loan and grant programs that may support mitigation initiatives and post-disaster recovery.

- Rural Business-Cooperative Development Service Business and Industrial Loans help create jobs and stimulate rural economies by backing rural businesses.
- Rural Housing Service Community Facilities Loans and Grants can be used to construct, enlarge or improve community services for health care, public safety, and public services.
- Water and Waste Grants and Loans are used to develop, replace, or repair water and waste disposal (including storm drainage) systems in rural areas and small towns.
- Farm Service Agency Emergency Conservation Program assistance can be used to rehabilitate certain farmland damaged by floods or other disasters.
- Farm Service Agency Tree Assistance provides cost-shared payments to orchardists, maple sugar producers, greenhouse operators and vineyard growers who incur losses due to damaging weather.
- Federal Multi-Peril Crop Insurance policies insure against losses due to natural causes such as drought, excessive moisture, hail, wind, frost, insects and disease.
- Non-insured Crop Disaster Assistance Program helps growers of crops for which crop insurance is not available.
- Farm Service Agency Flood Risk Reduction allows farmers to voluntarily execute contracts to receive payments on lands with high flood potential in return for foregoing certain USDA program benefits.
- Supplemental Revenue Assistance Payment Program (SURE) for crop losses in communities declared a disaster by the Secretary of Agriculture.
- Emergency Loans program provides loans to restore or replace essential property damaged in the disaster; finance production losses to crops and livestock; fund essential family living and farm operation expenses, or refinance certain debts.
- Emergency Conserve Program provides funding to address new conservation problems created by disaster that, if not treated, would impair or endanger the land. Funds can be used to rehabilitate farmland damaged by wind erosion,

floods, hurricanes, or other natural disasters and to carry out water conservation measures during drought.

4.5.6 US Small Business Administration (SBA)

The SBA has the authority to separately declare disaster areas based on the number of homes and businesses that are affected, even if the event does not warrant a declaration by the President. SBA provides low-interest loans, and can authorize loan amounts up to 20% above the costs of restoration if the applicant agrees to implement mitigation measures. Individuals and businesses can use SBA funds to pay for the non-federal share of HMGP and FMA projects to elevate-in-place, relocate, or flood proof buildings in flood hazard areas.

Business Physical Damage Loan Program

Available to help businesses and nonprofit organizations repair or replace uninsured damaged property such as real estate, machinery and equipment, inventory, and supplies. SBA requires borrowers to obtain and maintain appropriate insurance, especially if located in a flood hazard area.

Economic Injury Disaster Loan

These loans of 'last resort 'provide working capital to small businesses and small agricultural cooperatives to help them through the recovery period.

Disaster Assistance Program Loans

These loans are available to eligible homeowners through the Robert T. Stafford Act as part of the Individual Assistance Program. The loans can include mitigation measures such as drainage improvement, floodproofing and hurricane shutter installation. This program provides an opportunity for citizens within declared jurisdictions to work independently of a traditional grant program to assume responsibility for mitigation of their disaster-prone property.

4.5.3 Other Funding Capabilities

Commonwealth of Virginia General Fund

Many structural mitigation projects for state assets can be incorporated into capital improvement budgets that support renovation of existing structures or initiate new construction. Facilities managers have been active participants in the planning process and serve an integral role in seeking non-traditional mitigation funding to support structural mitigation projects.

Increased Cost of Compliance (ICC)

If a house or business is damaged by a flood, individuals may be required to meet certain building requirements in their community to reduce future flood damage before repairs are
made or rebuilding occurs. To help meet the costs of meeting those requirements, the NFIP includes Increased Cost of Compliance (ICC) coverage for all new and renewed Standard Flood Insurance Policies. Flood insurance policyholders in special flood hazard areas can receive up to $30,000 to help pay the costs to bring their home or business into compliance with their community's floodplain ordinance. ICC assisted with recovery from Hurricane Isabel and will continue to be a critical funding source as the non-federal match for all HMA programs that require a match.

Homeland Security Grant Program (HSGP)

One of the core missions of DHS is to enhance the ability of state, territory, local, and tribal governments to prevent, protect against, respond to and recover from terrorist attacks and other disasters. The HSGP includes a suite of risk-based grants that provide grantees with the resources required for implementation of the National Preparedness System and working toward the National Preparedness Goal of a secure and resilient nation. Together, these three grant programs comprise the HSGP and fund a range of preparedness activities, including planning, organization, equipment purchase, training, exercises, and management and administration across all core capabilities and mission areas.

1. State Homeland Security Program - provides funding to support the implementation of risk-driven, capabilities-based State Homeland Security Strategies to address capability targets.
2. Urban Area Security Initiative (UASI) - provides funding to enhance regional preparedness and capabilities in designated high-threat, high-density areas. National Capital and Hampton Roads are currently UASI regions.
3. Operation Stonegarden - provides funding to enhance cooperation and coordination among state, local, tribal, territorial, and federal law enforcement agencies to jointly enhance security along the United States land and water borders.

Virginia Disaster Relief Fund

The DRF is a Commonwealth-managed relief fund to financially assist Virginia residents who are impacted by disasters. In August 2011, the governor made the fund a permanent part of the Commonwealth’s disaster relief tools, serving as a fund of last resort if other state, federal, and private aid was not available to assist with disaster recovery. Donations to the fund are accepted from individuals, companies, nonprofit organizations and faith-based groups.

4.6 Summary

Table 4-3 summarizes mitigation programs available for use in the Commonwealth. The programs listed are resources that have potential use in the state's mitigation programs. The following terminology is used to describe a program's contribution to mitigation or loss reduction:

- **Support** – programs, policies or other assistance that help develop mitigation projects;
- **Facilitate** – programs, policies or technical assistance that assist with implementation of mitigation measures; and,
- **Funding** – programs that provide financial assistance for mitigation planning and projects.

Table 4-3 – Recovery and Mitigation Programs

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
Virginia Department of Emergency Management (VDEM)	Commonwealth of Virginia Emergency Operations Plan	✓	✓		Directs emergency operations in response to any large-scale disaster impacting the Commonwealth. Assigns duties and responsibilities to agencies and support organizations for disaster preparedness, response, recovery and mitigation. Funding is achieved through appropriations in the biennial budget development process orchestrated by the Virginia General Assembly, and is supplemented in response to disaster declarations through sum-sufficient provisions that can provide state match to federal funding for individual assistance, public assistance and mitigation programs.	✓	✓	✓
Federal Emergency Management Agency (FEMA)	Hazard Mitigation Assistance Programs (HMA)		✓	✓	HMGP, BRIC, FMA, and PDM are grant programs for eligible projects to reduce the long-term risk from natural hazards. The grant programs promote mitigation planning and structural projects, primarily aimed at the goal of reducing future flood risk.	✓	✓	
Federal Emergency Management Agency (FEMA)	Public Assistance Program		✓	✓	To be eligible disaster recovery work performed on an eligible facility must: •Be required as the result of a major disaster event, •Be located within a designated disaster area, and •Be the legal responsibility of an eligible applicant. The following project categories are eligible for reimbursement: Debris Removal, Emergency Protective Measures, Roads and Bridges, Water Control Facilities, Buildings and Equipment, Utilities, Parks, Recreational, and other Facilities		✓	

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
Federal Emergency Management Agency (FEMA)	Individual and Housing Programs	✓	✓	✓	Federal law authorizes grants to disaster victims with disaster related expenses and needs that cannot be met through other available governmental disaster assistance programs. The federal share of a grant to an individual family under this program shall be equal to 75% of the actual cost of meeting such an expense or need and shall be made only on condition that the remaining 25% of such costs is paid to the individual or family from funds made available by the State. No individual or family shall receive any grant or grants under this program aggregating more than a maximum amount established by federal regulation with respect to any one major disaster. The Commonwealth maintains an Individual and Family Grant Program Administrative Plan, coordinates administration of the Individual and Family Grant Program through VDEM supervised by the State Coordinating Officer.		✓	
Virginia Department of Emergency Management (VDEM)	Virginia Disaster Relief Fund	✓	✓	✓	The Virginia DRF was established to provide financial assistance to Virginia residents who were impacted by the April 2011 tornados. Since that time, it has been expanded to aid Virginia residents for other disasters. Fund proceeds will be distributed to local long-term recovery groups, members of the Virginia VOAD and other non-profit and faith-based organizations as a grant. Many of these groups work directly with individuals and families following a disaster. The DRF benefits projects that include: repair or rebuilding of underinsured dwellings, transportation assistance, replacing essential household items, helping renters establish a new rental residence, and temporary living expenses while recovering from loss.		✓	
Federal Emergency Management Agency (FEMA)	Disaster Housing	✓	✓	✓	Temporary Housing Program: Residents within declared areas are eligible for temporary housing assistance. The FEMA Administrator or their designee determines that other circumstances necessitate temporary housing assistance. Home Repair Program: Home repairs may be provided to those eligible applicants who are owner-occupants of the primary residence to be made habitable, whose property can be made habitable by repairs to the essential living area within 30 days following feasibility determination. The FEMA Region III Director may extend this period.		✓	

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
US Department of Housing and Urban Development (HUD)	Mortgage Assistance from HUD's Federal Housing Administration	✓	✓	✓	For a declared disaster, FHA activates a mortgagee letter making a variety of insured loan programs available for disaster victims and putting into play use of special loan servicing and underwriting requirements.	✓	✓	
Department of Housing and Community Development (DHCD)	Virginia Uniform Statewide Building Code	✓	✓		Through the Virginia Uniform Statewide Building Code, buildings which are substantially damaged are required to meet the code's flood design standards for new buildings. This requirement is based on the provisions of the NFIP.	✓	✓	
Federal Emergency Management Agency (FEMA)	Risk Map	✓	✓	✓	FEMA's Risk MAP (Mapping, Assessment, and Planning) is a 5-year initiative that builds on the recently completed Map Modernization program that updated and put in digital format much of the State's floodplain maps. Risk MAP has a broader and more holistic approach than Map Modernization, emphasizing not just the delivery of accurate maps but working with communities to understand the causes of flooding and help with mitigation strategies. Risk MAP is characterized by a full alignment of FEMA's programs - from discovering local needs, mapping with better base data, working with community representatives in assessing risk and vulnerability - with planning and mitigation considerations throughout.	✓		
Virginia Department of Conservation and Recreation (DCR)	Virginia Flood Risk Information System (VFRIS)	✓	✓		DCR, in collaboration with VIMS, has developed VFRIS, an online tool that allows users to view and assess flood risk and help communities plan for resiliency. VFRIS includes all SFHAs in Virginia, flood depth grids, the Limit of Moderate Wave Action, parcel boundaries, the ability to download flood insurance studies and flood risk reports, among other things	✓		
Virginia Department of Conservation and Recreation (DCR)	Community Rating System (CRS)	✓	✓	✓	The NFIP's Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions that reduce flood damage to insurable property.	✓		

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
Virginia Department of Conservation and Recreation (DCR)	Division of Dam Safety and Floodplain Management	✓	✓	✓	Coordinates all flood activities in the state, as well as the dam safety regulations. The division is responsible for the Dam Safety/Floodplain Management Grant program, as well as the Commonwealth's Floodplain Management Plan.	✓	✓	
Virginia Department of Conservation and Recreation (DCR)	Division of Dam Safety and Floodplain Management	✓	✓	✓	Community Flood Preparedness Fund fills pressing needs by prioritizing low-income communities and providing a permanent funding stream to finance flooding resilience projects, studies, and capacity-building initiatives. The Regional Greenhouse Gas Initiative (RGGI) is a program made up of 11 states that aims to reduce greenhouse gas emissions. RGGI holds carbon dioxide auctions, which funds the Virginia CFPF. Project types include: planning and capacity building in low income communities, flood prevention and protection studies, and projects to support hybrid or nature-based solutions.	✓		
Federal Emergency Management Agency (FEMA)	National Dam Safety Program (NDSP)	✓	✓	✓	Grants to reduce the risks to life and property from dam failure, through the establishment and maintenance of an effective dam safety program.	✓	✓	
US Department of Agriculture, Natural Resources Conservation Service (NRCS)	Emergency Watershed Protection	✓	✓	✓	When funding is allocated to a project, NRCS contracts the heavy construction work to local contractors, spurring creation of jobs. Typical projects funded under EWP include removing debris from waterways, protecting eroded stream banks, reseeding damaged areas, and in some cases, purchasing floodplain easements on eligible land. NRCS funds up to 75% of project costs, with local sponsors paying the remaining 25% in either cash or in-kind services.	✓	✓	
US Department of Agriculture, Farm Service Agency (FSA)	Supplemental Revenue Assistance Payment Program			✓	The SURE program provides cash payments to eligible producers who have incurred crop production losses or crop quality losses, or both.		✓	

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
US Department of Agriculture, Food and Nutrition Service (FNS)	Disaster Assistance, Food Assistance	✓	✓	✓	The Food and Nutrition Service (FNS) coordinates with state, local and voluntary organizations to: Provide food for shelters and other mass feeding sites; distributes food packages directly to households in need in limited situations; issues emergency SNAP benefits. As part of the National Response Framework, FNS supplies food to disaster relief organizations for mass feeding or household distribution. FNS also authorizes States to operate a Disaster Supplemental Nutrition Assistance Program (D-SNAP).			✓
US Department of Agriculture (Rural Development)	Housing and Community Facilities Loans	✓	✓	✓	Program assistance is provided in many ways, including direct or guaranteed loans, grants, technical assistance, research and educational materials. Loans are available for residential and facility development such as hospitals, roads, and bridges.		✓	
US Department of Agriculture Farm Service Agency (FSA)	Emergency Farm Loans	✓	✓	✓	Emergency Conservation program shares with agricultural producers the cost of rehabilitating eligible farmlands damaged by natural disaster. Provides emergency loans to assist producers recover from production and physical losses due to drought, flooding, other natural disasters or quarantine. Natural Resources Conservation Service's Emergency Watershed Protection Program provides emergency measures, including purchase of floodplain easements for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on the watershed. Food and Nutrition Service's Food Distribution division has the primary responsibility of supplying food to disaster relief organizations.	✓	✓	✓
US Department of Housing and Urban Development (HUD)	Community Development Block Grants	✓	✓	✓	Grants to entitlement communities: Preferred use of funding is for long-term needs but may be used for emergency response activities. Multi-family home mortgage insurance. Guaranteed/insured loans to finance the acquisition of proposed, under construction or existing single-family units. Qualified homeowners are permitted to make a low down payments. Special Mortgage Insurance for low and moderate income families. The program can be used to finance rehabilitation of sub-standard properties. Displaced households qualify for special terms. This funding is separate from state CDBG funding, and is granted directly to the entitlement community. State funds cannot be used in entitlement areas.	✓	✓	✓

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
					Co-insurance: Joint mortgage insurance by the federal government and private lenders to facilitate homeownership financing. Co-insuring lender determines whether to make the loan.			
NOAA National Weather Service (NWS)	Forecasts and Warnings	✓	✓		Public forecasts and warnings of hazardous weather phenomena and floods, and training programs on disaster safety rules. Available to agencies and the public.	✓		
US Department of Energy	Disaster-related Power Outage				Implements emergency related functions under the Federal Response Plan.			✓
US Department of Homeland Security (DHS)	Urban Areas Security Initiative (UASI)	✓	✓	✓	A discretionary grant program that provides funding to metropolitan areas, including counties and mutual aid partners, to prepare for, prevent and respond to terrorist incidents.	✓		✓
US Department of Homeland Security (DHS)	Emergency Management Performance Grants (EMPG)	✓	✓	✓	The EMPG assists in the development, maintenance and improvement of state and local emergency management capabilities. These also include an Urban Search and Rescue and Interoperable Communications Grant.	✓		
VDEM, through its Volunteers and Donations Program with National and Virginia VOAD members.	Collection and Distribution of Donated goods	✓	✓		Support the establishment and management centers for receipts and distribution of donated goods such as food, clothing, furniture, medical supplies, building materials, cleaning supplies, bedding, utensils and tools. This is usually organized with a designated collection and/or distribution centers.		✓	
DBHDS, Department of Social Services, DCJS, and VDEM through partnership with National and Virginia VOAD.	Behavioral health, crisis first aid, emotional care	✓	✓		Crisis intervention counseling designed to assist disaster survivors and responders in coping with their situation to avoid serious psychological impairment.		✓	

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
Department of Agriculture and Consumer Services, and VDEM, through its partnership with National and Virginia VOAD.	Solidly frozen and/or non-perishable	✓	✓	✓	Food can be provided to disaster survivors and workers in several ways: 1. Direct provision of food stocks donated by individuals and groups to disaster survivors through distribution centers 2. Direct grants for food purchase or food stamp allotments provided to disaster survivors 3. Meals provided at or from feeding centers by mobile kitchens 4. Provision of food stocks for emergency mass feeding or distribution to an area suffering a major disaster or emergency. In large scale disasters, FEMA will act as main agent in distribution of food.		✓	
VDEM, through its Volunteers and Donations Program, Virginia Guard, AmeriCorps, Others	Personnel	✓	✓	✓	Provision of personnel to supplement the labor necessary to respond to emergency disaster events, especially for clean-up and damaged home repair.		✓	✓
Department of Health, VDEM, State Police, Virginia Guard, ARC, Medical Examiner's Office	Medical Assistance			✓	Professional medical aid in the treatment of disaster victims, prevention or control of disease and handling and identification of persons killed during the event.			✓
VDEM, through its partnership with National and Virginia VOAD, Department of Housing and Community Development, Department of Health, AmeriCorps, NGOs	Repair of Houses	✓	✓	✓	Aid to homeowners to repair their homes in the absence of or to supplement FEMA's Individual Assistance Program.		✓	

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
Local governments, Local governments' EOP's partners and/or State Shelter plan.	Shelter	✓	✓	✓	Establishment of shelters to protect the lives and health of persons forced to evacuate their homes due to an emergency or disaster occurs on a local, as needed basis. Shelters are short-term facilities; families are returned to their homes or placed in temporary housing locations as quickly as possible. Shelter locations are pre-designated in local Emergency Operations Plans.	✓		
Virginia Department of Historic Resources (DHR)	State Historic Preservation Office (SHPO)	✓	✓	✓	SHPO provides information and guidance to private and public historic property owners/managers regarding the protection, preservation, and repair/mitigation of historic buildings, structures, archaeological sites, and other culturally significant assets. DHR reviews and comments on state and federal projects that are subject to the State Environmental Review Act, Section 106 of the National Historic Preservation Act, and other applicable state and federal laws and regulations. Funding is available for archeological sites that are endangered by erosion through DHR's Threatened Sites Program.	✓	✓	✓
Department of Forestry (VDOF)	Forest Protection Program	✓	✓	✓	The department provides training and equipment to local fire departments that fight brush and forest fires. A network of dry hydrants throughout the state to supplement water sources such as rivers, reservoirs, lakes and ponds. An aggressive woodland homes wildfire prevention program is also managed. The agency also has a nationally credentialed incident management team which can provide planning and logistical support as well as incident command and control to support recovery and mitigation activities.	✓	✓	✓
Federal Bureau of Investigation (FBI)	Disaster Squad	✓	✓	✓	Fingerprint identification of disaster victims for any authorized state or local law enforcement agency.			✓
Virginia Department of Health (DOH)	Emergency Health Assistance	✓	✓	✓	Public Readiness and Emergency Preparedness Act Commonwealth: Code of Virginia Statutes and Corresponding Authorities during Mass Countermeasure Dispensing Event; Code of Virginia Statutes and Corresponding Authorities for Disease Surveillance, Investigation & Control in Virginia; Code of Virginia Statutes Relating to Other Significant Public Health Issues; Virginia Laws Governing Medical Examiner Notification and Jurisdiction; Virginia Administrative Code and Corresponding Authority	✓	✓	✓

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
					Funding: HHS PHEP Cooperative Agreement administered by the Centers for Disease Control and Prevention (CDC); Hospital Preparedness Program Cooperative Agreement administered by the Office of the Assistant Secretary for Preparedness and Response (ASPR) Public Health & Healthcare Preparedness Capabilities: Community Preparedness; Community Recovery; Emergency Operations Coordination; Emergency Public Information & Warning; Fatality Management; Information Sharing; Mass Care; Medical Countermeasure Dispensing; Medical Materiel Management & Distribution; Medical Surge; Non-Pharmaceutical Interventions; Public Health Laboratory Testing; Public Health Surveillance & Epidemiological Investigation; Responder Safety & Health; Volunteer Management. Healthcare Preparedness Capabilities: Foundation for Health Care & Medical Readiness; Health Care & Medical Response Coordination; Continuity of Health Care Service Delivery; and Medical Surge			
US Army Corps of Engineers (USACE)	Public Law 84-99 - Flood Control and Coastal Emergency Act	✓	✓	✓	USACE has authority for emergency management activities, including disaster preparedness, advanced measures, emergency operations (flood response and post-flood response), rehabilitation of flood control works threatened or destroyed by flood, protection or repair of federally authorized shore protective works threatened or damaged by coastal storm, and provisions of emergency water due to drought or contaminated source. Depending on the type of support, funds may be 100% federal, cost-shared, or on a reimbursable basis.	✓	✓	✓
US Army Corps of Engineers (USACE)	Public Law 93-288 - Robert T. Stafford Act	✓	✓		USACE assists the Department of Homeland Security and FEMA on a reimbursable basis by coordinating and organizing public works and engineering related support. Typical Emergency Support Function # 3 assistance includes mission assignments for the following: needs assessments, temporary power, ice and water, debris management, emergency infrastructure assessments, critical public facility restorations, demolition/structural stabilization, and technical assistance.		✓	

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
US Army Corps of Engineers (USACE)	Department of Defense Directive 3025.18 - Defense Support of Civil Authorities	✓	✓		This directive allows USACE to take immediate action in response to a request for assistance from a civil authority, under imminently serious conditions and if time does not permit approval from higher authority, USACE may provide an immediate response by temporarily employing the resources under their control to save lives, prevent human suffering, or mitigate great property damage within the US.			✓
US Army Corps of Engineers (USACE)	Rivers and Harbors Act of 1899, Sections 15, 19, and 20, as amended	✓	✓	✓	USACE has the authority in an emergency to remove sunken vessels or similar obstructions from navigation channels in accordance with current regulations and guidance.		✓	✓
US Army Corps of Engineers (USACE)	Rehabilitation and Inspection Program	✓	✓	✓	Public Law 84-99 gives USACE the authority for the inspection and rehabilitation of federal and non-federal flood risk management projects. Eligible projects can receive flood-fight assistance during a flood event and rehabilitation/repair assistance after getting damaged from a flood.		✓	✓
US Army Corps of Engineers (USACE)	Inspection of Completed Works Program	✓	✓		As an operations and maintenance program within the Rehabilitation and Inspection Program, provides for the periodic inspection of active federal flood risk management projects to determine if the project is being maintained in accordance with USACE criteria.	✓		
US Army Corps of Engineers (USACE)	Levee Safety Program and Dam Safety Program	✓	✓		USACE developed and maintains the online National Levee Database and National Inventory of Dams available to the public to help communicate risk.	✓		
US Army Corps of Engineers (USACE)	Silver Jackets Program	✓	✓	✓	Program leverages multiple perspectives to help solve water resources problems at the state and local level. Federal participation typically includes USACE, FEMA, National Weather Service, US Geological Survey, National Resources Conservation Service, etc.	✓		

Agency(s)	Programs, Plans, Policies, Regulations, Funding and Practices	Contribution to Loss Reduction			Description	Pre-Disaster	Post Disaster	Emergency Response
		Support	Facilitate	Funding				
US Army Corps of Engineers (USACE)	Floodplain Management Services Program	✓	✓	✓	Provides floodplain management technical assistance and general planning guidance to state and local governments, Native American Indian tribes, and other non-federal public agencies without charge. Program services are offered to non-water resource federal agencies and to the private sector on a 100% cost recovery basis.	✓		
US Army Corps of Engineers (USACE)	Planning Assistance to the States Program	✓	✓	✓	USACE can assist states, Native American Indian tribes, local governments, or other non-federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. Studies are cost-shared 50/50 between the federal government and non-federal sponsor (may include 100% work in kind) up to $500,000 annually. Typically, individual studies, of which there may be more than one per state or tribe per year, generally cost $25,000 to $75,000.	✓		
US Army Corps of Engineers (USACE)	Continuing Authorities Program	✓	✓	✓	Congress has provided USACE with a number of standing authorities to study, design, and construct small scale (less than $10 million) water resource projects for various purposes without additional project specific congressional authorization. The sponsoring agency may be a state, county, city, tribe, or other group and must cost share in the project. Projects can include streambank and shoreline protection, flood risk management, navigation improvements, beneficial uses of dredged material, aquatic ecosystem restoration, and USACE project modifications for improvement to the environment. Cost-sharing for study and project costs can vary by business line.	✓		
US Army Corps of Engineers (USACE)	General Investigations Program	✓	✓	✓	Congress can authorize USACE to study, design, and construct major flood risk management, navigation, and ecosystem restoration projects that may cost more than $10 million. A feasibility study is cost-shared 50/50 between the federal government and non-federal sponsor, where the cost-sharing for other project costs can vary by business line.	✓		

[i] Virginia Department of Conservation and Recreation. *Dam Safety and Floodplains Website.* Verified 06.05.19 from http://www.dcr.virginia.gov/dam_safety_and_floodplains/dam-safety-index
[ii] Code of Virginia, §10.1-603.16 et seq.
[iii] Code of Virginia §10.1-604 et seq.)
[iv] Virginia Department of Conservation and Recreation. *Dam Safety and Floodplain Management Grants*. Verified 06/06/2019 from https://www.dcr.virginia.gov/dam-safety-and-floodplains/dsfpm-grants

Contents

5.1 2023 Plan Update

The primary focus of this update is to review the status of existing mitigation actions, update retained actions, add new actions as necessary, and remove those actions that are no longer relevant or feasible for Virginia. In addition, planners included an evaluation of the impact of the remaining actions on socially vulnerable populations, mindful of the NRI data provided in the HIRA, and added several new mitigation actions related to the human-caused hazards in Appendix D. As required by DMA 2000 §201.4(c)(3)(iii), many of the actions were tied to local or regional hazard mitigation plans or community budgeting tools, and some of the specific actions and projects identified therein.

5.2 Introduction and Vision

The Mitigation Strategy is a critical part of the planning process that outlines and prioritizes actions in order to reduce future risk from natural hazards. The HIRA identifies flooding as the most frequent and costly hazard in terms of loss of life and property in Virginia; there is no coincidence, therefore, that the Mitigation Strategy contains many actions targeted at reducing the impacts of flooding.

The Commonwealth of Virginia Hazard Mitigation Plan begins with a mitigation vision supported by four major goals and several related objectives. Mitigation actions, which contribute to reducing risk in the Commonwealth and support the Mitigation Vision, were developed by Working Group members at Working Group Workshop #2b in July 2022.

VISION:
Promote resiliency and reduce the long-term impacts of hazards on human, economic, and natural resources throughout the state.

5.3 Mitigation Goals

During the plan update process, the previously identified mitigation goals, as well as several new recommended objectives, were reviewed by both the Advisory Committee and the Working Group members at Working Group Meeting #2a. The goals and objectives were either validated or modified through detailed discussions and eventual consensus among the attendees. These statements document the guidance for the plan's mitigation activities. Table 5-1 documents the changes.

Table 5-1 – Revisions to Mitigation Goals

2018 Mitigation Goals	2023 Mitigation Goals and Objectives
2018 Goal #1 Identify and implement projects that will reduce or eliminate long-term risk, directly reduce impacts from hazards, and maintain continuity of critical societal functions. This includes reducing risk to repetitive loss and severe repetitive loss properties.	**Goal #1 Identify, prioritize and implement projects that will directly reduce impacts from hazards and minimize long-term risk.** • **Objective 1.1** Reduce risk to flood-prone and repetitively flooded properties through increased flood insurance coverage and property protection measures. • **Objective 1.2** Improve resilience of community lifelines and infrastructure. • **Objective 1.3** Maintain partnerships with local and regional agencies that support project administration. • **Objective 1.4** Develop mitigation actions that inform the statewide recovery plan.
2018 Goal #2 Incorporate mitigation concepts and objectives into existing and future policies, plans, regulations, and laws in the Commonwealth.	**Goal #2 Incorporate mitigation concepts into existing and future policies and plans, including the development, execution and implementation of regulations and laws of the Commonwealth.** • **Objective 2.1** Partner with local, regional, and state resiliency planners to pursue parallel goals. • **Objective 2.2** Provide mitigation cross-training across all State agencies. • **Objective 2.3** Incorporate mitigation into state government agency strategic planning performance measures.

2018 Mitigation Goals	2023 Mitigation Goals and Objectives
2018 Goal #3 Improve the quality and accessibility of the data used in the hazard identification and risk assessment and analysis process in state, multi-jurisdictional, and higher education hazard mitigation plans.	**Goal #3 Improve quality and accessibility of data available for use in the hazard identification and risk assessment processes of state, multi-jurisdictional, and higher education hazard mitigation plans, and for other purposes.** • **Objective 3.1** Identify data uses, gaps and highest priority needs for mitigation planning purposes. • **Objective 3.2** Incorporate climate change projections and future conditions into hazard data analyses and project development. • **Objective 3.3** Promote use of and increase accessibility to data across multiple levels of government and stakeholders.
2018 Goal #4 Promote and support a whole community approach to awareness of hazards, their risk, and potential mitigation actions in order to increase resiliency.	**Goal #4 Achieve equity in awareness of hazards, their risk, and access to potential mitigation assistance for actions that increase resiliency.** • **Objective 4.1** Identify high-risk communities most in need of assistance and training to launch mitigation projects. • **Objective 4.2** Maximize working partnerships with non-traditional stakeholders that engage with small towns on a regular basis. • **Objective 4.3** Prioritize social vulnerability in mitigation projects.

5.4 Mitigation Action Categories

Each of the four goals is to be implemented through projects that fall into one of seven categories: prevention of future risk, protection of the built environment, natural resource protection, hazard modification through construction, emergency services, public education and awareness, and risk analysis. Each category is described below with examples illustrating how the categories might be applied.

1. Prevention of Future Risk

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

- Planning and zoning
- Building codes
- Open space preservation
- Floodplain regulations
- Stormwater management regulations
- Drainage system maintenance

- Capital improvement programming
- Setbacks for high hazard areas

2. Protection of the Built Environment

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

- Acquisition and demolition
- Acquisition and relocation
- Structural elevation
- Critical facilities and infrastructure protection
- Retrofitting (*e.g.*, windproofing, floodproofing, seismic design techniques, ignition-resistant construction materials)
- Safe rooms, shutters, shatter-resistant glass
- Insurance
- Impervious surface modifications
- Wildfire protection through building material selection

3. Natural Resource Protection

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

- Floodplain protection
- Watershed management
- Riparian buffers
- Forest and vegetation management (e.g., fire-resistant landscaping, fuel breaks, defensible space)
- Erosion and sediment control
- Wetland preservation and restoration
- Habitat preservation
- Slope stabilization

4. Hazard Modification through Construction

Structural mitigation projects lessen the impact of a hazard by modifying the natural progression of a hazard event through construction. The resultant structures are designed by engineers and usually managed or maintained by public works staff:

- Reservoirs
- Dams/levees/dikes/floodwalls
- Diversions/detention/retention structures

- Channel modifications
- Storm sewers
- Drainage improvements
- Minor localized flood reduction projects

5. Emergency Services

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

- Alert and Warning systems
- Evacuation planning and management
- Emergency response training and exercises
- Continuity of operations planning
- Sandbagging for flood protection
- Elevating contents for flood protection
- Installing temporary shutters for wind protection
- Generator and quick connects
- Community Wildfire Protection Plan (CWPP) implementation
- Dry hydrant installation

6. Public Education and Awareness

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

- Outreach projects
- Speaker series/demonstration events
- Hazard map information
- Real estate disclosures
- Library materials
- Educational programs in schools
- Hazard expositions

7. Risk Analysis

Analyzing risk is the backbone of developing a project scope of work or comparing the effectiveness of various mitigation actions. Examples of measures to analyze risk include:

- Hazard identification and risk assessment
- Threat Hazard Identification and Risk Assessment (THIRA)

- Benefit-cost analysis (BCA)
- Probability
- Hazard history
- Dollar losses and impacts

After validating the goals and objectives, the next step was to tie them to the results of the HIRA. Table 5-2 shows the relationship between the hazards and the categories of mitigation actions commonly associated with mitigation of the hazard impacts.

Table 5-2 – Mitigation Categories Matrix

Mitigation Technique		Prevention of Future Risk	Protection of Built Environment	Natural Resource Protection	Hazard Modification Through Construction	Emergency Services	Public Education and Awareness
HIGH RISK HAZARDS	Flooding	✓	✓	✓	✓	✓	✓
	Hurricane	✓	✓	✓		✓	✓
	Winter Weather	✓	✓			✓	✓
MEDIUM RISK HAZARDS	Tornado	✓	✓			✓	✓
	Non-Tornadic Wind	✓	✓	✓		✓	✓
	Extreme Heat	✓	✓	✓	✓	✓	✓
	Drought	✓		✓		✓	✓
	Extreme Cold	✓	✓		✓	✓	✓
LOW RISK HAZADRS	Impoundment Failure	✓	✓	✓	✓	✓	✓
	Wildfire	✓	✓	✓	✓	✓	✓
	Erosion	✓	✓	✓			✓
	Earthquake	✓	✓			✓	✓
	Landslide	✓		✓	✓	✓	✓
	Karst (Sinkholes)	✓					✓
	Pandemic	✓		✓		✓	✓
NEGLIGIBLE	Land Subsidence	✓					✓
	Space Weather	✓					✓

5.5 Strategy and Project Prioritization

The Advisory Committee and Working Group chose to keep the prioritization criteria from the previous plans: human health and safety, continuity of operations, cost and feasibility, loss reduction and economic recovery, benefits multiple agencies and organizations, multi-hazard mitigation, and focused mitigation efforts. Table 5-3 provides descriptions of those criteria.

Table 5-3 - Prioritization Criteria

Criteria	Description
Human Health and Safety	Action protects human health, enhances public safety, protects vulnerable populations, or mitigates significant damage potential.
Continuity of Operations	Action protects the Commonwealth's ability to maintain continuity of operations, communications, critical infrastructure, and emergency management functions during a disaster
Cost and Feasibility	Action is technically feasible and environmentally sound in terms of cost-effectiveness, ability to be completed in a timely fashion, availability of expertise and technical support, and ease of implementation
Loss Reduction and Economic Recovery	Action will reduce long-term financial losses and promote rapid economic recovery
Benefits multiple agencies and organizations	Action benefits several groups, communities, or state agencies covering a large geographic area
Multi-Hazard Mitigation	Action mitigates damage to critical resources from more than one hazard
Focused Educational Efforts	Strategies for educational efforts will be carried out in a timely and relevant manner, messages are consistent, simple, and straightforward and in the appropriate media format, including alternative formats for people with different needs, and are directed toward people and property that are located within high hazard areas.

For the 2023 update, each Advisory Committee and Working Group member had the opportunity to review the previous plan's actions and validate, affirm, or change the prioritization of each action, as applicable. There were very few changes to the action priorities. If the action was new, the Advisory Committee and Working Group members prioritized actions based on the prioritization criteria established in Table 5-2; however, the prioritization was completed as a verbal exercise within the planning group or provided by the lead facilitators based on conversations with agency representatives.

A new rating of High, Medium, or Low was added to each mitigation action to indicate potential or perceived impact on socially vulnerable populations. Since many of the mitigation actions were not specific enough to tie them to a community, this rating was often augmented by commentary related to what the ranking might be if socially vulnerable populations were targeted by a specific action.

5.6 Mitigation Actions

This section includes updated mitigation actions identified in previous versions of this plan, as well as new strategies that were submitted under this revision. The action description includes the goal, category, status, priority ranking, cost estimate (if available), expected timeline, hazard to be mitigated, and lead agency.

Table 5-4 provides a summary of mitigation actions from the 2018 plan that were removed. As noted in the table, actions may have been removed because they were completed, combined with another action, or deleted for some other reason as shown. The mitigation action numbers cited reference the action numbers from the 2018 plan unless otherwise noted.

Table 5-4 - Mitigation Actions Removed from 2018 Plan

2018 Mitigation Strategy	Reason for Removal
FL-4 – Tidewatch Program	Completed
FL-8 – Mitigation Reconstruction of Severe Repetitive Loss Properties	Action partially complete; mitigation/reconstruction combined with FL-5
FL-11 – Integrate Mitigation of Repetitive Loss Structures into Local Hazard Mitigation Plans	Completed through VDEM policies and procedures
FL-12 – Identification of Repetitive Loss Properties with Non-Specific Addresses	State agencies lack input/controls over NFIP policy addresses; this is better suited to local HMPs
FL-13 - Identification of Repetitive Loss Properties that have been Mitigated by Means other than HMA Funds	Local jurisdictions may choose to implement, but state agencies lack resources and data required.
FL-14 – Real Time Flood Inundation Program	Combined into new and modified FL-1
FL-15 - Incorporate Updated Flood Frequency Data into Updated DFIRMs	Completed
FL-16 - Hazard Evaluation of Critical and State-Owned Facilities in Coastal Areas	Completed through Coastal Resilience Master Planning and EO-24
FL-23 - Continue to Encourage Communities to Increase Design Flood Elevation in Local Floodplain Ordinances	Completed
MH-6 - HMGP 5% Initiative Projects	This is not really an action, but a type of funding. VDEM programs provide assistance with eligible projects.
MH-8 - Utility Replacement at University of Virginia's College at Wise	Completed
MH-10 - Installation of Emergency Power Systems	Agency did not respond to status requests. Action is captured by other mitigation actions.
MH-11 - Encourage the Integration of Hazard Identification and Risk Assessment Data into Other State Plans/Programs	Completed
MH-14 - Continuity of Government Planning	Several recent VDEM capabilities capture the intent of this action.

2018 Mitigation Strategy	Reason for Removal
MH-15 - Gain Support to Incorporate Hazard Mitigation Planning into Local Comprehensive Plans	Completed
MH-16 - Operational Security Review of Sensitive Data	Completed
MH-17 - Continued Natural Hazard Information Collection and Sharing	Combined into new MH-8
MH-18 - Incorporate Hazard Mitigation into Data Collection Processes for State Facilities and Assets	Combined into new MH-8
MH-23 - Train VDEM Divisions in Mitigation Project Development	Combined into new MH-14
MH-25 - Building Emergency Evacuation Program	Building evacuation programs included in new MH-2
MH-26 - Use State Facility HIRA to Attempt to Reduce Insurance Premiums for State Owned Facilities	This action is no longer a priority for DTRM. Highest priority for VDEM is to create database with better information to analyze risk.
MH-27 - Assessment of Inundation Hazards Related to Mining-Related Impoundments	This is no longer a priority for Virginia Energy.
MH-29 - Encourage Analysis of Pipelines and other Critical Infrastructure in Local Hazard Mitigation Plans	Completed
MH-30 - Official Recognition of the Virginia Hazard Mitigation Advisory Committee and Working Group	Benefits of this action are not considered sufficient to pursue further.
MH-32 - Encourage Analysis of Emergency Preparedness for Pipeline Emergencies in State and Local Hazard Mitigation Plans	Completed
MH-33 - Develop Hazard Mitigation Plan Database Tool	PDCs may choose to implement this action; not a state level action. VDEM is implementing tracking tool for state mitigation actions.
MH-34 - Joint Commonwealth of Virginia / Federal Agency Data Format Pilot Initiative	Action was not pursued.
G-2 - Delineation of Watersheds & Recharge Areas for Karst Aquifers in VA and Compilation of GIS-based Comprehensive Karst Hydrology for Virginia	Combined with G-3 because these delineations are part of the existing mapping program
HC-1 - Install Fire Alarm and Sprinkler Systems at DBHDS Facilities	Completed
HC-2 - Improve Fire Safety in University Buildings	Completed
HC-3 - Virginia Mine Mapping System	Completed
HC-5 - Newsletter to Virginia Food Industry on Food Security	Needs have changed, and the agency's Rapid Response Team and On-Farm Readiness Review Programs fill related needs in different manner
S-2 - Solar Storm - COOP Functions	Combined these concepts with S-1

Each of the following mitigation actions contributes toward satisfying the mitigation goals and therefore contributes to the overall Mitigation Vision. The mitigation actions are grouped by hazard with the following prefixes: Flooding (FL), Erosion (E), Multi-hazard (MH), Wildfire (WF), Geologic (G), Impoundment Failure (IF), Human-Caused (HC), Pandemic (P), Extreme Heat (EH) and Space Weather (S).

Flood Strategies

Real-Time Flood Warning System & Evacuation Planning

Mitigation Action FL-1

Improve state, regional, and county advanced warning systems for riverine and coastal applications, install additional weather/stream gauging components, assemble evacuation planning tools, and deploy public information resources in order to prepare community officials and residents in case of impending flooding or potential impoundment failure.

BACKGROUND INFORMATION

Cost Benefit:	When citizens have adequate time to prepare for a hazard event and know what actions to take ahead of time, damages are reduced and lives are saved. Gauging systems that collect detailed hydrologic data help improve future flood forecasting, and document changing climate conditions.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Impoundment Failure, Tornadoes
Goal(s) Addressed:	Goal 1, Goal 3, Goal 4
Category(s) Addressed:	5,6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High – prioritize communities with high NRI rating for flood
Estimated Cost:	To be determined
Potential Funding Sources:	USACE: Planning Assistance to States, Flood Plain Management Services, Silver Jackets; DHS: HMGP, PDM; NWS; USGS
Lead Agency/Responsible Department:	VDEM, DCR with VIMS, VDOT, DEQ Surface Water Investigations, local jurisdictions
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Real-Time Flood Warning System & Evacuation Planning

Mitigation Action FL-1

Tidewatch Charts (https://www.vims.edu/bayinfo/tidewatch/index.php), developed by VIMS, provide an effective way to visualize and predict the magnitude and impacts of coastal flooding at specific locations within the Chesapeake Bay and along Virginia's seaside Eastern Shore.

DCR is currently developing a state-wide Substantial Damage Plan, which will also assess the data capabilities of current technologies to develop a real-time flood warning system. In 2019, DCR and Silver Jackets initiated an inundation mapping project of the Upper Roanoke Valley in collaboration with USGS and NWS. This study involves developing a steady flow HEC-RAS model to show the extent of flooding expected over a given area. Modeling includes estimated flood depths over a range of flood frequencies, generally at one-foot intervals from the NOAA-NWS-defined "Action" stage up to the flood of record. This helps to indicate when, and with what level of severity, roadways, streets, buildings, airports, etc. are likely to be impacted by floodwaters. Work is ongoing and expected to be completed in 2022.

Through Cooperative Gaging Programs, USACE works with the USGS and NWS to help fund installation and maintenance of gages that are associated with a USACE study, project, or activity.

In the Richmond-Crater regional hazard mitigation plan, New Kent County, City of Richmond, Chesterfield County, Colonial Heights, Goochland County, and Hanover County expressed a need for some or all of the following components:

- Developing a more advanced flood warning system to increase the ability to locally and specifically forecast flood events and flood depths.
- Partnering with other organizations including the NWS, U.S. Geological Survey (USGS), DEQ Surface Water Investigations and local watershed organizations.
- Acquire additional resources to build components of a local evacuation plan, including: new gauges, high hazard water crossing elevations for county and state-owned roads, and a flood alert system.
- Create more targeted flood messages and family preparedness planning that can be conveyed to citizens. Include dam owners and downstream property owners.

Acquire and Install Additional Stream Gauges

Mitigation Action FL-2

Update the NOAA-Atlas 14 with best available and current precipitation data.

BACKGROUND INFORMATION

Cost Benefit:	In light of increased precipitation related to climate change, current precipitation data to be used for rehabilitation or design of infrastructure and structures increases the life span and reduces damage to components.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding; Impoundment Failure
Goal(s) Addressed:	Goal 2: Objective 2.1, Goal 3
Category(s) Addressed:	5,6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	$1,000,000
Potential Funding Sources:	DHS: HMGP
Lead Agency/Responsible Department:	DCR, VDEM
Implementation Schedule:	Completion targeted for 2024
Status:	**New**

ADDITIONAL COMMENTS

Virginia is part of an interstate agreement to update the data. An updated cooperative agreement was signed in April 2022 in which Pennsylvania and South Carolina were added.

Reduce Impact of Flooding on University Campuses

Mitigation Action FL-3

Use FEMA floodplain maps, HIRA data, and previous DRU-recommended actions to identify flood-prone structures on state-owned university campuses. Collect lowest floor elevations of vulnerable flood-prone structures and cause(s) of flooding. Outline evacuation, floodproofing, elevation, or other structural needs. Implement cost effective measures to increase student/staff safety and reduce damages.

BACKGROUND INFORMATION

Cost Benefit:	University campuses house large populations and several of those university facilities are at risk of flood inundation. Ensuring students and staff have safe evacuation paths, floodproofed utilities, and other mitigation tools at hand will reduce damages.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding
Goal(s) Addressed:	Goal 1, Goal 3
Category(s) Addressed:	2,4,5,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Low to Moderate
Estimated Cost:	To be determined
Potential Funding Sources:	USACE; DHS: HMGP, PDM, BRIC; Virginia CFPF
Lead Agency/Responsible Department:	DCR with University Facilities Managers
Implementation Schedule:	Within 5 years
Status:	**Retained with major modifications**

ADDITIONAL COMMENTS

An example of this mitigation action is the ODU DRU prepared in 2007 (see excerpt below). The plan includes a detailed analysis of each of the facility's vulnerabilities to a variety of hazards, specifically wind and flood. Potential mitigation actions are identified for each building, such as elevating HVAC equipment and installing a sprinkler system for fire suppression. Those mitigation actions represent a large number of potential measures that would increase the resiliency and decrease damages across the Commonwealth's Institutes of Higher Education.

Oceanography and Physics Building

Primary Building Use: Academic

Building Mitigation Priority by Hazard:
Wind: Medium Flood: Med-Low

Building Data	
Date of Construction:	1997
Sq. Ft.	92,987
Number of Stories	4
Construction Type	Reinforced Masonry
Replacement Value	$19,393,988
Contents Value	$5,818,196
First Floor Elevation	9.38 feet
Surge Zone	Category 2
Foundation Type	Slab-on-grade
Roof Type	Built-up/composite
Generator	Yes – 400 Kw

Vulnerability Assessment:

- A four-story brick building with no basement. The building has a loading dock that is below grade.
- The interior walls are constructed of gypsum board.
- The building has a flat roof with a tar and gravel surface.
- The rooftop mechanical equipment appears to be adequately secured and there are three additional levels of mechanical rooms.
- There is some below-grade mechanical equipment.
- There is a fire alarm and an automatic sprinkler system in the hallways.
- Although the building is not in a mapped 100-year special flood hazard area, it is shown in a Category 2 surge zone.

Potential Mitigation Actions/Best Practices:

- Install an alarm system tied to a central security system to protect the chemicals.
- Ensure adequate drainage/pumping from the bottom of the loading dock area.
- Evaluate the windows to determine their ability to withstand hurricane-force winds and debris impacts. Retrofit the windows with storm shutters or impact resistant glazing as needed.
- Elevate below-grade mechanical equipment.

Acquisition and Demolition of Flood Prone Properties

Mitigation Action FL-4

Acquire and demolish flood-prone structures to eliminate future damages. In some cases, properties may then be deed restricted as open space in perpetuity to ensure that no structure can be built on the parcel of land that could sustain future damages. NFIP Repetitive Loss and Severe Repetitive Loss properties are targeted for this project type.

In less hazardous areas, mitigation reconstruction (demolition of the existing structure and construction of a code-compliant and hazard-resistant structure on an elevated foundation system) is an option, particularly for NFIP repetitive loss properties.

BACKGROUND INFORMATION

Cost Benefit:	The acquisition and demolition of flood prone properties are typically cost effective, depending on the first-floor elevation, history of flooding, and fair market value of the structure. Structures may be grouped together and benefits combined.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Primarily Flooding, but also Hurricanes
Goal(s) Addressed:	Goal 1; Goal 4
Category(s) Addressed:	2, 3
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High – target repetitive flood loss areas with high NRI rating for flood as identified in the HIRA
Estimated Cost:	Acquisition costs are dependent on current real estate market. Demolition costs generally range from $4,000 to $14,000 based on size. For mitigation reconstruction, eligible costs are limited to $150,000 federal share per property.
Potential Funding Sources:	DHS: HMGP, BRIC, FMA, PDM, NFIP SRL; USACE: Continuing Authorities, Planning Assistance to States, Flood Plain Management Services, and Silver Jackets; Virginia CFPF; ARPA; CDBG
Lead Agency/Responsible Department:	VDEM, DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Acquisition and Demolition of Flood Prone Properties

Mitigation Action FL-4

VDEM and local communities across the Commonwealth have successfully acquired and demolished over 400 flood-prone properties. This project type is completely voluntary and requires written voluntary participation agreements from property owners.

The Accomack-Northampton Planning District Commission 2021 hazard mitigation plan includes a mitigation action for the Town of Onancock to demolish and remove the “HOS Shop Building”, an abandoned and dangerous building at risk of high wind damage from hurricanes.

Acquisition and Relocation of Flood Prone Properties

Mitigation Action FL-5

Acquire and relocate flood-prone structures to eliminate future damages. The remaining parcel of land in the floodplain is then deed restricted to be open space in perpetuity. This ensures that no structure can be built on the parcel of land that could sustain future damages. NFIP Repetitive Loss and Severe Repetitive Loss properties are targeted and prioritized for this project type.

BACKGROUND INFORMATION

Cost Benefit:	Cost effectiveness is project-dependent; however multiple properties can be included together for an aggregate benefit cost ratio.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding; Impoundment Failure
Goal(s) Addressed:	Goal 1; Goal 4
Category(s) Addressed:	2, 3
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High – target repetitive flood loss areas with high NRI rating for flood as identified in the HIRA
Estimated Cost:	Moving structures is costly; costs of acquiring land outside floodplain must also be included.
Potential Funding Sources:	DHS: HMGP, BRIC, FMA, PDM,, USACE
Lead Agency/Responsible Department:	VDEM, DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Acquisition and relocation projects were very successful in reducing risk in the Central Shenandoah Valley, particularly Glasgow after Hurricane Fran in 1996. This project type is voluntary and requires written voluntary participation agreements from property owners. Individual property owners cannot apply directly to FEMA, they are required to work through their community or other eligible entity as a sponsor.

Floodproofing of Public, Commercial, and Historic Buildings	
Mitigation Action FL-6	
Implement floodproofing measures to protect flood-prone businesses, public buildings, and historical buildings. NFIP Repetitive Loss and Severe Repetitive Loss properties are targeted and prioritized for this project type. Floodproofing critical infrastructure to protect against floodwater intrusion or collapse is also included.	
BACKGROUND INFORMATION	
Cost Benefit:	Floodproofing may be less costly than acquisition or elevation and may provide complete protection to the 100-year flood event.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Flooding; Impoundment Failure
Goal(s) Addressed:	Goal 1; Goal 4
Category(s) Addressed:	2, 3
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High – target repetitive flood loss areas with high NRI rating for flood as identified in the HIRA
Estimated Cost:	
Potential Funding Sources:	USACE: Continuing Authorities, Planning Assistance to States, Flood Plain Management Services, and Silver Jackets; DHS: HMGP, BRIC, FMA, PDM,
Lead Agency/Responsible Department:	VDEM, DCR with local partners, DHR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**
ADDITIONAL COMMENTS	
Floodproofing projects have been implemented for businesses in the cities of Salem and Staunton. Flood-prone commercial structures in the Town of Chincoteague, the Town of Stony Creek, and the City of Franklin may be suitable for floodproofing projects in the future as identified in mitigation actions in their respective hazard mitigation plans. Elevation measures are proposed in the local mitigation plan to protect the Town of Onancock Town Hall and Police Station from flooding, at an estimated cost of $15,000.	

Floodproofing of Public, Commercial, and Historic Buildings
Mitigation Action FL-6
The Middle Peninsula Planning District Commission is supporting this mitigation action through their Fight the Flood (FTF) initiative, through a strategy to "reduce or eliminate flood damage to residential/business structures that are highly vulnerable for continual flood damage." Another FTF strategy is to floodproof "existing water dependent commercial buildings against flooding, including surge velocities . . ., to ensure continuity and viability of the seafood industry and other water-dependent businesses." DHR/SHPO is available to provide technical assistance to state agencies, local governments, and private property owners on appropriate treatments and methods to mitigate their historic properties while retaining historic designations.

Localized Flood Reduction Projects

Mitigation Action FL-7

Implement localized flood reduction projects to lessen the frequency or severity of flooding and decrease flood damages. Examples may include installation or modification of culverts, stormwater management retention or detention ponds, tidal backflow preventers, or green infrastructure installations such as rain gardens, permeable pavements, green roofs, infiltration planters, and rainwater harvesting.

BACKGROUND INFORMATION

Cost Benefit:	Cost benefit is project dependent. If proposed solution protects structures, roads, and utilities, it is more likely to be cost effective.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Primarily Flooding, also Hazardous Materials Incident
Goal(s) Addressed:	Goal 1
Category(s) Addressed:	2,3,4
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High – target repetitive flood loss areas with high NRI rating for flood as identified in the HIRA
Estimated Cost:	Costs range from low cost, minor alterations ($100,000) to large-scale watershed-based initiatives.
Potential Funding Sources:	DHS: HMGP, BRIC, FMA, PDM,; USACE may provide related study assistance
Lead Agency/Responsible Department:	VDEM, DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Implementation of the City of Richmond RVAH2O Green Infrastructure Master Plan is a priority action identified in the Richmond-Crater Hazard Mitigation Plan. The city has invested considerably in identifying opportunities to improve existing stormwater systems with green infrastructure.

The Resilient Hampton Initiative, based on the idea of living with water, has identified multi-objective opportunities for flood mitigation, economic growth, mobility and access, green infrastructure, natural

Localized Flood Reduction Projects

Mitigation Action FL-7

resources, and revitalization of flood-prone areas. Implementation is cited in the most recent Hampton Roads hazard mitigation plan.

The City of Harrisonburg is planning a stormwater improvement project to decrease flooding. A draft 2022 stormwater report recommends 1) installation of an upstream regional BMP to assist in attenuating stormwater flow and 2) improving neighborhood infrastructure by constructing trapezoid concrete channels and improving culvert crossings at several City streets. Project cost is currently estimated at $2.5 million.

The 2021 Accomack-Northampton Planning District Commission regional hazard mitigation plan includes several mitigation actions that fall under this umbrella action, including: 1) a plan to study stormwater flooding and biohazards via a drainage study of Nelsonia north of Fisher Corner and US Route 13; 2) retrofitting undersized box culverts in the Town of Bloxom to mitigate stormwater flooding; 3) backflow prevention in stormwater drains in Onancock; 4) floodgates on 5 culverts entering Finney Creek which cross Atlantic Avenue in Wachapreague; and 5) hydrodynamic modeling and survey work to support a breakwater project in the Town of Wachapreague at estimated cost of $100,000. Cheriton and Nassawadox also expressed the need for drainage planning and assistance with drainage system maintenance.

In several local hazard mitigation plans, there are local (City of Petersburg, Isle of Wight County) or regional actions (Southside PDC) indicating a need to continue coordinating with VDOT to ensure that stormwater infrastructure in the State ROW is cleaned and maintained to prevent localized yard and street flooding. The West Piedmont PDC regional hazard mitigation plan includes an action to participate in a regional study by 2023 to inspect and assess stormwater drainage and sewer system capacity for major rain events and identify potential mitigation actions and to coordinate this need with VDOT in unincorporated areas.

Elevation of Flood Prone Properties

Mitigation Action FL-8

Implement elevation projects to raise flood-prone structures to or above the BFE, in accordance with State and local floodplain management requirements. Repetitive Loss and Severe Repetitive Loss properties are targeted and prioritized for this project type.

BACKGROUND INFORMATION

Cost Benefit:	Cost effectiveness is project dependent; however, multiple properties can be included together for an aggregate benefit cost ratio.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding; Impoundment Failure
Goal(s) Addressed:	Goal 1; Goal 4: Objective 4.1, 4.3
Category(s) Addressed:	2,3
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High – target repetitive flood loss areas with high NRI rating for flood as identified in the HIRA
Estimated Cost:	Project Dependent; see examples with costs below
Potential Funding Sources:	DHS: BRIC, HMGP, FMA; USACE: Continuing Authorities, Planning Assistance to States, Flood Plain Management Services, and Silver Jackets; Virginia CFPF
Lead Agency/Responsible Department:	VDEM, DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Structure elevation may be achieved through a variety of methods, including elevating on continuous foundation walls; elevating on open foundations, such as piles, piers, posts, or columns; or elevating on fill. Foundations will require designs to properly address all loads, appropriate connections to the floor structure above, and elevation of utilities.

Specific examples of elevation projects in Virginia include:

Elevation of Flood Prone Properties

Mitigation Action FL-8

- Project to elevate 4 homes in the Northern Neck and one in Essex County at cost of $860,930
- Project to elevate additional 6 homes in the Northern Neck, with estimated cost of $1.3 million

Maintain Statewide NFIP Repetitive Loss Areas Shapefile

Mitigation Action FL-9

Make statewide NFIP repetitive loss areas shapefile (developed during the 2023 HIRA development) available for use in VFRIS, in local hazard mitigation and CRS planning, and for other purposes. Update shapefiles every 2 years according to CRS guidance. Cross-reference RL and SRL lists with ICC properties, properties mitigated using HMA funds, and local demolition records to identify and request removal of mitigated properties. Clarify non-specific addresses in RL and SRL lists. Complete AW-501 worksheets to request Federal list error corrections.

BACKGROUND INFORMATION

Cost Benefit:	This low cost activity will aid State, local and regional planners in quickly focusing mitigation efforts in areas with repetitive flooding, and those with high social vulnerability. In addition, availability of identified repetitive flood loss areas developed using the CRS guidance will lower a boundary to CRS participation.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding
Goal(s) Addressed:	Goal 1: Objective 1.1, Goal 2, Goal 3: Objectives 3.1, 3.3; Goal 4
Category(s) Addressed:	1,2,6,7
Priority (High, Medium, Low):	High
Estimated Cost:	Maintenance ~ $2500/year Data Collection/AW501 ~ $5,000-$10,000/year
Impact on Socially Vulnerable Populations:	High –State and local planners can target repetitive flood loss areas with high vulnerability
Potential Funding Sources:	Existing agency funds; Virginia CFPF
Lead Agency/Responsible Department:	DCR with VDEM
Implementation Schedule:	Update shapefile every 2 years
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Encouraging NFIP Participation	
Mitigation Action FL-10	
Develop and implement education/outreach program for PDCs, localities, private non-profits, and citizens regarding the NFIP program and flood insurance, to include the following specific actions: 1. Courses on NFIP participation, floodplain management, and flood insurance with DCR as workshop/course facilitator; 2. Annual check-in with communities not in the NFIP; and 3. Continuation of annual flood awareness week and flood insurance outreach campaigns.	
BACKGROUND INFORMATION	
Cost Benefit:	Increased participation in NFIP will make Federal flood insurance available to more people in the Commonwealth, increasing coverage and reducing damage recovery costs.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Flooding; Impoundment Failure
Goal(s) Addressed:	Goal 2, Goal 4
Category(s) Addressed:	1,6
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Medium to High
Estimated Cost:	$150,000
Potential Funding Sources:	FEMA CAP-SSSE
Lead Agency/Responsible Department:	DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**
ADDITIONAL COMMENTS	
Workshops and courses are offered to communities, non-profits (VFMA, APA, Silver Jackets, etc.), and professional organizations (Building Officials, surveyors, zoning officials). Moving forward, the effort will focus on socially vulnerable populations with repetitive flood losses, and with low coverage ratios for Federal flood insurance, as identified in the HIRA. Virginia has 19 communities not in the NFIP with flood hazard areas identified, and 2 communities suspended from the Regular Program of the NFIP.	

Participate in Silver Jackets Program

Mitigation Action FL-11

Continue to participate in the Silver Jackets Program across the state. Silver Jackets acts as a catalyst in the identification and resolution of flood hazards to support the reduction of flood risk.

BACKGROUND INFORMATION

Cost Benefit:	Potential projects reduce flood risk through flood observation and warning systems, planning, flood hazard mapping, flood hazard mitigation, dam mitigation projects, and flood response and recovery activities

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Impoundment Failure
Goal(s) Addressed:	Goals 1, Goal 2, Goal 3, Goal 4
Category(s) Addressed:	1,2,3,4,5,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Project specific
Estimated Cost:	Project specific
Potential Funding Sources:	USACE
Lead Agency/Responsible Department:	DCR, VDEM, DEQ
Implementation Schedule:	Ongoing
Status:	**Ongoing**

ADDITIONAL COMMENTS

Virginia Silver Jackets brings agency representatives together to collaborate, share information, and leverage resources that solve unique flood hazard issues. The Virginia Team includes USACE, as well as staff from VDEM, DEQ, DCR, NRCS, FEMA, NWS and USGS.

FEMA Risk Map Program	
Mitigation Action FL-12	
Support FEMA in its outreach and education efforts when rolling out the Risk Map Program.	
BACKGROUND INFORMATION	
Cost Benefit:	Flood Risk Products can help guide land use and development decisions and help communities take mitigation action by highlighting areas of highest risk, areas in need of mitigation, and areas of floodplain change.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Flooding
Goal(s) Addressed:	2,3,4
Category(s) Addressed:	1,2,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	Not Determined
Potential Funding Sources:	FEMA CAP-SSSE, CTP
Lead Agency/Responsible Department:	DCR, VDEM
Implementation Schedule:	Ongoing
Status:	**Retained**
ADDITIONAL COMMENTS	
FEMA's Risk Map Program has 5 goals, which include addressing gaps in flood hazard data, outreach and education, hazard mitigation planning, enhanced digital platform, and alignment and synergies. DCR has previously participated in each phase of the RiskMAP lifecycle, and co-facilitated engagement touchpoints.	

Support Virginia Flood Risk Information System

Mitigation Action FL-13

As new data on flood risk and buildings located in the floodplain become available, ensure that those data are incorporated into the Virginia Flood Risk Information System (VFRIS).

BACKGROUND INFORMATION

Cost Benefit:	VFRIS provides the following benefits: • Current flood hazard data and risk information, including available dam inundation zones, are available to the public through an interactive website. • Anyone with internet access can search by address, county or political area, and view the flood hazards at the site. • Users can print a custom flood hazard map that contains the same information as a DFIRM, but allows the user to select the area that is shown within the map. • The site serves as a source of maps and data for local hazard mitigation plans.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding
Goal(s) Addressed:	Goal 3, Goal 4
Category(s) Addressed:	1,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium
Estimated Cost:	Staff time
Potential Funding Sources:	USACE, VDEM, FEMA CAP-SSSE and CTP
Lead Agency/Responsible Department:	DCR
Implementation Schedule:	Ongoing
Status:	**Retained**

ADDITIONAL COMMENTS

Consider adding multi-hazard layers and other data.

Increase Participation in the Community Rating System

Mitigation Action FL-14

Increase participation in the NFIP Community Rating System (CRS) by:

1. Assisting interested communities in making application to the program;
2. Assisting participating communities to identify and implement actions to further lower their rating;
3. Include NFIP repetitive loss areas in VFRIS;
4. Include CRS components in State Flood Protection Master Planning;
5. Include CRS components in Coastal Resilience Master Planning.

BACKGROUND INFORMATION

Cost Benefit:	CRS activities reduce flood risk; participation in the CRS program reduces NFIP flood insurance premiums for most policyholders in the community.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding; Impoundment Failure
Goal(s) Addressed:	Goal 4
Category(s) Addressed:	6
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Medium, depending on which communities are targeted as new participants
Estimated Cost:	Existing staff time
Potential Funding Sources:	CAP-SSSE, Agency Funds
Lead Agency/Responsible Department:	DCR and DEQ Coastal Zone Management Program
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

As of June 2022, there are 27 communities participating in the CRS, an increase of 2 communities since the 2018 Commonwealth of Virginia Hazard Mitigation Plan. The DEQ Coastal Zone Management Program funds Wetlands Watch to help interested communities make application through the Coastal Virginia CRS Workgroup and dedicated workshops for individual localities.

Flood Mitigation Workshop for Businesses

Mitigation Action FL-15

Develop curriculum and support materials and conduct flood mitigation workshops tailored to businesses.

BACKGROUND INFORMATION

Cost Benefit:	Keeping businesses open after a flood event is crucial to local economies and a community's recovery process. By taking steps before a disaster, future risk can be reduced, while ensuring resiliency and continuity for a business.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Impoundment Failure
Goal(s) Addressed:	Goal 4
Category(s) Addressed:	5, 6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High – if geared toward small businesses in socially vulnerable communities with identified flood risks.
Estimated Cost:	$6,000-$10,000/workshop
Potential Funding Sources:	DHS: HMGP; Agency Funds; USACE
Lead Agency/Responsible Department:	DCR with VDEM, Silver Jackets, Virginia Dept. of Small Business and Supplier Diversity
Implementation Schedule:	Within 2 years
Status:	**Retained**

ADDITIONAL COMMENTS

Work with local Chambers of Commerce, Planning District Commissions, FEMA, Virginia Silver Jackets, and DCR to develop a pilot workshop and then conduct the workshop multiple times per year. USACE National Nonstructural Committee is available to assist with flood proofing mitigation workshop. The National Nonstructural Committee was founded in 1985 to promote the use of nonstructural methods, and has many materials online that may be useful in program development: https://www.usace.army.mil/Missions/Civil-Works/Project-Planning/nnc/

Develop Substantial Damage Plan

Mitigation Action FL-16

Prepare Substantial Damage Plan, associated administrative procedures, and training to prepare communities for use during disaster. Integrate the plan into VDEM's Crisis Track tools and other response programming. Post-disaster, assist communities with developing mitigation actions for specific buildings or critical infrastructure.

BACKGROUND INFORMATION

Cost Benefit:	Ensuring that substantially damaged structures (from any cause) are rebuilt to modern design standards reduces average annual damages, particularly from flooding.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Primarily Flooding & Impoundment Failure, but potentially Earthquake, Hurricane, Non-Tornadic Wind, Tornado, and Wildfire
Goal(s) Addressed:	Goal 1, Goal 3
Category(s) Addressed:	1,2,5,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	~$75,000
Potential Funding Sources:	DHS: HMTAP, HMGP; USACE: Planning Assistance to States, Flood Plain Management Services, & Silver Jackets
Lead Agency/Responsible Department:	DCR with VDEM
Implementation Schedule:	Within 3 years
Status:	**New, with components of previous mitigation action FL-24**

ADDITIONAL COMMENTS

Detailed Building Descriptions in VAPS

Mitigation Action FL-17

Link Virginia Department of General Services (DGS) and Virginia Department of the Treasury Risk Management Division (DRM) state facility databases. Collect/verify/incorporate data regarding location, structure value, lowest floor elevations for structure and utilities, building materials, and building age.

BACKGROUND INFORMATION

Cost Benefit:	Better data on these critical elements will improve the ability to target at-risk state facilities for flood (and other hazard) mitigation. Asset valuations and location data support the ability to analyze the costs and benefits of various mitigation measures to reduce risks and may allow HAZUS Level 2 analysis of risk.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding
Goal(s) Addressed:	1,4
Category(s) Addressed:	2,4,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium to High
Estimated Cost:	To be determined
Potential Funding Sources:	Agency Funds
Lead Agency/Responsible Department:	DGS, DRM
Implementation Schedule:	Within 2 to 3 years
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Both DGS and Virginia Department of the Treasury Risk Management Division maintain databases of state facilities. By requiring building managers to include additional information on the buildings, a more robust analysis may be conducted for purposes of risk analysis and future mitigation project planning and prioritizing. Leased property values remain an outstanding item in the databases.

Mitigate Repetitive Flood Loss Properties

Mitigation Action FL-18

Provide direct mailings, technical workshops, web-based guidance, and mitigation project grant application assistance to high priority communities that have repetitive flood losses. Provide technical support to maximize use of FEMA grant programs.

BACKGROUND INFORMATION

Cost Benefit:	Mitigating repetitive losses reduces flood damages in a community. Properties may be bundled to increase benefits.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding
Goal(s) Addressed:	Goal 4
Category(s) Addressed:	6
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	High – if communities with repetitive losses in socially vulnerable areas (as identified in the HIRA) are prioritized
Estimated Cost:	~$6,000 per workshop
Potential Funding Sources:	Agency Funds; DHS: HMGP, BRIC, FMA, PDM,; Virginia CFPF
Lead Agency/Responsible Department:	VDEM with DCR
Implementation Schedule:	Ongoing
Status:	**Retained with minor modifications**

ADDITIONAL COMMENTS

These outreach projects may extend to properties and residents that are not insured against flood, and whose owners have fewer options after a disaster. These outreach projects to repetitive loss properties are also supported on the Middle Peninsula by the Fight the Flood initiative there.

VDEM staff continue to participate in planning meetings for local hazard mitigation plans, and DCR has worked with VDEM to deploy 13 Sub Regional Hazard Mitigation Assistance Grants Equity Workshops in recent years.

Flood Mitigation Plan for Virginia DOC Facilities

Mitigation Action FL-19

1) Identify DOC asset locations relative to 100-year and 500-year FEMA floodplains, levee systems, and dam break inundation zones.
2) Collect lowest floor elevations and other building characteristics of flood-prone critical assets; determine flood elevations during 100-year event, average annual damages from flood, and benefits of various flood mitigation alternatives.
3) Identify and implement:
- building and infrastructure retrofits to mitigate structural damage,
- evacuation plans to protect inmates and staff,
- response plans to minimize damage before, during and after flood events, including development of access/egress plans during floods.

BACKGROUND INFORMATION

Cost Benefit:	According to the HIRA, DOC has 448 buildings located in or very near the SFHA. This action will evaluate and implement measures to reduce average annual damages to the facilities and the occupants.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Impoundment Failure; Hazardous Materials Incident
Goal(s) Addressed:	Goal 1, Goal 4
Category(s) Addressed:	2,3,4,5
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	1) ~$15,000 2) $50,000 - $125,000 3) TBD based on projects identified, likely in excess of >$1 million for all buildings
Potential Funding Sources:	USACE; DHS: BRIC, HMGP, FMA; see also University Programs in Capability Assessment
Lead Agency/Responsible Department:	VA DOC
Implementation Schedule:	Seek funding immediately
Status:	**New**

ADDITIONAL COMMENTS

Flood Mitigation Plan for Virginia DOC Facilities
Mitigation Action FL-19
State asset database does not specify the location of individual structures at each facility; therefore, data collection in steps 1 and 2 is extensive. St. Brides, Haynesville, Bland, Indian Creek, and State Farm Correctional Centers are of particular concern to DOC officials. Retrofit measures may include demolition, relocation, elevation, floodproofing, relocation of hazardous materials, or infrastructure protection (such as elevating HVAC and other utilities). Mitigation may also include infrastructure solutions such as stormwater management system installation/modification, rain gardens, or other green infrastructure with multi-objective goals. Several facilities include buildings no longer in use. Flood-prone abandoned buildings may be ideal for demolition in order to reduce flood-borne debris or hazardous materials releases during flood events.

Model Interlocal Agreement for Mitigation	
Mitigation Action FL-20	
Develop a model interlocal agreement to establish a relationship between towns and counties for building official and permitting responsibilities, mitigation planning elements, and post-disaster grant administration.	
BACKGROUND INFORMATION	
Cost Benefit:	Many towns lack funds and staff capacity to administer all aspects of these programs adequately. Through low-cost partnerships with counties, towns can reap the benefits of more robust mitigation grant funding for cost beneficial projects that reduce hazard risk.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Primarily Flooding
Goal(s) Addressed:	Goal 1: Objective 1.3; Goal 2: Objectives 2.1, 2.2; Goal 4
Category(s) Addressed:	1, 7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Medium to High
Estimated Cost:	~40 work hours
Potential Funding Sources:	Existing agency budgets; CAP-SSSE
Lead Agency/Responsible Department:	DCR
Implementation Schedule:	Within 4 years
Status:	**New**
ADDITIONAL COMMENTS	

Floodplain Management Portal

Mitigation Action FL-21

Finalize and socialize the Floodplain Management Database Tool for the Commonwealth's jurisdictional floodplain managers.

BACKGROUND INFORMATION

Cost Benefit:	This web-based application includes a low-cost method of providing technical assistance to NFIP communities in Virginia, similar to Florida's 1-800 number for floodplain managers.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding
Goal(s) Addressed:	Goal 1, Goal 4
Category(s) Addressed:	1, 7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	$50,000
Potential Funding Sources:	Existing agency budgets; CAP-SSSE
Lead Agency/Responsible Department:	DCR
Implementation Schedule:	Within 1 year
Status:	**New**

ADDITIONAL COMMENTS

Erosion Strategies

Groundwater Modeling on Eastern Shore

Mitigation Action E-1

Model and analyze anticipated climate change and sea level rise impacts on the Eastern Shore of Virginia sole source aquifer. Update the surficial aquifer model and then conduct numerous future scenarios with varying sea level rise, precipitation and drought patterns, land cover, and evapotranspiration rates.

BACKGROUND INFORMATION

Cost Benefit:	Future land use decisions in the region depend on having high quality current and future scenario data regarding sea level rise, saltwater intrusion and other water supply concerns.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Primarily Erosion, also Flooding, Land Subsidence
Goal(s) Addressed:	Goal 1, Goal 2, Goal 3
Category(s) Addressed:	1,2,3,7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	$250,000
Potential Funding Sources:	Multiple jurisdictions budgets; USGS
Lead Agency/Responsible Department:	Accomack-Northampton Planning District Commission
Implementation Schedule:	Within 7 years
Status:	**New**

ADDITIONAL COMMENTS

Multi-Hazard Strategies

Structural Retrofit of Existing Buildings

Mitigation Action MH-1

Identify vulnerable structures and implement structural retrofit projects, to include modifications to the structural elements of a building to reduce or eliminate the risk of future damage and to protect inhabitants.

BACKGROUND INFORMATION

Cost Benefit:	Due to the relative low probability of strong earthquakes and extreme winds in or around Virginia, the ability to demonstrate cost effectiveness for these projects is low.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Earthquake, Non-Tornadic Wind, Tornado, Flood, Winter Weather, Hurricanes, Erosion, Extreme Heat/Cold, Impoundment Failure, Wildfires
Goal(s) Addressed:	Goal 1, Goal 4
Category(s) Addressed:	2
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	High, if prioritization criteria include socially vulnerable populations, previously damaged areas such as repetitive flood loss areas identified in HIRA as highly socially vulnerable (e.g., Alexandria, Hampton, Newport News, Poquoson, Norfolk, Portsmouth, Tangier and Chincoteague Islands, and Accomack County)
Estimated Cost:	Project Dependent; home elevation generally costs $75k to $125k
Potential Funding Sources:	DHS: HMGP, BRIC, FMA, HHPD; USACE; ARPA; Virginia CFPF
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Ongoing
Status:	**Retained with Modifications**

Structural Retrofit of Existing Buildings
Mitigation Action MH-1
ADDITIONAL COMMENTS
VDEM will assist localities, state agencies such as Department of Historic Resources and Department of Corrections, PDCs and eligible PNPs with needs assessment, identifying appropriate grant programs, application preparation, and implementation of projects. Both Brunswick County and the Town of Alberta included a mitigation action to examine large glass windows, full glass doors and metal siding of critical and highly significant county/town facilities for vulnerabilities, and then install storm shutters, window slips for mounting plywood, or to pursue other protective measures when warranted. Both communities estimated the effort to cost $750,000.

Non-Structural Retrofit of Existing Buildings	
Mitigation Action MH-2	
Identify vulnerable structures and implement non-structural retrofit projects, to include modifications to non-structural elements of a building or facility to reduce or eliminate the risk of future damage and to protect inhabitants. Examples include bracing of building contents to prevent earthquake damage, elevation of heating and ventilation systems, or evacuation of occupants.	
BACKGROUND INFORMATION	
Cost Benefit:	Non-structural retrofits may be more cost effective for earthquake mitigation due to the low probability of strong earthquakes in Virginia. Depending on expected flood depths, elevating utilities above BFE may prove cost effective when other measures will not.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Earthquake, Flooding, Hurricanes, Impoundment Failure, Wildfires, Extreme Heat/Cold
Goal(s) Addressed:	Goal 1, Goal 4
Category(s) Addressed:	2
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations	High. Weatherization Program has income limits
Estimated Cost:	Project dependent; some projects are relatively low cost (i.e., <$2500)
Potential Funding Sources:	DHS: HMGP, BRIC, FMA, PDM,; USACE; DHCD Virginia Weatherization Assistance Program
Lead Agency/Responsible Department:	VDEM DHCD
Implementation Schedule:	Ongoing
Status:	**Retained with Modifications**

ADDITIONAL COMMENTS
VDEM will assist localities, state agencies such as Department of Historic Resources and Department of Corrections, PDCs and eligible PNPs with needs assessments, identifying appropriate grant programs, application preparation, and implementation of projects.

Infrastructure Retrofit	
Mitigation Action MH-3	
Identify vulnerable structures and implement infrastructure retrofit projects, to include measures that reduce risk to existing utility systems, roads, and bridges.	
BACKGROUND INFORMATION	
Cost Benefit:	Expected failure of a utility system/bridge/road after a disaster can produce significant benefits; however, cost benefit ratios remain highly dependent on the overall cost of design and construction within grant parameters.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Flooding, Earthquake, Erosion, Hurricanes, Impoundment Failure, Karst, Landslides, Non-Tornadic Wind, Wildfires, Winter Weather
Goal(s) Addressed:	Goal 1, Goal 4
Category(s) Addressed:	2,3,4,5
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Project and location dependent
Estimated Cost:	To be determined based on project needs
Potential Funding Sources:	DHS: HMGP, PDM, HHPD, FMA; USACE; Virginia CFPF
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Ongoing
Status:	**Retained with Modifications**
ADDITIONAL COMMENTS	
VDEM will assist localities, state agencies such as VDOT and DOC, PDCs and eligible PNPs with needs assessments, identifying appropriate grant programs, application preparation, and implementation of projects. One potential infrastructure project from the Crater PlanRVA local hazard mitigation plan is replacement of the I-95 bridge over Stony Creek to reduce flooding impacts to the road and the town.	

Soil Stabilization

Mitigation Action MH-4

Identify vulnerable structures and apply for funding to implement soil stabilization projects, which includes projects to reduce risk to structures or infrastructure, including installing geo-textiles, stabilizing sod, installing vegetative buffer strips, preserving mature vegetation, decreasing slope angles, and stabilizing with rip rap and other means of slope anchoring.

BACKGROUND INFORMATION

Cost Benefit:	These projects often have potential to provide protection to multiple structures and utilities, which multiplies direct benefits.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Drought, Flooding, Erosion, Landslides, Karst, Earthquake, Impoundment Failure, Wildfires
Goal(s) Addressed:	Goal 1
Category(s) Addressed:	2,3,4
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	Project and location dependent
Estimated Cost:	Project dependent
Potential Funding Sources:	DHS: HMGP, PDM, BRIC, HHPD, FMA; Virginia CFPF; USACE
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Ongoing
Status:	**Retained with Modifications**

ADDITIONAL COMMENTS

VDEM will assist localities, state agencies such as VDOT, PDCs and eligible PNPs with needs assessments, identifying appropriate grant programs, application preparation, and implementation of projects.

Soil stabilization projects require a lot of pre-engineering to identify the problem, probability of occurrence, and proposed solution. A history of erosion or slope reduction, and rate of erosion must also be quantified.

Post-Disaster Code Enforcement

Mitigation Action MH-5

Implement code enforcement-related programs to ensure building codes are met during post-disaster reconstruction. Examples may include performance of building department functions such as building inspections and conducting substantial damage determinations under the NFIP.

BACKGROUND INFORMATION

Cost Benefit:	Strict adherence to building codes during reconstruction helps reduce average annual damages over the life of the structure.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Earthquake, Erosion, Flooding, Hurricanes, Impoundment Failure, Karst, Landslides, Non-Tornadic Wind, Tornado, Wildfire, Winter Weather
Goal(s) Addressed:	Goal 1, Goal 2
Category(s) Addressed:	1
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	To be determined based on nature of future event
Estimated Cost:	Dependent on event;
Potential Funding Sources:	DHS: BRIC; CDBG
Lead Agency/Responsible Department:	VDEM, DHCD, local code officials
Implementation Schedule:	As needed
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

In limited circumstances, FEMA may fund post-disaster code enforcement projects. These programs are eligible under HMA funds associated with a major disaster declaration in which there was extraordinary, widespread damage.

Emergency Power for Vulnerable University Facilities

Mitigation Action MH-6

Evaluate and install emergency power generators sufficient to maintain critical business and research functions within vulnerable buildings.

BACKGROUND INFORMATION

Cost Benefit:	Many research functions and residential functions of universities depend on continuous power supply to function adequately.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Earthquake, Flooding, Hurricanes, Impoundment Failure, Non-Tornadic Wind, Tornado, Wildfires, Winter Weather
Goal(s) Addressed:	Goal 1, Objectives 1.2
Category(s) Addressed:	2,5
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	Not Determined
Potential Funding Sources:	University Funds, DHS: HMGP, BRIC
Lead Agency/Responsible Department:	Virginia Tech, University of Virginia
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Virginia Tech - Generator switching gear installed in multiple buildings; these buildings are designated as shelter areas per the Virginia State Coordinated Regional Shelter Plan (2021). Further infrastructure improvements are still required.

University of Virginia - Assessment has documented service needs of those buildings presently with generators. Assessment in progress for those buildings which do NOT have generators and would require them to maintain life safety.

Electrical Wiring for Future Emergency Generators

Mitigation Action MH-7

Provide necessary electrical hook-up, wiring, and switches to allow readily accessible connections to emergency generators at State-owned National Guard armories throughout the Commonwealth.

BACKGROUND INFORMATION

Cost Benefit:	National Guard facilities are often used by both the Guard and localities during natural disasters as command posts and places of temporary refuge. Loss of power to the building hampers emergency aid efforts and affects the safety and well-being of any occupant.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 1: Objective 1.2 and 1.3
Category(s) Addressed:	5
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	$1.5 Million
Potential Funding Sources:	DHS: HMGP; Existing budgets
Lead Agency/Responsible Department:	Virginia Department of Military Affairs
Implementation Schedule:	As Funding Becomes Available
Status:	**In Progress**

ADDITIONAL COMMENTS

Virginia Facilities Management is tracking 47 Readiness Centers and 14 Field Maintenance Shops. Twelve Readiness Centers have operational Emergency Generators; another 4 have generators on site but have not been installed. Studies are underway for an additional 17 Readiness Centers to have generators installed in the future.

Improve Accessibility of HIRA Data

Mitigation Action MH-8

Update, maintain and provide readily-accessible hazard data used to develop this plan's HIRA, including hazard histories and state asset data for example, to PDCs, contractors and other interested parties, particularly those conducting hazard mitigation plan updates at the local level. Identify state agencies that collect data specific to state-owned and operated facilities and assets, and identify ways to incorporate information needed for mitigation in their data collection process.

BACKGROUND INFORMATION

Cost Benefit:	Hazard mitigation planning and updating is more costly if hazard histories and asset data are not regularly updated and maintained. By increasing the efficiency of conducting a HIRA update, planners can focus on the development and prioritization of an actionable mitigation plan.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 2, Goal 3
Category(s) Addressed:	1,5,7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	~$5k to $10k
Potential Funding Sources:	Agency Funds
Lead Agency/Responsible Department:	VDEM, with DCR, DGS, Other Agencies
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Disaster Resistant University (DRU) Planning

Mitigation Action MH-9

Promote DRU plans to public universities that do not currently have plans. Provide outreach to institutions with existing DRU plans regarding the need for updates. Integrate DRU mitigation actions into local and state hazard mitigation plans.

BACKGROUND INFORMATION

Cost Benefit:	Virginia's institutions of higher education contain many priceless buildings and collections, and research facilities in the medical, biotech and hazardous materials fields. Planning to help identify, prioritize and implement beneficial mitigation projects will reduce average annual damages from an array of hazards.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 2
Category(s) Addressed:	1,7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	$90,000 to $225,000 per institution
Potential Funding Sources:	DHS: DRU
Lead Agency/Responsible Department:	VDEM with university partners
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

If eligible applicants apply on their behalf, private universities can also participate in the DRU process. William & Mary, Old Dominion University, Southwest Virginia Community College, Virginia Commonwealth University, the University of Mary Washington, Virginia Tech, and the University of Virginia have received funding to develop DRU plans in the past. Several need current updates. Additional universities with significant coastal hazard exposure include Norfolk State University, Hampton University, Christopher Newport University, and Eastern Shore Community College.

Expand Role of All Hazards Planners or Create VDEM Liaison to Institutions of Higher Education (IHE)	
Mitigation Action MH-10	
Work with IHEs to expand the role of academia in hazard mitigation and DRU planning, hazard and emergency management research, and response coordination with other state, regional and local agencies/stakeholders. Train new practitioners in Emergency Management and Mitigation Planning.	
BACKGROUND INFORMATION	
Cost Benefit:	IHEs have broad expertise that is low cost and underused in State and local planning and response frameworks, particularly with regard to hazard mitigation.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 2: Objectives 2.1, 2.2; Goal 3
Category(s) Addressed:	5, 7
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	Low to Medium
Estimated Cost:	$25,000 to $90,000/year
Potential Funding Sources:	DHS: DRU; VDEM Existing budgets
Lead Agency/Responsible Department:	VDEM with university partners
Implementation Schedule:	Within 7 years
Status:	**New**
ADDITIONAL COMMENTS	
IHEs have a unique role in training future planners and emergency managers, conducting research that impacts the planning process, and coordinating response to disasters that impact their students, staff and facilities. Existing partnerships can be modeled or expanded, such as the RAFT and ICAR, as discussed in the Capability Assessment.	

Mitigation Strategies for State Assets

Mitigation Action MH-11

Solicit site-specific structural and non-structural mitigation projects for state-owned facilities (and contents) at high risk.

BACKGROUND INFORMATION

Cost Benefit:	State assets are rarely specifically addressed in these mitigation actions despite the benefits of potential projects to reduce average annual damages, especially with regard to flooding and hurricanes.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	4
Category(s) Addressed:	1,2,3,4,5,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium
Estimated Cost:	Not Determined
Potential Funding Sources:	USACE; DHS: HMGP, PDM, FMA; CFPF; ARPA; CDBG
Lead Agency/Responsible Department:	VDEM, with multiple agency facilities managers
Implementation Schedule:	Within 2 years
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

New Regional Recovery and Mitigation Specialists (RAMS) provide support to assigned partners in recovery and mitigation in the immediate aftermath of an event. Their duties include damage assessments, data collection, coordinating requests for public assistance, briefings, exploratory calls, recovery scoping meetings, mitigation opportunities, and site visits before or after a disaster declaration. They provide technical assistance to local, state, tribal, and nonprofit grant and recovery programs, including grant scope-of-work development, eligibility review, alignment to priorities, and implementation, along with education, training, and communication resources.

Hazard Mitigation Planning Toolkit

Mitigation Action MH-12

Review, revise and redeploy the hazard mitigation toolkit, which includes FEMA and VDEM planning and project documents, and a mechanism for reporting annually on the status of local and state mitigation strategies. Partner with the state's planning district commissions to facilitate interaction with local counties, cities and towns.

BACKGROUND INFORMATION

Cost Benefit:	The PDCs are well-positioned to act as liaison between communities and VDEM. Costs can likely be absorbed into existing budgets and staff responsibilities.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 2: Objective 2.1; Goal 3; Goal 4: Objectives 4.1, 4.2
Category(s) Addressed:	1,6
Priority (High, Medium, Low):	Medium to High
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	10-20 staff hours to review/redeploy toolkit; ~50 staff hours annually to distribute, collect and assemble reports.
Potential Funding Sources:	Existing agency budgets and staff time
Lead Agency/Responsible Department:	VDEM partnering with PDCs
Implementation Schedule:	Annually
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

PDCs need to be contacted by RAMS annually, notifying the PDCs that they should collect the information from each community regarding status of mitigation actions in the local hazard mitigation plan(s). Action may include training on grant availability, data collection, and planning assistance. Collection and assembly of these data will expedite subsequent local and state hazard mitigation planning processes by providing quick and easy information on action status.

State Hazard Mitigation Website Maintenance

Mitigation Action MH-13

Develop and maintain web site to provide current information and data about the state and local hazard mitigation planning processes and plan statuses. Include information related to local efforts, state efforts, links to HIRA data, and mitigation planning guidance. Include best practices for structural mitigation project funding and implementation.

BACKGROUND INFORMATION

Cost Benefit:	The data are readily available to VDEM planners; compilation on a web site is low cost with high visibility among the Commonwealth's Emergency Managers

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 3, Goal 4
Category(s) Addressed:	6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	$25,000
Potential Funding Sources:	State resources and existing staff time
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Within 2 years
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Hazard Mitigation Planning Training and Technical Assistance

Mitigation Action MH-14

Provide updated training and technical assistance to PDCs on the Hazard Mitigation Planning Process (G318).

BACKGROUND INFORMATION

Cost Benefit:	Training materials are already developed, so this action is relatively low cost with high impact on planners and plan reviewers at the local level. If PDCs can do their own plan updates, significant cost savings may result.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	4
Category(s) Addressed:	6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium
Estimated Cost:	~$6,000 per workshop, with 2 offerings per year
Potential Funding Sources:	Agency Funds
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Course G318 is typically administered 2 times a year. VDEM mitigation staff regularly attend a variety of mitigation planning meetings (such as FEMA Region III meetings, PDC meetings, tribal meetings, etc.) and provide technical assistance. Training offered to VDEM personnel in other departments may also be beneficial for identifying additional agency mitigation actions in the future.

FEMA will work with VDEM Regional Planners to support these trainings to any PDCs updating their plans or anticipating kickoffs.

Mitigation Best Practices Development

Mitigation Action MH-15

Identify, record, and broadly share mitigation success stories from across the Commonwealth. Identify the critical information/data needed to show the full benefits of a mitigation project over time.

BACKGROUND INFORMATION

Cost Benefit:	Sharing success stories and losses avoided through mitigation helps interested persons envision future projects and begin to understand the benefits.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Primarily, Flooding, Earthquake, Hurricane, Impoundment Failure, Pandemic, Tornado, Wildfires
Goal(s) Addressed:	Goal 3, Goal 4
Category(s) Addressed:	6
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Medium
Estimated Cost:	$40,000
Potential Funding Sources:	Agency Funds
Lead Agency/Responsible Department:	VDEM, with ODU's VMASC, DHCD, VDOF and DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

As projects are completed, VDEM identifies potential best practices. The VDEM web site is a potential location for sharing success stories and best practices.

Loss avoidance studies are an excellent way to demonstrate that mitigation works, and that the upfront investment saves money long term. Four Loss Avoidance Studies were conducted in 2021 and 2022.

Building Emergency Evacuation Program

Mitigation Action MH-16

Develop and distribute internet-based evacuation plans for all facilities managed by DGS serving approximately 5 million sq. ft. Based on the general structure, the procedures for each building would be customized to meet actual requirements using video and digital picture technology.

BACKGROUND INFORMATION

Cost Benefit:	Not Determined

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	2
Category(s) Addressed:	5
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	Not Determined
Potential Funding Sources:	DHS: HMGP, BRIC; Virginia CFPF
Lead Agency/Responsible Department:	DGS
Implementation Schedule:	As funding becomes available
Status:	**Not Started; Retained**

ADDITIONAL COMMENTS

Enhanced Statewide Public Education Program

Mitigation Action MH-17

Increase the general public's knowledge of disaster preparedness with emphasis on hurricane through an enhanced public education program, including: www.vaemergency.gov/prepare; www.vaemergency.gov/hurricanes; www.knowyourzoneva.org; www.vaemergency.gov/partners-in-preparedness/

BACKGROUND INFORMATION

Cost Benefit:	Public awareness reduces damage by helping property owners prepare for and respond to disasters and minimize impacts on life and property.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Drought, Hurricane, Flooding, Tornado, Earthquake, Space Weather, Land Subsidence, and Winter Weather
Goal(s) Addressed:	Goal 4
Category(s) Addressed:	6
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Medium; methods other than web-based distribution may increase impact
Estimated Cost:	Project dependent
Potential Funding Sources:	Agency Funds, DHS: HMGP
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Virginia continues to practice a Statewide Tornado Drill each spring. The annual Great Southeast Shakeout typically has more than a quarter million Virginians registered to participate. The Partners in Preparedness program that launched in May 2022 is aimed at identifying gaps in communication to vulnerable populations (those at an economic disadvantage, language and literacy barriers, access and functional needs, isolation, age, lack of internet, etc.). The program partners with people who are considered "trusted messengers" in their community and works with these partners to help identify the unique needs of each of those communities and the barriers preventing them from receiving preparedness information before, and communications during and after a disaster.

Annual HMA Grant Workshops

Mitigation Action MH-18

Continue conducting annual HMA grant workshops concurrent with the annual grant application period. Prioritize training for representatives of high risk, small towns with socially vulnerable populations and insufficient staff capacity to pursue mitigation projects on their own.

BACKGROUND INFORMATION

Cost Benefit:	Workshops help identify cost beneficial projects by interacting personally with leaders in the communities.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 4, all objectives
Category(s) Addressed:	6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High, if outreach to towns is included
Estimated Cost:	$2,000-$3,000 per workshop
Potential Funding Sources:	Agency Funds
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

These workshops focus on the 3 HMA grant programs and how to build a strong application. The location of these workshops is determined by each VDEM region. If there are HMGP funds available, HMA workshops will be included in HMGP briefings through webinars. Many project submissions result from discussions had at the annual workshops. In addition to the regional meetings, VDEM will host webinars to walk through the grants portal submission process.

Integrate mitigation component into Public Assistance (PA) Program

Mitigation Action MH-19

Identify a percentage of PA funds for Virginia that would be the target goal for Section 406 mitigation projects. The national average is 3 cents per dollar of PA funds. Firmly establish a higher ratio for every federal declaration in Virginia.

BACKGROUND INFORMATION

Cost Benefit:	Section 406 funds are specifically targeted at projects that mitigate future damages.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 1, Objectives 1.1, 1.2, 1.4; Goal 2
Category(s) Addressed:	1
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Dependent on nature/location of future disasters
Estimated Cost:	Staff time
Potential Funding Sources:	Agency Funds
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

The 406 grant program is managed by the State under funding provided for in the Stafford Act. Section 406 mitigation measures are funded under the Public Assistance, or Infrastructure, program. The 406 funding provides discretionary authority to fund mitigation measures in conjunction with the repair of disaster-damaged facilities, so is limited to declared counties and eligible damaged facilities. Section 406 is applied on the parts of a facility that were damaged by the disaster and the mitigation measure(s) directly reduce the potential of future, similar disaster damages to the eligible facility.

In instances where federal funds, licenses, or permits are involved, consultation with DHR/SHPO is necessary pursuant to Section 106 of the National Historic Preservation Act, as alterations to historic properties may jeopardize their historic status. Unauthorized alterations may jeopardize funding.

Disaster Mitigation Plan for Historic Resources

Mitigation Action MH-20

Prepare Disaster Mitigation Plan to address Virginia's historic resources. Distribute the Historic Surry Disaster Mitigation Plan template for use in other communities. Produce content and design for web page to assist local governments and individual property owners access and understand mitigation, and assist in identifying projects for future damage reduction. Identify additional historic resources that should be targeted for protection, prioritizing communities with high social vulnerability.

BACKGROUND INFORMATION

Cost Benefit:	Historic assets preserve the culture and artifacts of the Commonwealth's rich history for future generations. Assets at risk may have longer lifespans if measures are put in place to protect those assets before, during and after disasters.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	1,2,3,4
Category(s) Addressed:	1, 2, 3, 6, 7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium to High
Estimated Cost:	Not Determined
Potential Funding Sources:	Agency Funds, National Park Service; DHS: HMGP, PDM, FMA, BRIC; /Virginia CFPF; USACE
Lead Agency/Responsible Department:	DHR, Silver Jackets
Implementation Schedule:	Ongoing
Status:	**New**

ADDITIONAL COMMENTS

This action is also required as part of a National Park Service grant for hurricanes Michael and Florence. In instances where federal funds, licenses, or permits are involved, consultation with DHR/SHPO is necessary pursuant to Section 106 of the National Historic Preservation Act, as alterations to historic properties may jeopardize their historic status. Unauthorized alterations may jeopardize funding.

Anchor Fuel Tanks and Generators at Virginia DOC Facilities

Mitigation Action MH-21

Secure above-ground fuel tanks and emergency generators (with fuel tanks attached) to the ground to prevent damage from wind, flood, earthquake or other incident.

BACKGROUND INFORMATION

Cost Benefit:	This action aims to reduce future damages at all DOC facilities by identifying high risk assets and mitigating the risk with low-cost structural retrofits.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Non-Tornadic Wind, Tornadoes, Hurricanes, Winter Weather, Flooding, Earthquake, Hazardous Materials Incident
Goal(s) Addressed:	Goal 1, Objective 1.1, 1.2, 1.4
Category(s) Addressed:	2
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High impact for inmates and staff
Estimated Cost:	TBD; estimated $10k-$20k per facility
Potential Funding Sources:	Virginia General Fund; DHS: HMGP, BRIC; ARPA
Lead Agency/Responsible Department:	VA DOC
Implementation Schedule:	Immediately
Status:	**New**

ADDITIONAL COMMENTS

Energy Resilience Measures at Virginia DOC Facilities

Mitigation Action MH-22

1) Partner with power companies to develop annual preventative tree trimming program across agency facilities. Develop agency tree trimming team (with property certifications) to implement program.
2) Transfer power lines from pole mounted to pad mounted transformers and underground utilities.
3) Strategically install solar panels to develop outage resiliency and provide continuous, reliable power at critical DOC facilities.
4) Introduce energy tracking software into facilities management protocols in effort to reduce energy consumption, especially during extreme heat and extreme cold events.
5) Ensure adequate refueling for emergency generators to keep them running during extended power outages.

BACKGROUND INFORMATION

Cost Benefit:	Energy resiliency reduces maintenance and repair costs, lowers fuel costs for generators, and mitigates storm damages as a result of power outages. Power outages during extreme heat and cold have negative impacts on health of staff and inmate populations.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Extreme Heat, Extreme Cold, Flooding, Hurricanes, Non-Tornadic Wind, Tornado, Space Weather, Winter Weather
Goal(s) Addressed:	Goal 1; Goal 3
Category(s) Addressed:	2
Priority (High, Medium, Low):	Medium (subtasks 1 through 3) to High (subtasks 4 and 5)
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	1) minimal cost; existing staff time 2) ~$100-150k per facility 3) ~$50,000-$75,000 per structure 4) $50,000 5) $20,000
Potential Funding Sources:	Existing DOC budgets, HMGP, BRIC, ARPA
Lead Agency/Responsible Department:	VA DOC, partnering with public utilities
Implementation Schedule:	Within 4 years; subtask #4 expected in 2022
Status:	**New**

ADDITIONAL COMMENTS
Subtasks #3 and #4 mitigate future climate change impacts from extreme heat and extreme cold events. Existing DOC plans for all facilities address extreme heat mitigation with fans, misters, ice supply, water supply and other measures. Sufficient fuel for generators decreases need for these short-term mitigation measures by helping ensure air conditioning remains functional.

Network of Extreme Weather Warming/Cooling Centers	
Mitigation Action MH-23	
Provide readily accessible data on the network of extreme cold and extreme heat cooling/warming centers when available, in the form of an interactive map and searchable database that provides information on location, hours, eligibility, intake procedures, capacity limits, alerts and contact information.	
BACKGROUND INFORMATION	
Cost Benefit:	Cooling and warming centers target the most socially vulnerable populations in the Commonwealth and provide critical life safety protection to reduce hospitalizations and deaths. Specific benefits of the centers are increased when the number of users increases, and providing access information about open centers is expected to increase users.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Extreme Cold, Extreme Heat, Winter Weather, and possibly Wildfires
Goal(s) Addressed:	Goal 1; Goal 2: Objective 2.1; Goal 3; Goal 4
Category(s) Addressed:	5,6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	$20,000 startup + upkeep/coordination costs
Potential Funding Sources:	DHS: HMGP, BRIC; Agency funds and local partners
Lead Agency/Responsible Department:	VDH, VDEM, Virginia Department of Social Services
Implementation Schedule:	Begin winter 2022
Status:	**New**

ADDITIONAL COMMENTS
Partner with state agencies, counties and non-profit organizations to create database that cuts across jurisdictional boundaries for individual weather events. Pennsylvania Department of Human Services has a similar program specifically for extreme cold: www.pa211.org/get-help/housing-shelter/extreme-cold-warming-centers/

Promote Use of Shelter Upgrade Fund

Mitigation Action MH-24

Increase promotion of the VDEM Shelter Upgrade Fund; efforts may include outreach via social media, web site materials, and targeted emails/phone calls to emergency managers and PDCs. Provide additional support to localities in preparing applications to the fund.

BACKGROUND INFORMATION

Cost Benefit:	The fund is designed to provide cost effective retrofits, including generators and related equipment, for facilities statewide. The benefits of the upgrades accrue primarily to the most socially vulnerable populations. Minimal costs for promotions and application assistance.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Earthquake, Extreme Cold, Extreme Heat, Flooding, Hurricanes, Impoundment Failures, Tornado, Wildfires, Winter Weather
Goal(s) Addressed:	Goal 1, Goal 4
Category(s) Addressed:	2,5
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	$5,000 to $10,000, annually
Potential Funding Sources:	Existing budgets; Shelter Upgrade Fund
Lead Agency/Responsible Department:	VDEM, partnering with PDCs
Implementation Schedule:	Within 1 year, and semi-annually thereafter
Status:	**New**

ADDITIONAL COMMENTS

Preserve future wetlands and floodplains.

Mitigation Action MH-25

Using future conditions modeling, identify and preserve/protect wetlands and floodplains needed to store or convey floodwaters under future flooding and sea level rise scenarios. Preserve a variety of wetland types in an effort to prevent destruction of vulnerable habitat.

BACKGROUND INFORMATION

Cost Benefit:	Protection of future-vulnerable areas preserves continuous habitat for threatened and endangered species and protects (re)development in areas subject to severe future flooding. Both measures reduce average annual damages primarily from flooding, but also keep damages from hurricanes, sea level rise, land subsidence, wildfire, and warming temperature from increasing.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Extreme Heat, Drought, Hurricane, Land Subsidence, Wildfire
Goal(s) Addressed:	Goal 1, Goal 2, Goal 3: Objective 3.2
Category(s) Addressed:	1, 3
Priority (High, Medium, Low):	Moderate – High
Impact on Socially Vulnerable Populations:	Moderate – provides open space for recreation, hunting, birdwatching, fishing
Estimated Cost:	Costs are highest along the coast and in or near previously developed areas such as Hampton Roads and Northern Virginia. Cropland averaged $4,790 per acre in Virginia in 2021 (per USDA).
Potential Funding Sources:	Private donors, Virginia Land Conservation Fund, Virginia Recreational Trails Fund, Virginia Outdoors Foundation, U.S. Fish & Wildlife Service (various grant programs)
Lead Agency/Responsible Department:	DWR, with DCR, DOF, DEQ, Nature Conservancy and other NPOs
Implementation Schedule:	Ongoing
Status:	**New**

ADDITIONAL COMMENTS
Vulnerable lands may currently be uplands that will be converted to floodplains or wetlands in the future. One specific project under this strategy is the expected acquisition of 8,500 acres of land in Accomack and Northampton counties for migratory bird habitat, fishing, hiking, hunting and other compatible activities by the state. The property, which will be managed primarily for native wildlife and public access, represents a once in a lifetime opportunity to conserve priority coastal habitat.

Wildlife Resource Mitigation Outreach Program

Mitigation Action MH-26

Develop comprehensive public awareness campaign to inform public of hazard risk being mitigated by DWR ongoing activities. While habitat loss is the driving need behind most agency efforts, risks from multiple hazards are simultaneously mitigated.

BACKGROUND INFORMATION

Cost Benefit:	Support from the community is needed to sustain many agency projects; this type of low cost outreach would benefit the agency and educate the public by imparting the benefits of DWR projects beyond the hunting, fishing, and boating safety activities that most Virginians associate with DWR.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Impoundment Failure, Extreme Heat, Hurricane, Land Subsidence, Wildfire
Goal(s) Addressed:	Goal 2; Goal 4: Objectives 4.2, 4.3
Category(s) Addressed:	6
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	$50,000-$150,000
Potential Funding Sources:	Existing agency funds, U.S. Fish & Wildlife Service, Silver Jackets, DHS: BRIC, Virginia CFPF
Lead Agency/Responsible Department:	DWR
Implementation Schedule:	Within 3 years
Status:	**New**

ADDITIONAL COMMENTS

The social media and web pages for DWR provide a wealth of public information regarding DWR activities; however, the benefits of agency programs in addressing hazards are rarely a focus. Also, web pages and social media posts may not reach the more socially vulnerable populations in Virginia.

Outreach campaign components may include activities geared specifically toward socially vulnerable populations: visits and citizen science activities with nursing homes and Title I elementary schools with the highest levels of poverty; flyers mailed with fishing/hunting/boating licenses; hazard mitigation-

Wildlife Resource Mitigation Outreach Program
Mitigation Action MH-26
related articles in the agency's *Virginia Wildlife Magazine*; or partnerships with DOF and DCR to install signage at specific locations in or near socially vulnerable areas where hazard benefits accrue from existing efforts.

Building Code Resilience Measures

Mitigation Action MH-27

Continue multi-agency representation on DHCD Resiliency Sub-Workgroup, charged with proposing state-specific amendments to the 2018 ICC codes that will reduce risk from flood (and other hazards). The group will continue meeting during the 2021 Code Development Cycle to develop proposals for Virginia's codes to increase resiliency, as well as review the resiliency impact of proposals submitted by others throughout the review cycle.

BACKGROUND INFORMATION

Cost Benefit:	Increasing the level of protection for new construction and improvements reduces the potential for future loss from numerous hazards.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding; Hurricanes; Non-Tornadic Wind; Tornado; Winter Weather; Extreme Heat/Cold; Earthquake; Radon
Goal(s) Addressed:	Goal 1, Goal 2
Category(s) Addressed:	1,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Moderate
Estimated Cost:	Existing staff time
Potential Funding Sources:	Community Funds, CAP-SSSE
Lead Agency/Responsible Department:	DHCD with DCR
Implementation Schedule:	Ongoing
Status:	**New**

ADDITIONAL COMMENTS

Analyze Hazard Damage Areas through Crisis Track

Mitigation Action MH-28

Use Crisis Track data to analyze areas that have repetitively damaged structures or infrastructure, caused by both common and unusual weather-related events.

BACKGROUND INFORMATION

Cost Benefit:	Crisis Track data allow examination of impacted areas that may not be captured by more traditional means.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	Goal 3: Objective 3.1
Category(s) Addressed:	7
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	Medium - High
Estimated Cost:	Undetermined
Potential Funding Sources:	DHS: HMGP 5%, HMA funds
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Within 5 to 7 years
Status:	**New**

ADDITIONAL COMMENTS

The West Piedmont PDC regional hazard mitigation plan included a similar measure related to gathering post-disaster damage assessment data in GIS format, expanding drone usage, and generally expanding data collection and analysis capabilities. The plan discussed using the data for future benefit cost analyses and tracking of Public and Individual Assistance expenditures.

Improve Outreach, Planning and Mitigation Program Assistance to Tribes

Mitigation Action MH-29

The current status, capabilities and effectiveness of individual tribes' emergency management and hazard mitigation programs is generally undetermined by VDEM and other state agencies. Develop a comprehensive program of outreach that includes programmed communications, training, and assistance to develop tribal mitigation plans and projects.

BACKGROUND INFORMATION

Cost Benefit:	Increased capabilities will improve tribal hazard awareness and identification, as well as mitigation action planning. Implementation of mitigation actions that are cost beneficial is the goal of the mitigation program.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All
Goal(s) Addressed:	All
Category(s) Addressed:	All
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	$75,000, annually
Potential Funding Sources:	DHS: BRIC, HMGP
Lead Agency/Responsible Department:	VDEM ODOI & Regional Planners
Implementation Schedule:	Within 5 to 7 years
Status:	**New**

ADDITIONAL COMMENTS

Wildfire Strategies

Site-Specific Wildfire Mitigation

Mitigation Action WF-1

Identify vulnerable structures and implement wildfire mitigation projects that reduce the risk to structures and associated loss of life from the threat of future wildfire through:

- Development of defensible space around structures;
- Application of ignition-resistant construction methods and materials (not common in Virginia);
- Hazardous fuels reduction or relocation;
- Mechanical treatments (e.g., thinning/pruning trees, creating fuel breaks); and
- Installation of dry hydrants.

BACKGROUND INFORMATION

Cost Benefit:	Wildfire mitigation projects generally have proven to be cost effective due to the relatively low cost to implement.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Wildfire
Goal(s) Addressed:	Goal 1
Category(s) Addressed:	2
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium - High, depending on project area priorities
Estimated Cost:	Defensible space costs ~$580/structure; hazardous fuels reduction costs ~$3,000/site; Mechanical treatments cost ~$750/acre Installation of dry hydrants costs ~$4500/hydrant
Potential Funding Sources:	USDA; National Fire Plan and DOF: Firewise; DHS: HMGP, HMGP Post-Fire Assistance, PDM, BRIC
Lead Agency/Responsible Department:	DOF, with VDEM, DWR, PDCs, and other agencies
Implementation Schedule:	Ongoing; 103, 22, and 12 sites were mechanically mitigated in 2018, 2019 and 2021, respectively
Status:	**Retained with modifications**

ADDITIONAL COMMENTS
These projects are voluntary, and require written voluntary participation agreements from property owners. VDOF is targeting the following counties for wildfire hazard mitigation work in FY 2023: Albemarle, Amelia, Carroll, Clark, Essex, Gloucester, Henry, Madison and Scott. VDOF plans to complete approximately 230 prescribed burns for just over 4000 acres; and plans to install 18 new dry hydrants and repair 8 existing inoperable dry hydrants in FY 2023. The Lenowisco local hazard mitigation plan includes a mitigation action to identify structures vulnerable to wildfire and apply for funding to mitigate the risk. Projects may include creation of defensible space, application of ignition-resistant construction, and hazardous fuels reduction. The Accomack-Northampton Planning District Commission 2021 hazard mitigation plan includes a mitigation action calling for installation of a dry hydrant in the Town of Onancock in order to allow the fire department to access creek water. Estimated cost is $5,000. The plan also calls for purchase of a boat for the Tangier Island Fire Department to improve fire suppression operations during flood events.

Training for Virginia's Fire Service	
Mitigation Action WF-2	
Continue fire and emergency services training to over 700 local Fire and EMS departments. Provide annual training on wildfire suppression and advanced incident management to increase the capacity of Virginia's Fire Service. Partner with VDEM to provide Fire Management Assistance Grant (FMAG) Program training to review the FMAG request process and provide an overview of the program.	
BACKGROUND INFORMATION	
Cost Benefit:	Effective incident management reduces damage from a large spectrum of hazards, and effective management in real time requires high quality, regular training.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Wildfire; Earthquake, Hurricane, Flooding, Impoundment Failure, Karst, landslide, Non-Tornadic Wind, Tornado, Winter Weather, Hazardous Materials Incident, Complex Coordinated Attack, Improvised Nuclear Device; Electromagnetic Pulse
Goal(s) Addressed:	Goal 1: Objective 1.3; Goal 2
Category(s) Addressed:	1,5
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium - High
Estimated Cost:	$34 Million annually (2021); 75% goes to counties/cities/towns; 25% goes to VDFP operational budget
Potential Funding Sources:	Virginia Aid to Localities (ATL) – derived from 1% of fire-related insurance coverage statewide
Lead Agency/Responsible Department:	VDFP with VDOF, DHCD, VDEM as training partners
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

The Virginia Department of Fire Programs (VDFP) is the only accredited entity for training Virginia's Fire Service and continues to provide Pro Board accredited training to Virginia's fire services community. In doing so, the agency continues to strengthen the preparedness of Virginia's localities in the event of a man-made or natural disaster. The Virginia Department of Forestry (VDOF) provides more than 11,000 annual class hours of wildfire suppression and advanced incident management training to increase capacity in Virginia's Fire Service.

In their local hazard mitigation plan, Brodnax, Lawrenceville and Halifax Fire Departments requested continuation of the current support for education, training and equipment of local fire departments. Prince George County included a mitigation plan for building a new Fire Department burn building, at an approximate cost of $718,306 as shown in the county's annual budget. Charles City County indicated a need for additional dry hydrants, and provided specific needs for 2 engines, 1 tanker truck, 12 firefighters, 3 ambulances and additional needs for the Volunteer Fire Department.

VDEM is conducting 2 hours of FMAG training in March 2023. The FMAG Program is available to states, local and tribal governments for the mitigation, management and control of fires on publicly or privately owned forests or grasslands. Target audience is local government and state agency personnel, with roles and responsibilities related to disaster recovery.

Develop Wildfire Emergency Plan for all VA DOC facilities.

Mitigation Action WF-3

Develop and implement appropriate wildfire mitigation measures for all DOC facilities. Study access/egress in the event of wildfire and ensure multiple points of access in the event an important route is blocked due to fire. Provide adequate firebreaks and access for firefighting equipment and personnel. Develop air quality monitoring and warning system to protect inmates. Work with VDOF to determine defensible space needs for facilities and flammable infrastructure in high wildfire risk zones and to refine wildfire evacuation plans.

BACKGROUND INFORMATION

Cost Benefit:	Wildfire at Virginia's Correctional Centers threatens inmates, staff, and infrastructure. Mitigation measures to help fight fires and to harden structures against the spread of wildfire reduce average annual damages from fire and protect health and safety of at-risk populations.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Wildfire
Goal(s) Addressed:	Goal 1; Goal 4, Objective 4.1
Category(s) Addressed:	2,3,4,5,7
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	Costs TBD during initial needs assessment.
Potential Funding Sources:	VDOF; DHS: HMGP, BRIC; ARPA
Lead Agency/Responsible Department:	VA DOC, VDEM, VDOF
Implementation Schedule:	Within 8 to 10 years
Status:	**New**

Geologic Hazard Strategies

Landslide Hazard Mapping Program

Mitigation Action G-1

Develop GIS layers that identify areas at higher risk for damage from landslides and debris flows, suitable for emergency and land use planning purposes. Target areas with a high susceptibility to landslides. Identify and map landslides using newly available 1-meter LIDAR data, if funding is secured.

BACKGROUND INFORMATION

Cost Benefit:	Landslide hazard maps are needed in Virginia to identify high risk areas for emergency and land use planning purposes. Landslide mapping permits land use decisions to incorporate the hazard, thereby reducing impacts through avoidance and minimization.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Landslide
Goal(s) Addressed:	Goal 3, Objective 3.3
Category(s) Addressed:	7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Moderate. Socially vulnerable populations in high risk areas may benefit from additional information.
Estimated Cost:	$16 Million
Potential Funding Sources:	HMGP, PDM
Lead Agency/Responsible Department:	Virginia Energy
Implementation Schedule:	Ongoing
Status:	**Ongoing**

ADDITIONAL COMMENTS

The Page County landslide project was complete as of 2013. Virginia Energy currently has PDM grants to create landslide hazard maps for Nelson and Albemarle Counties. The western half of the project was delivered in March 2022. The eastern project area is scheduled for completion in September 2023.

Karst Hazard Mapping Program

Mitigation Action G-2

Complete geologic mapping, digital conversion, and quality assurance of existing karst and sinkhole location data. Produce more derivative maps that delineate the relative susceptibility to karst development and related hazards of mapped carbonate bedrock formations in the Valley and Ridge physiographic province. Continue delineating watersheds and defining recharge areas for karst aquifers. Complete GIS-based VA Karst Hydrology Atlas detailing karst groundwater dye tracing investigations.

BACKGROUND INFORMATION

Cost Benefit:	Karst Program dye tracing will provide a hydrologic basis for defining conservation site boundaries for significant caves. Knowledge of underground flow paths is invaluable for planning and emergency services personnel in the event of a hazardous materials event in karst areas.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Karst, Hazardous Materials, Subsidence
Goal(s) Addressed:	Goal 1, Objective 1.4; Goal 3, Objective 3.3
Category(s) Addressed:	6,7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	To be determined. Additional mapping needed to determine risk relative to social vulnerability.
Estimated Cost:	$1 million
Potential Funding Sources:	State funding, USGS, HMGP
Lead Agency/Responsible Department:	Virginia Energy, DCR, DEQ
Implementation Schedule:	Ongoing, and as funding becomes available
Status:	**In Progress.** Virginia Energy secured 2021 USGS funding to complete a derivative karst hazard map in northern Shenandoah Valley using 1m LIDAR data. A second karst hazard mapping project has been funded.

ADDITIONAL COMMENTS

Need identified for GIS data related to karst hydrology and subsidence potential. DEQ will continue to inventory springs in karst areas to support this effort. Delineating areas underlain by carbonate bedrock is also included in this effort.

Update Virginia Radon Hazard Map

Mitigation Action G-3

Virginia Energy will collaborate with College of William & Mary and VDH to update/improve statewide radon hazard map using 2020 update to state geologic map and radon test kit results.

BACKGROUND INFORMATION

Cost Benefit:	Radon exposure has a high cost; it is a known cause of lung cancer, especially in smokers. Radon tests are inexpensive (<$50) and structural mitigation is inexpensive. The results of additional testing and map refinement will provide local and state officials with additional tools to advise homeowners when testing is advised, resulting in mitigation of lung cancer. Leaders at local, regional and State level will gain information to determine if a change in capabilities is warranted (e.g., building code requirements, real estate disclosures).

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Radon Exposure
Goal(s) Addressed:	Goal 3, Objectives 3.1, 3.3
Category(s) Addressed:	7
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	To be determined. Socially vulnerable populations may be prioritized for testing.
Estimated Cost:	Estimated $50/structure, plus mapping costs
Potential Funding Sources:	USGS, EPA, HMGP, BRIC
Lead Agency/Responsible Department:	Virginia Energy, William & Mary, VDH
Implementation Schedule:	Within 5 years
Status:	**New**

ADDITIONAL COMMENTS

This project will build on the GIS radon mapping initiative of William & Mary in Williamsburg, and is similar to actions proposed in the Hampton Roads and PlanRVA/Crater local hazard mitigation plans.

Fault and Earthquake Data Information System

Mitigation Action G-4

Make earthquake and fault data available on Virginia Energy web site and as part of a GIS-based web viewer. Update the data as new information becomes available.

BACKGROUND INFORMATION

Cost Benefit:	Publicly available information on the risk posed by earthquake hazards informs new building design and retrofits.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Earthquake
Goal(s) Addressed:	Goal 3, Objective 3.3; Goal 4
Category(s) Addressed:	6,7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	$25,000
Potential Funding Sources:	HMGP, USGS, State funding
Lead Agency/Responsible Department:	Virginia Energy, Virginia Tech
Implementation Schedule:	Within 8 years
Status:	**New**

ADDITIONAL COMMENTS

Geohazard Web Viewer	
Mitigation Action G-5	
Develop a web-based, searchable viewer that provides users with information about geologic hazard tailored to their search location.	
BACKGROUND INFORMATION	
Cost Benefit:	Publicly available information on the risk posed by earthquake, landslides and karst informs land use decisions.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Earthquake, Landslide, Karst
Goal(s) Addressed:	Goal 2; Goal 3; Objective 3.3; Goal 4
Category(s) Addressed:	6,7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	$25,000
Potential Funding Sources:	HMGP, USGS, State funding
Lead Agency/Responsible Department:	Virginia Energy, Virginia Tech
Implementation Schedule:	Within 8 years
Status:	**New**
ADDITIONAL COMMENTS	
This action would combine the various geologic data sets that are available to s state staff, or that are under development, into a single web-based source for engineers, planners, property owners and other interested parties.	

Impoundment Failure Strategies

Comprehensive Dam Information Database Development

Mitigation Action IF-1

Continue identifying and collecting relevant data for use in database of all dams located in or affecting the Commonwealth of Virginia, Dam Safety Information System (DSIS).

BACKGROUND INFORMATION

Cost Benefit:	DSIS enables users to access information about all dams in Virginia that DCR tracks. Depending on the level of access granted, users may view, edit, download, upload or enter information. The system streamlines and reduces costs of input/maintaining data, and accessing/using data.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Impoundment Failure
Goal(s) Addressed:	3,4
Category(s) Addressed:	6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High, if inundation areas for dams in socially vulnerable areas are prioritized
Estimated Cost:	$175,000 annually
Potential Funding Sources:	Agency Funds; USACE: Planning Assistance to States, Flood Plain Management Services, and Silver Jackets
Lead Agency/Responsible Department:	DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

USACE maintains the National Inventory of Dams, and DCR Division of Dam Safety and Floodplain Management provide data from Virginia.

Dam Inundation Areas Mapping and Risk Assessment

Mitigation Action IF-2

Map and assess the dam inundation areas in the Commonwealth of Virginia. This action requires protection of sensitive data as completed.

BACKGROUND INFORMATION

Cost Benefit:	Inundation area mapping provides critical information needed to assess downstream impacts of dam failure. This type of risk assessment allows local, State and regional planners to focus their efforts on specific needs, timing, and structures.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Flooding, Impoundment Failure
Goal(s) Addressed:	Goal 3, Goal 4
Category(s) Addressed:	6,7
Priority (High, Medium, Low):	Medium
Estimated Cost:	Costs vary for each dam based on characteristics of dam and downstream areas and are the responsibility of the dam owner.
Impact on Socially Vulnerable Populations:	Medium to High, if socially vulnerable inundation areas are targeted
Potential Funding Sources:	Dam Owners; USACE: Planning Assistance to States, Flood Plain Management Services, and Silver Jackets
Lead Agency/Responsible Department:	DCR
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS
Regulated dam owners are now required to perform downstream dam inundation modeling. Since this effort is based on individual dam owners, collection, digitization and sharing of the data is an ongoing process. DCR continues to improve, add data and increase access to the DSIS. The West Piedmont PDC regional hazard mitigation plan includes an action to develop an enhanced dam inundation GIS layer and/or mapping product for all high hazard potential dams [affecting the region].

Dam Removal/Decommissioning

Mitigation Action IF-3

Identify, and partially or fully decommission dams that are no longer serving intended purpose, contribute significant negative effects on the structure and function of river ecosystems, or have significant negative downstream impacts to people and infrastructure upon failure or overtopping. Options may include no action, structural repair, dam removal, partial dam removal or changes to dam operations (fish passage continuity, modification of water release, aeration and temperature modification of releases).

BACKGROUND INFORMATION

Cost Benefit:	Two primary benefits of full decommissioning are reestablishment of natural river ecosystem functions, such as fish migration and spawning, and reduction in downstream flood risk.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Impoundment Failure, Flooding
Goal(s) Addressed:	Goal 1
Category(s) Addressed:	4
Priority (High, Medium, Low):	Medium – High
Impact on Socially Vulnerable Populations:	High – prioritize dams with vulnerable downstream populations
Estimated Cost:	19 high hazard dams identified to date; ~$2 to 3 million/dam
Potential Funding Sources:	DHS: HHPD, HMA; USACE; U.S. Fish & Wildlife Service; National Fish & Wildlife Foundation; NOAA Community-Based Restoration Program; Virginia Dam Safety, Flood Prevention and Protection Assistance
Lead Agency/Responsible Department:	DCR, with DWR
Implementation Schedule:	Ongoing
Status:	**New**

ADDITIONAL COMMENTS

Future conditions modeling of older dams highlights design deficiencies and hazards associated with increased precipitation levels as climate changes.

Specific dams targeted for removal or decommissioning include:

Dam Removal/Decommissioning

Mitigation Action IF-3

Ashland Mill Dam
Ashland Mill Dam is a concrete dam located along the South Anna River approximately 140 feet upstream of US Route 1 in Hanover County, Virginia. The existing dam is a “run-of-the river” structure which means it is located (built) across an established river with water constantly flowing over its defined top elevation (top of dam). Dams such as these are typically concrete or brick built to span the entire riverway and are used for various purposes such as flood control, aid boaters moving up-river, or as in this case, previously used for mill purposes.

Ashland Mill Dam is approximately 14 feet tall, with a total length (river width) of approximately 230 feet based on Google Earth aerial imagery. Based on information in DCR’s DSIS, the dam has a normal pool volume (volume behind dam below top elevation) of approximately 70 acre-feet. The drainage area to Ashland Mill Dam is approximately 452 square miles, which spans approximately 7 Virginia Counties (Albemarle, Fluvanna, Greene, Goochland, Hanover, Louisa, and Orange counties) with its headwaters in Albemarle / Orange Counties. The drainage area is largely comprised of agricultural land and forested areas, with some urbanized areas, residential communities, roadways, railways, and other landscape features.

Natural Bridge Dam #4 and Natural Bridge Dam #5
DCR is seeking funding to remove two dams along Cedar Creek located on the property of Natural Bridge State Park in Rockbridge County. The project has three objectives: 1) decommission Natural Bridge Dam #4and Natural Bridge Dam #5 so that they no longer pose a potential failure and flood risk downstream of the dams; 2) eliminate potential hazard to aquatic species because of sedimentation; and 3) re-establish the natural aquatic and riparian systems that existed prior to dam construction. Removal of Natural Bridge Dam #5 and Natural Bridge Dam #4 will fully open approximately 30 miles of Cedar Creek to aquatics species.

Dam removal will benefit aquatic life along this section of Cedar Creek by re-establishing the surface water hydrology that existed prior to dam construction. Studies indicate Cedar Creek downstream from Natural Bridge Dam #4 and Natural Bridge Dam #5 is a clean-flowing, high gradient, rocky, well-oxygenated reach, and will support freshwater habitats. Based on the initial reconnaissance, the channel upstream of Natural Bridge Dam #4 and Natural Bridge #5 should re-form naturally as a bedrock lined and controlled channel. Sediment bars and banks that remain post-dam removal will likely require vegetative and possibly structural stabilization to control erosion and sediment transport downstream. Riparian plantings should be sufficient to stabilize and restore the channel banks without full channel reconstruction.

Pittsylvania Power Station Raw Water Storage Basin Dam, Pittsylvania County
The Pittsylvania Power Station Raw Water Storage Basin Dam is scheduled for removal in fall 2022 as part of the decommissioning of the power station. This is a pumped storage facility, meaning that the dam receives water pumped from the nearby Roanoke River, rather than impounding an existing waterway. The dam is an earthen embankment approximately 42 feet tall and 2430 feet long, encircling the entire 11-acre reservoir. Plans for removal of this dam include draining the reservoir in a controlled fashion, and excavating the embankment, using the material to return the site to approximate original contour.

Dam Removal/Decommissioning

Mitigation Action IF-3

White Mill Dam, City of Danville
White Mill Dam is a low head dam spanning the Dan River in the City of Danville. The dam is approximately 1050 feet long and less than 6 feet high. It is size exempt from DCR regulations due to its height. Danville City Council voted in July 2022 to remove the dam, but plans for when and how the dam will be removed have not been announced.

Fitts Dam, Franklin County
Fitts Dam is an earthen embankment dam near Rocky Mount, in Franklin County. The dam is approximately 260 feet long, 30 feet tall, and creates an impounding capacity of about 50 acre-feet on an unnamed tributary to the Blackwater River. The dam is located approximately 600 feet upstream of the Blackwater River, and approximately 1200 feet upstream of US Route 220. A portion of the Mountain Valley Pipeline (MVP) was constructed immediately below the toe of the dam, resulting in the elevation of the dam's Hazard Classification to High. MVP purchased the property in the summer of 2022 and is currently evaluating options for the property, including rehabilitating the dam or removing it.

College Lake Dam, City of Lynchburg
The College Lake Dam is scheduled for removal in the near future, as part of a larger project to build a new bridge for US Route 221 Lakeside Drive and restore the natural stream and upland lake back to natural conditions. The existing earthen embankment dam is approximately 300 feet in length, approximately 35 feet tall with an impounding normal pool lake area of about 15 acres. This dam has had overtopping issues that caused an evacuation of downstream areas in August 2018 which was highly publicized in various media outlets. Plans for removal of this dam include draining the existing reservoir using siphoning methods, excavation, and removal of the existing earthen embankment, restoration of the stream through existing reservoir and dam embankment footprint using natural stream/wetland habitat restoration concepts, installation of site erosion and sediment control measures, and permanent stabilization of disturbed soil areas. The existing roadway over the impounding structure is proposed to be relocated under a separate project.

Woodberry Dam, Powhatan County
Woodberry Dam is a privately-owned, stone-faced earthen embankment dam built circa 1790. The dam is approximately 130 feet long and 22 feet high with a top impounding capacity of 180 acre-feet. The dam experienced a sunny day failure likely due to piping on February 27th, 2022. The owner plans to decommission the dam and may rebuild in kind or replace upstream in the future. An alteration permit was approved to provide 3:1 slopes at the breach location.

Human-Caused Hazard Strategies

Statewide Inventory of Abandoned Mines and Quarries

Mitigation Action HC-1

Complete statewide inventory of abandoned mining sites and provide location and hazard information to emergency planners and responders and other interested parties in a GIS- and web-based information delivery system.

BACKGROUND INFORMATION

Cost Benefit:	Abandoned mines and quarries in many parts of Virginia have not been accurately located or assessed for hazard potential. A thorough inventory is necessary in order to prioritize reclamation activities aimed at mitigating risks to citizens.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Human Caused, Subsidence
Goal(s) Addressed:	Goal 1; Goal 3: Objectives 3.1, 3.3
Category(s) Addressed:	6,7
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	$975,000
Potential Funding Sources:	State funding
Lead Agency/Responsible Department:	Virginia Energy
Implementation Schedule:	Ongoing, as funding becomes available
Status:	**In Progress**

ADDITIONAL COMMENTS

Virginia Energy has recorded a partial inventory of abandoned mines, but the inventory is incomplete. Not all abandoned mines have been thoroughly cataloged, and some locations of mines in the existing inventory are of questionable accuracy, as they were located before the agency began using GPS technology. Not all sites have been assessed for their risk to public safety. This work continues with one grant-funded staff person but is expected to take decades at this rate and resource level. The agency continues to seek sources of external funding to complete this work.

Avoid and Reduce Risk of Hazardous Materials Incident within DOC

Mitigation Action HC-2

1) In planning location of future infrastructure, avoid areas in close proximity of hazardous materials plants or storage facilities.
2) Develop detailed response plan for Green Rock Correctional Center (GRCC) in event of hazardous materials incident. There are numerous chemical production and storage facilities south of the facility.

BACKGROUND INFORMATION

Cost Benefit:	Avoiding and minimizing placement of future infrastructure is low cost. Development of a rapid response plan for GRCC can reduce future damages from air, water or land releases of toxic chemicals and reduce impact on inmates and staff.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Hazardous Materials Incident
Goal(s) Addressed:	Goal 1, Objectives 1.2, 1.4
Category(s) Addressed:	1,2,5
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Medium
Estimated Cost:	Avoidance is low cost; response plan development for GRCC estimated at $50k
Potential Funding Sources:	DHS: BRIC, HMGP
Lead Agency/Responsible Department:	VADOC
Implementation Schedule:	Within 5 years
Status:	**New**

ADDITIONAL COMMENTS

Integrate Human-Caused Hazards into Local EOPs, COOPs and Mitigation Plans

Mitigation Action HC-3

Local and regional multi-jurisdictions hazard mitigation plans in Virginia take varying approaches to human-caused hazards. Provide training and outreach to the PDCs and planning partners regarding inclusion of human-caused hazards in planning efforts and provide regular briefing to these same groups on VDEM/Fusion Center's ongoing planning efforts, programs and projects with regard to these hazards. Ensure that both state and local hazardous materials plans are updated in a timely fashion to comply with planning cycles.

BACKGROUND INFORMATION

Cost Benefit:	Increasing planning efforts with regard to human-caused hazards will help reduce impacts, increase public confidence in government, and ready all levels of government for response.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All Human-Caused Hazards in Appendix D
Goal(s) Addressed:	Goal 1: Objectives 1.3, 1.4; Goal 2: Objectives 2.1 and 2.2
Category(s) Addressed:	1,5,6,7
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	Medium
Estimated Cost:	$6,000 - $10,000 per quarter
Potential Funding Sources:	DHS: HMGP; existing agency budgets
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Within 2 years
Status:	**New**

ADDITIONAL COMMENTS

Maximize Data Sharing Partnerships

Mitigation Action HC-4

Maximize partnerships between Virginia Fusion Center, other state agencies and local/regional response partners to share critical information, as appropriate, to reduce the probability of deliberate physical human-caused or cyber-driven activities designed to disrupt, harm or otherwise damage people, systems, structure, or infrastructure.

BACKGROUND INFORMATION

Cost Benefit:	Sharing information across various response partners can substantially eliminate or reduce impacts of deliberate, planned actions.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All Human-Caused Hazards in Appendix D
Goal(s) Addressed:	Goal 1, Goal 2, Goal 3
Category(s) Addressed:	1,5,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Undetermined; based on specific incidents
Estimated Cost:	Undetermined
Potential Funding Sources:	Existing agency budgets
Lead Agency/Responsible Department:	Virginia Fusion Center
Implementation Schedule:	Ongoing
Status:	**New**

ADDITIONAL COMMENTS

Current outreach efforts of the Virginia Fusion Center include: maintaining a mailing list for law enforcement and other NDA'd individuals with products being pushed out about cyber issues/products; offering response assistance to SLTT and private entities experiencing cyber incidents; providing education opportunities such as teaching classes on cyber hygiene; and preparation of a guide for localities including how to respond to an incident and a few resources that are helpful for preventing them.

Harden Structures Against Human-Caused Hazards

Mitigation Action HC-5

Identify and prioritize physical vulnerabilities of structures, infrastructure and natural resources to human-caused hazards. Implement activities to mitigate potential consequences from human-caused events.

BACKGROUND INFORMATION

Cost Benefit:	The historical record of human-caused events is short, infrequent, and less predictable than weather-related events; however, events of this nature can be catastrophic. Identifying vulnerabilities and calculating benefits of protection remains important, but difficult.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	All Human-Caused Hazards in Appendix D
Goal(s) Addressed:	Goal 1: Objective 1.2; Goal 4
Category(s) Addressed:	1,2,3,4,5,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Undetermined
Estimated Cost:	Undetermined; based on projects identified
Potential Funding Sources:	Existing agency budgets
Lead Agency/Responsible Department:	VDEM
Implementation Schedule:	Within 5 years
Status:	**New**

ADDITIONAL COMMENTS

Protect critical IT infrastructure from cyber attack.

Mitigation Action HC-6

1. Conduct routine audits of IT systems to highlight previously unknown vulnerabilities.
2. Continuing education for IT professionals and general staff.
3. Continued networking and partnership-building to include information sharing between colleagues that serves to keep IT professionals informed of new developments for security and threats.
4. Regular checks of IT/cyber infrastructure, such as double checking any configurations, perhaps using a second party, and ensuring unauthorized changes have not been made.

BACKGROUND INFORMATION

Cost Benefit:	The costs of implementation of security measures must be summed and measured against the costs of multiple possible cyberattacks, yet the probability connected to various attack scenarios is unknown. The average data breach in the US costs a company or agency an average $3.86 million and takes an average of 280 days to identify and contain.[1]

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Cyber Attack, possibly Complex Coordinated Attack
Goal(s) Addressed:	Goal 1: Objectives 1.2, 1.3; Goal 3: Objectives 3.1, 3.3; Goal 4: Objective 4.2
Category(s) Addressed:	1,5,6,7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Undetermined
Estimated Cost:	$150,000
Potential Funding Sources:	Existing agency budgets
Lead Agency/Responsible Department:	Virginia Fusion Center
Implementation Schedule:	Ongoing
Status:	**New**

ADDITIONAL COMMENTS

[1] IBM Security: Cost of a Data Breach Report, 2020. Accessed onlined at: https://www.capita.com/sites/g/files/nginej291/files/2020-08/Ponemon-Global-Cost-of-Data-Breach-Study-2020.pdf Study based on 524 organizations of various sizes, across a wide range of geographies and industries, including public agencies.

Protect critical IT infrastructure from cyber attack.
Mitigation Action HC-6
Routine audits may include forgotten task items that could serve as an access point for malicious/threat actors (*e.g.,* former staff accounts that should have been deleted but were overlooked). Log audits can show access records, including those by unauthorized actors. Continuing education for IT professionals includes: 1. Current working knowledge of Common Vulnerabilities and Exposures, allowing IT professionals to close the doors and windows to a system before they are exploited; 2. Knowledge of threat actor Tactics, Techniques, and Procedures can allow IT staff to notice things early and potentially stop an incident (i.e. seeing initial entry of a ransomware gang and stopping their access/spread before ransomware is actually deployed) 3. Changes in "best practices" that can be implemented as they develop. Continuing education for general staff includes cyber hygiene training, which is important for preventing social engineering and unauthorized access.

Pandemic Strategies

Monitor Communicable Diseases by Advancing Surveillance and Laboratory Science

Mitigation Action P-1

Strengthen the existing programs, including infectious disease surveillance, laboratory detection, and epidemiologic investigation. Specifically:
- Conduct or support ongoing systematic collection, analysis, interpretation, and management of public health-related data to effectively detect, verify, characterize, and manage a threat, hazard, risk, or incident of public health concern throughout and following an incident;
- Continue Laboratory testing services; and
- Office of Epidemiology will continue to collect and analyze health data from participating emergency departments and urgent care centers to identify emerging trends of public health concern.

BACKGROUND INFORMATION

Cost Benefit:	Although benefits vary by incident or disease, these mitigation measures reduce long-term impacts and help prevent incidents from worsening.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Pandemic
Goal(s) Addressed:	Goal 1, Goal 3, Goal 4
Category(s) Addressed:	1, 6, 7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	Not Determined
Potential Funding Sources:	CDC; DHS: HMGP, BRIC, PDM; Agency budgets
Lead Agency/Responsible Department:	VDH
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

VDH continues to support the monitoring, preventive measures, and public education of communicable diseases to mitigate the impact of communicable diseases. Virginia utilizes a passive disease surveillance system (VEDSS) as a primary tool for monitoring the health of communities. This system relies on healthcare providers, laboratories, and other entities required by the Code of Virginia to provide information to local health departments.

Reduce Impacts of Communicable Disease Outbreaks

Mitigation Action P-2

Recommend, implement, and support public health interventions that contribute to the mitigation of a threat, hazard, risk, or incident, and monitor intervention effectiveness.

Continue development of VDH Foresight and Analytics program within the Office of Emergency Preparedness to ensure modeling and analytics are incorporated into planning and response to public health threats.

BACKGROUND INFORMATION

Cost Benefit:	The goal of this program is to enable timely, effective decision-making to improve outbreak response using data, modeling, and analytics.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Pandemic
Goal(s) Addressed:	Goal 1, Goal 3, Goal 4
Category(s) Addressed:	1, 6, 7
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	Annual costs vary and are included in regular agency costs.
Potential Funding Sources:	CDC; DHS: HMGP, BRIC, PDM; Agency budgets
Lead Agency/Responsible Department:	VDH
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

The Foresight and Analytics Program also serves as a liaison with the newly launched CDC Center for Forecasting and Outbreak Analytics (CFA).

Provide Public Information and Education on Public Health Threats

Mitigation Action P-3

Continue to use the internet, clinician letters, social media, and traditional media outlets to disseminate information, alerts, warnings, and notifications to the public and incident management personnel.

BACKGROUND INFORMATION

Cost Benefit:	Early notification reduces impacts and alerts the public to personal mitigation measures that may be necessary.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Pandemic
Goal(s) Addressed:	Goal 1, Goal 3, Goal 4
Category(s) Addressed:	6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	Annual costs vary and are included in regular agency costs.
Potential Funding Sources:	CDC; DHS: HMGP, BRIC, PDM; Agency budgets
Lead Agency/Responsible Department:	VDH
Implementation Schedule:	Ongoing
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Update HVAC Systems

Mitigation Action P-4

Develop and implement a strategic plan to assess needs and then implement upgrades to HVAC systems at state higher education facilities.

BACKGROUND INFORMATION

Cost Benefit:	Poor air quality is associated with higher risks of communicable disease transmission, and other chronic ailments. Mitigating these health risks can reduce insurance costs, increase productivity of staff and students, and improve quality of life.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Primarily Pandemic, also Extreme Heat
Goal(s) Addressed:	Goal 1
Category(s) Addressed:	2
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	Moderate to High
Estimated Cost:	Strategic planning approximately $75,000 per institution; retrofit implementation costs to be determined as part of strategic planning process
Potential Funding Sources:	DHS: HMGP, BRIC
Lead Agency/Responsible Department:	Individual Institutions with strategic plan oversight and funding assistance by VDEM
Implementation Schedule:	Within 8 years
Status:	**New**

ADDITIONAL COMMENTS

Each university will assess their own system performance to contribute to strategic plan. Then, state partners can determine priorities for, and availability of, funding.

Extreme Heat Strategies

Virginia Environmental Health Tracking Program (VEHTP)	
Mitigation Action EH-1	
Reduce the impact of environmental and extreme climate events by continuing development of extreme heat plan based on historical weather data and heat-related illness and fatality data. This program will track environmental hazards, environmental exposures and environmental health effects.	
BACKGROUND INFORMATION	
Cost Benefit	Program goal is to increase understanding of how environmental factors impact the health, health inequities and lives of Virginians.
MITIGATION ACTION DETAILS	
Hazard(s) Addressed:	Extreme Heat
Goal(s) Addressed:	Goal 1, 3, 4
Category(s) Addressed:	1, 3, 5, 6
Priority (High, Medium, Low):	High
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	VDH will receive $635,000 per year for five years
Potential Funding Sources:	CDC
Lead Agency/Responsible Department:	VDH
Implementation Schedule:	Grants funds received 2022; project underway
Status:	**New**
ADDITIONAL COMMENTS	

Space Weather Strategies

Identify electronic data storage needs

Mitigation Action S-1

Identify, prioritize and address alternate electronic data storage needs. Also, identify which agency functions are most critical for both normal electric power grid operation and recovery operations, and then determine which components are essential to ensuring those functions will survive.

BACKGROUND INFORMATION

Cost Benefit:	Redundant data storage can be met in several ways. Identifying low cost, effective storage solutions can have multiple benefits for recovery after severe solar storm or other space weather event.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Space Weather
Goal(s) Addressed:	1,4
Category(s) Addressed:	1,6
Priority (High, Medium, Low):	Medium
Impact on Socially Vulnerable Populations:	Low
Estimated Cost:	~$75,000
Potential Funding Sources:	Agency funds
Lead Agency/Responsible Department:	VITA, VDEM
Implementation Schedule:	3-5 years
Status:	**Incomplete; retained with minor modifications**

ADDITIONAL COMMENTS

Results can be tied into COOP for VITA, VDEM and other agencies, as necessary.

Solar Storm – Power Grid Vulnerability Assessment

Mitigation Action S-2

Work with electric power providers to assess the vulnerabilities in the electric power grids to solar and geomagnetic storms, and the potential service impacts of these storms.

BACKGROUND INFORMATION

Cost Benefit:	Grid vulnerabilities during space weather events can have far-reaching impacts on power, communications, transportation, and other networks that may last for extended periods. By identifying vulnerabilities in the power grid prior to events, the impacts may be reduced in future events.

MITIGATION ACTION DETAILS

Hazard(s) Addressed:	Space Weather
Goal(s) Addressed:	1
Category(s) Addressed:	1,6
Priority (High, Medium, Low):	Low
Impact on Socially Vulnerable Populations:	High
Estimated Cost:	Not Determined
Potential Funding Sources:	Agency budgets; DHS: HMGP, BRIC; Dominion (private funds)
Lead Agency/Responsible Department:	VDEM, SCC
Implementation Schedule:	3-5 years
Status:	**Retained with modifications**

ADDITIONAL COMMENTS

Contents

6.1 2023 Update

This chapter provides details on funding for hazard mitigation plans, historic plan development processes, plan updates, as well as technical assistance provided by VDEM and other agencies participating in the VHMAC and the VHMWG. The information has been updated to provide current program descriptions and priorities, and to reflect recent data on funding and technical assistance. Information on the state's first tribal hazard mitigation plan was also appended.

6.2 History of Local Hazard Mitigation Plan Development in Virginia

To support the development of local hazard mitigation plans, VDEM provides assistance to tribal organizations, local and regional jurisdictions through several mediums, including interim guidance and training materials. FEMA Pre-Disaster Mitigation (PDM) funding for hazard mitigation plan development initially became available in 2002. At that time, VDEM staff in partnership with the DCR Floodplain Management Program and FEMA, began an aggressive campaign to initiate local hazard mitigation planning in Virginia. Table 6-1 provides an overview of the burst of planning activity that occurred between 2002 and 2006 as local hazard mitigation plans began being developed in the Commonwealth, and information on the first tribal plan approved by FEMA in 2022. Since 2006, the local plans have been updated on a rolling 5-year basis; however, existing Disaster Resistant University (DRU) plans have not been updated as regularly.

Table 6-1 – Local and Tribal Hazard Mitigation Plan Development Overview, 2002 to 2022

Year	Hazard Mitigation Planning Activity
2002	PDM and Flood Mitigation Assistance (FMA) funding was provided to six regional PDCs located in southwest Virginia, the Roanoke Valley, and the Central Shenandoah Valley.
2003	VDEM created and delivered mitigation planning workshops and developed local planning assistance guidance.
2003	PDM, FMA, and Hazard Mitigation Grant Program (HMGP) funding was provided to three regional PDCs and two universities: Rappahannock-Rapidan, Northern Virginia, Middle Peninsula, Virginia State University, and Radford University.
2003	HMGP funding from Hurricane Isabel supported 12 regional plans that were generally aligned with PDC regions: Accomack-Northampton, Richmond Regional, Crater, Northern Neck, Region 2000, West Piedmont, George Washington Regional, Thomas Jefferson, the Peninsula, Southside Hampton Roads, and Northern Shenandoah Valley. In addition, two county plans (Southampton and Amelia) and one single jurisdiction plan (City of Franklin) were funded.
2004	Single jurisdiction plans were developed by the City of Chesapeake and the City of Poquoson; both were self-funded.
2005	PDM funds were used to develop a hazard mitigation plan for George Mason University.
2006	PDM and HMGP funds were used to develop hazard mitigation plans for the University of Virginia, Virginia Commonwealth University, and the University of Mary Washington.
2007-present	Local plans were updated on a rolling 5-year basis
2022	FEMA Region 3 approved its first tribal-only Hazard Mitigation Plan for the Chickahominy Tribe.

As shown in Table 4-1 in Section 4 of this plan, Virginia currently has 20 local hazard mitigation plans that have been submitted and approved by VDEM and FEMA Region III, as well as the recently approved Chickahominy Tribe's plan. There are 2 plans that expired in 2022, and another 2 that will expire in 2023. All of these plans are currently being revised or will soon be revised once funding is secured.

In 2020, the Chickahominy Indian Tribe secured tribal funds to begin the process of preparing their first hazard mitigation plan. VDEM representatives joined with Tribal elected officials and members, and their selected planning consultants in a series of meetings held between September 2020 and October 2021. Due to the ongoing COVID-19 pandemic, workshops were held virtually. The plan demonstrates the Tribe's commitment to reducing risks from hazards and serves as a tool to help decision makers direct and coordinate mitigation activities and resources, including local land use policies. The adoption and implementation will assist the Tribe in becoming eligible to received pre- and post-disaster assistance from FEMA through a variety of existing programs such as BRIC, HMGP and FMA. Actions include a variety of projects such as safe rooms, development of a Tribal EOP, and partnerships with the County, to reduce damage from hazards such as flooding, hurricanes, tornadoes, drought, and wildfire. It was approved by FEMA on August 4, 2022.

The Rappahannock and Upper Mattaponi Tribes participated in the Middle Peninsula PDC's Regional Hazard Mitigation Plan update in 2020-2021. They participated in the same context as the localities and the Middle Peninsula PDC's HMP has been adopted by the tribes. The Pamunkey Tribe also falls within the Middle Peninsula PDC's service area, but they have a tribal addendum that is included in the HMP as an appendix. This addendum provides more specific detail about the tribe's history, needs, concerns, projects, etc., but uses most of the HAZUS and hazard analysis data that Middle Peninsula PDC incorporates in their Regional HMP. The Chickahominy Indians Eastern Division fall within the Richmond-Crater Regional Hazard Mitigation Plan service area, but they did not participate in the HMP update in 2021-2022.

6.3 Defining planning jurisdictions

One of the key issues facing the Commonwealth as it started supporting the local mitigation planning process was to define 'locality' sufficiently to meet current FEMA standards. The definition of a 'locality' provided in the DMA2K regulations was written to encompass the broad variety of community types across the United States. As such, the definition was much broader than Virginia's political organizations. In order to simplify the planning process as much as possible, the FEMA and Virginia regulatory definitions were researched and a Virginia-specific definition of those communities that would be required to take part in the hazard mitigation planning process was developed. The basis of the DMA2K local government definition was the National Flood Insurance Program (NFIP) definition of a 'locality.[i] FEMA Region III's position is that the definition of a locality responsible for development of a hazard mitigation plan is:

Any area or political subdivision within the Commonwealth of Virginia as defined by the Code of Virginia that has authority to create, adopt and/or enforce land use, zoning, or subdivision ordinances and regulations for the areas within its boundaries.

Within the Commonwealth of Virginia, this definition encompasses the counties, cities, and incorporated towns recognized by the *Code of Virginia*. Virginia counties, cities, and incorporated towns have independent land use management authority within their respective boundaries. The PDCs are regional planning organizations that provide technical and planning support to the localities within their respective regions. They are an excellent resource for mitigation plan development as they have a grasp on local planning initiatives. However, while the PDCs do perform land use planning at the request of their localities, they cannot implement or enforce the plans they create for those localities. Implementation and enforcement remain the responsibility of the cities, counties, and towns for which plans were developed.

The definition also includes any federally recognized Native American tribes. As discussed in Section 3 of this plan, Virginia has seven federally recognized tribes: the Pamunkey Indian Tribe, Chickahominy Indians, Chickahominy Indians Eastern Division, Upper Mattaponi Indian Tribe, Rappahannock Tribe, Nansemond Indian Nation, and Monacan Indian Nation. Virginia recognizes all seven Federally recognized tribes as well as four additional tribes, the Mattaponi Tribe, Nottaway Indian Tribe, Cheroenhaka (Nottoway) Indian Tribe, and the Patawomeck Tribe.

The Commonwealth of Virginia recognizes 38 independent cities, 95 counties, and 190 incorporated towns. There also are 21 PDCs in Virginia as shown in Figure 3-4 in Section 3 of this plan. Based on the DMA2K requirements and the locality definition from FEMA, each of Virginia's cities, counties, and towns are required to develop (or take an active role in the development of) and adopt a hazard mitigation plan in order to retain eligibility for HMA funds. The PDCs are not required to develop a separate hazard mitigation plan for their regions, as they do not have the enforcement authority of the cities, counties, and incorporated towns. However, it has been the practice of the Commonwealth to combine as many of the mitigation plans as possible into regional, multi-jurisdictional plans using the PDCs as the planning agency for these efforts. Not coincidentally, several of the regional plans also include mitigation action items that are expected to be led by regional stakeholders such as the PDCs.

6.4 Funding for Mitigation Planning

Funding of the development or update of a local hazard mitigation plan or DRU plan is an eligible activity under the PDM, HMGP, BRIC and FMA programs. FMA planning funds can only be used to update the flood section of the hazard mitigation plan. Each of the grant programs have cost shares ranging from 0% non-federal share to 25% non-federal share, and have had a significant impact on the status of local mitigation plans in Virginia.

As of November 2022, there are ten DRU plans in place in the Commonwealth, including: George Mason University (expired 2009); Old Dominion University (expired 2012); Radford University; Mary Washington University (expired 2019); University of Virginia (expired 2009); Virginia State University (expired 2007); Virginia Tech (expired 2020, with update underway); Virginia Commonwealth University (expired 2011, with update underway); Southwest Virginia Community College; and the College of William & Mary (expired 2019).

By February 2007, all localities within the Commonwealth had a FEMA-approved and adopted hazard mitigation plan. Local hazard mitigation plans and DRU plans must be updated every five years; therefore, localities have applied for funding through available HMGP and PDM funds, and more recently, through BRIC funding. Table 6-2 provides details of open or pending HMA grants to update hazard mitigation plans:

Table 6-2 – Local Hazard Mitigation Plan and DRU Funding Sources

Plan Name	Funding Source for Update (current or most recent)
Accomack-Northampton Planning District	HMGP 4411
Commonwealth Regional	PDM 2019
Central Shenandoah Planning District Commission	HMGP 4291
Cumberland Plateau Planning District Commission	PDM 2017
George Washington Regional Commission	BRIC 2020
Hampton Roads Planning District Commission	PDM 2019
LENOWISCO Planning District Commission	HMGP 4401
Middle Peninsula District Commission	HMGP 4401

Plan Name	Funding Source for Update (current or most recent)
Mount Rogers Planning District Commission	PDM 2016
New River Valley Planning District Commission	BRIC 2020
Northern Neck Regional Planning Commission	BRIC 2020
Northern Shenandoah Valley Regional Commission	PDM 2015
Northern Virginia	PDM 2018
Rappahannock-Rapidan Regional Commission	PDM 2016
Central Virginia Planning District Commission	HMGP 4262
Radford University	PDM 2016
Richmond-Crater Regional Planning Commission	HMGP 4411
Roanoke Valley-Alleghany Regional Commission	HMGP 4262
Southside Planning District	HMGP 4262
Southwest Virginia Community College	PDM 2016
Thomas Jefferson Planning District Commission	HMGP 4411
West Piedmont Planning District Commission	PDM 2018
Virginia Commonwealth University	PDM 2019
Virginia Tech DRU	PDM 2019

FEMA, the Commonwealth of Virginia, and local planning grant sub-recipients have contributed over $5.6 million dollars since 2010 to develop and revise local hazard mitigation plans and DRUs throughout the Commonwealth. This funding displays the commitment of all entities to effectively identify local risks and develop cost-effective actions to break the cycle of repetitive damages. A distribution of annual funds and cost shares can be found in Table 6-3. Historically, the Commonwealth has provided sum-sufficient funds to assist only when there is a presidentially declared disaster, and HMGP funding is made available by FEMA.

Table 6-3 – Funding for Local Plans and DRUs

Funding Source	Local Share	State Share	Federal Share	Award Amount
HMGP (DR-1874)	$11,995	$47,979	$179,923	$239,897
HMGP (DR-1905)	$13,250	$53,000	$198,750	$265,000
HMGP (DR-4042)	$6,250	$25,000	$93,750	$125,000
HMGP (DR-4072)	$13,343	$53,370	$200,139	$266,852
HMGP (DR-4092)	$6,666	$26,666	$100,000	$133,332
PDM FY10	$186,765	$0	$560,295	$747,060
PDM FY14	$41,697	$0	$124,970	$166,667
PDM FY15	$89,728	$0	$263,648	$353376
PDM FY16	$69,250	$0	207,750	$277,000
HMGP (DR-4262)	$14,260	$57,040	$213,900	$285,200
HMGP (DR-4291)	$5,069	$20,277	$76,039	$101,385
HMGP (DR-4401)	$11,553	$46,212	$173,295	$231,060
HMGP	$22,306	$89,224	$334,590	$446,120

Funding Source	Local Share	State Share	Federal Share	Award Amount
(DR-4411)				
BRIC 2020	$78,023	$0	$234,069	$312,092
PDM FY17	$38,550	$0	$115,649	$154,198
PDM FY18	$100,000	$0	$300,000	$400,000
PDM FY19	$295,362	$0	$886,086	$1,181,448
Total	**$1,004,067**	**$418,768**	**$4,262,853**	**$5,685,687**

Many of the early DRU plans expired due to lack of ongoing funding, lack of staffing or staff turnover, and lack of awareness of the need for updates. Other institutions of higher education decided to change their approach to mitigation planning and participate in the PDC multi-jurisdictional planning processes for their region, taking advantage of the experience and knowledge of local planners and emergency managers, and more fully sharing in the opportunity to gain perspective from the larger group of stakeholders that participate in those larger efforts. Post-COVID, some institutions recommitted to the individualized DRU planning process, including Virginia Tech and Virginia Commonwealth University. VDEM recognizes that all these institutions of higher education represent large employers, non-traditional populations, and significant footprints in their communities. They also can be strong partners for data collection, analysis, and outreach.

Newly hired VDEM staff focused on mitigation planning will once again concentrate on efforts to engage these and other learning institutions throughout the Commonwealth in discussions that help ascertain the best planning solution for each based on a variety of factors such as:

- Size of the physical plant and the risk associated with various hazards;
- Size and nature of the student body, and factors such as campus housing, parking and walkability;
- Future development plans;
- Institutional financial strength; and,
- Staff capabilities regarding emergency management (response, outreach, recovery), planning (data collection, analysis), and grant administration for both mitigation projects and planning.

6.4.1 Prioritizing Funding for Local Hazard Mitigation Plans

Funding for local hazard mitigation plan revisions helps ensure that all local jurisdictions at risk remain eligible to apply for funds through FEMA's Hazard Mitigation Assistance (HMA) programs. The prioritization criteria from the previous plan remain the same with minor editorial changes to improve readability. Priority status denotes those plans for which VDEM believes grant funding is most critical in order to update or implement the plan. Priority status changes over time and may be influenced by the following factors:

1. **Expiration Date**: VDEM's goal is to keep all local jurisdictions in the Commonwealth eligible for HMA funds to reduce risk and assist in maintaining critical societal functions.

Local hazard mitigation plans that expire sooner will be given priority over plans that expire at a later date.

2. **Hazard History and Probability:** Localities with a history of damaging events are more likely to experience similar events in the future. These jurisdictions are considered more vulnerable to damages from future events and should be given priority over other jurisdictions.
3. **Population and Population Growth**: Localities that have a higher population are at a higher risk of injuries and fatalities should a disaster occur. In addition, population centers have more infrastructure that could also sustain damage. The Commonwealth's mitigation vision is to reduce the impacts of hazards on humans as well as economic and natural resources throughout the state.
4. **Regional Plans**: Multi-jurisdictional or regional plans are more cost effective methods of developing hazard mitigation plans. With limited mitigation planning staff at the state level, local plans must remain regionalized to the extent possible.
5. **Plan Implementation:** Localities that are actively implementing plan recommendations have the most urgent need for continuing updates to their mitigation plans. Localities that are actively reducing risk through HMA grants or other funding sources will receive higher priority than those localities or regions that are not.
6. **Recent Disaster (HMGP Only):** The jurisdiction in which a recent disaster declaration has occurred will have a higher priority for receiving funds to revise the hazard mitigation plan than those jurisdictions or regions outside of the impacted area. If the jurisdiction or region impacted already has secured funding for plan revision, then the closest jurisdictions or regions outside of the impacted area that have not secured funding will receive highest priority.
7. **Areas with Repetitive Flood Losses and Severe Repetitive Flood Losses:** Areas with higher numbers of repetitive loss and severe repetitive loss properties are an indicator of repetitive damages. These locations will be targeted for mitigation projects through HMA grants to reduce the amount of insurance claims against the NFIP.
8. **Budget and Scope of Work:** The budget and scope of work are important factors in the national PDM grant review. The state must review the budget and scope of work using similar criteria because VDEM will be managing PDM grants on the state level.

6.4.2 Prioritizing Funding for Local Hazard Mitigation Project Grants

The prioritization for project-related grants has changed in recent years due to limits on applications being lifted for annual grants. Currently, States are allowed to submit as many BRIC and FMA applications as needed for each annual grant cycle and, although there is a priority for the projects that are submitted, VDEM is able to submit all projects that meet grant criteria. The criteria for submitted project requests prioritizes: 1) projects that benefit previously identified vulnerable communities[1]; and 2) project types that are most directly related to the stated grant priorities or criteria. VDEM has focused on promoting or soliciting mitigation project grant requests from our most vulnerable communities using recent HMGP COVID (DR-4512) grant funds and has no plans to alter this practice. VDEM recently hired a contractor to work on building project applications within communities that lack staff and funding to complete the application process alone.

VDEM expects to continue this commitment to assisting the Commonwealth's most vulnerable communities in working together to mitigate threats across the Commonwealth. Project prioritization criteria for any future post-disaster scenarios are expected to also focus on benefitting: 1) vulnerable neighborhoods or areas within affected or declared communities; 2) vulnerable cities and counties, which may be updated or identified through various means; and 3) vulnerable populations or infrastructure that serves vulnerable populations.

6.5 VDEM Technical Assistance

Development and update of local and tribal hazard mitigation plans and DRU plans is supported by 10 all hazard planners from the VDEM Regional Support, East and West Divisions. Each region has one all hazard planner with the exception of Region 7, which has four. Planning technical support may include all or some of the following tasks:

- Participation and presentations for local or tribal meetings and conferences;
- Availability by phone for consultation, trouble-shooting, and technical assistance;
- Development of draft plan outlines for use at local, tribal and regional levels;
- Compilation of hazard data at the state level to supplement data available locally;
- Facilitation of local training workshops for local or tribal plan steering committees, planning agency staff, and DRU staff;
- Detailed review of draft plan sections and final plan prior to submission to FEMA Region III for final approval;
- Provision of support to local jurisdictions, tribes and universities during the plan implementation, monitoring, evaluation, and update process;
- Support of local, tribal, university, agency, and regional contacts in developing HMA applications; and
- Providing assistance in improving local or tribal risk assessment information and providing GIS support as needed or requested.

[1] In 2020, VDEM assessed flood risk and 10 equity factors for all cities and counties to determine the most at-risk populations for flood. Following this, VDEM held a series of workshops with the most vulnerable populations.

6.5.1 Providing Support for Plan Revisions

VDEM mitigation planning staff have been working with regional planners and contractors since 2007 to encourage plan implementation and monitoring, meeting annually to discuss progress on mitigation action items, and providing guidance on obtaining financial support for local hazard mitigation plan revisions. Since FEMA began allowing federally recognized tribal governments to receive their own major disaster declaration for the first time, VDEM has added tribal leaders to their stakeholder lists for local plan development, workshops and stakeholder engagement efforts, or requested that local planners do so as part of the local plan development process. The Act lets tribes apply directly to FEMA for disaster aid. In addition, VDEM all hazards regional planners recommend to local planners that the tribal representatives be invited to participate in regional efforts, either as full participants who adopt the plan, or as stakeholders with adjacent land holding interests.

An interactive Hazard Mitigation Toolkit was developed by VDEM mitigation planning staff and distributed to each of the plan sponsors, beginning in 2007. The toolkit included a combination of FEMA and VDEM planning guidance as well as HMA grant guidance. There were various worksheets, FAQs, and examples to provide the user with a one-stop-shop for local mitigation planning. Update of the toolkit is currently identified as a mitigation action in the Mitigation Strategy of this plan found in Section 5, and VDEM planners are currently working to identify the specific materials to be included in the new toolkit.

VDEM all hazards regional planners attend as many of the planning meetings as possible as each plan goes through the 5-year update process. Local plans contain attendance logs showing which meetings are attended by VDEM planners, including kickoff meetings, advisory or steering level meetings, public sessions, and interactive workshops to develop and modify mitigation actions. These professional planners provide feedback and guidance when processes appear to contradict FEMA guidance, as well as encouragement when committees take laudatory actions that strengthen the process and subsequent plan. They coach the projects through the process, providing feedback along the way and coordinating approvals at the end.

VDEM regional planners play a critical role in ensuring that local and tribal mitigation plans are effectively linked to and integrated with the Commonwealth of Virginia HMP. Their familiarity with and participation in both planning processes and intimate knowledge of planning deadlines, HIRA data sources, and high priority mitigation actions allows them to provide guidance to local and tribal planners on actions and data identified in the state plan. Similarly, their familiarity with local plans allows them to provide effective guidance to the state-level planners regarding the Commonwealth's plan update process, timing, data needs, and mitigation actions. These mutually beneficial communications strengthen plans at both the state and local level, and provide an effective level of plan integration that extends beyond the planning periods of the various plans and into the implementation of the mitigation actions from each of the plans.

As shown in Table 4-1, several local HMPs expired for some time during 2022, including plans for: Northern Virginia, Hampton Roads, George Washington, New River Valley, Richmond-Crater, West Piedmont, Middle Peninsula, and Accomack-Northampton. Similarly, in 2023 the local HMPs for Commonwealth and Northern Neck expired. While the specific details for the planning delays are unique to each PDC, a few prevailing issues contributed to all of the delays. Staff turnover and shortages at VDEM and at the local PDCs (often resulting from COVID-related job market changes) increased workload and combined with restrictions on in-person meetings/training, lowered mitigation planning requirement awareness at the local level. A lack of local or regional funding for mitigation planning has led the PDCs and communities to now fully rely on Federal planning grants for mitigation plan updates. Delayed approval periods for those planning grants, such as the 15 months required for BRIC 2020 funding, reduced the overall time available for plan update execution since work cannot begin on the plans until the funding stream is in place and the scope of work is approved.

VDEM is aware of the potential impacts of expired plans on local communities, including non-eligibility for BRIC and FMA grants, delays in Congressional earmark projects and delays in funding for HMGP projects. The plans are reviewed semi-annually for upcoming expiration. In the last two years, the agency has increased staff (both salaried and contracted) to work with PDCs and communities and is focusing efforts on increased training opportunities for the PDCs, local mitigation planners, stakeholders, and partnering state agencies to raise awareness of the continuing update requirements and the impacts of plan expiration. VDEM planning leadership is committed to more detailed tracking of expiration dates and focused provision of assistance to the PDCs in obtaining timely grants, contracting the work, and developing suitable timetables for execution of the updates. These combined efforts are expected to contribute to on-time updates and adoptions for subsequent planning cycles.

6.5.2 Local hazard mitigation planning workshops

VDEM Training Education, and Exercise Division hosts an average of two mitigation planning workshops a year across the Commonwealth. The G-393 course is a revision of the G-318 course, which now focuses more on the emergency manager's role in hazard mitigation. The course is designed to enable the non-technical emergency worker to acquire skills in the use of mitigation. It provides training in how to perform mitigation activities fundamental to reducing and eliminating long-term risk from hazards. It also addresses the important roles of the emergency program manager (or other local government representative) in mitigation: motivator, coordinator, and monitor in local implementation of the National Mitigation Strategy.

Between 2013 and 2017, the following training sessions were offered in the Commonwealth:

G393 - Mitigation for Emergency Managers

- October 2013 – Town of Marion (Smyth County)

- May 2014 – City of Newport News
- May 2014 – Prince William County
- December 2015 – Fairfax County
- August 2017 – Henrico County

Since 2017, VDEM has offered the following courses and workshops to facilitate local planning and plan implementation; attendance records are provided in Appendix G as additional documentation of the assistance provided by these recent workshops:

G393: Mitigation for Emergency Managers, twice in 2018. (February – Salem, July – Newport News) Participants were required to bring a copy of their community's mitigation plan to class, if available. If the jurisdiction did not have a mitigation plan, or the plan was incomplete, the participant was advised to bring the community's hazard analysis or any other parts of the plan that may be completed.

Hazard Mitigation Assistance Application Process Webinar, three times in 2018. (Virtual) This one-hour webinar provided an overview of the HMA application process. Participants were instructed how to complete the VDEM HMA Application. Local government officials and state agency personnel interested in applying for hazard mitigation assistance grants were encouraged to enroll.

Hazard Mitigation Assistance Pre-Application Process Webinar, three times in 2018. (Virtual) This one-hour webinar provided an overview of the HMA pre-application process. Participants were instructed how to complete the VDEM Hazard Mitigation Assistance Pre-Application form. Local government officials and state agency personnel interested in applying for hazard mitigation assistance grants were also encouraged to enroll.

E0276 Mitigation Benefit-Cost Analysis (BCA), once in 2018. (Richmond) This two-day course introduced participants to the fundamental concepts and tools used to complete a Benefit-Cost Analysis (BCA), which calculates a Benefit-Cost Ratio (BCR). A favorable BCR of 1.0 or higher is necessary for hazard mitigation projects to be deemed cost-effective and therefore eligible for grant funding. To assist in assessing cost-effectiveness, FEMA has developed software modules and guidance for conducting a BCA for proposed projects. This course applies to and is valid for all FEMA HMA grant programs.

G329 State Hazard Mitigation Plan Update for Virginia, once in September 2021. (Richmond) This 1-day (8 hour) course helped prepare state agencies, stakeholders, and other members of the SHMWG for this plan's 2023 update. The course condensed the essentials of the L329 (State Hazard Mitigation Planning) course and included a discussion on areas of focus, expanding planning team and stakeholder collaboration, new planning guidance, and Enhanced

State Hazard Mitigation Planning considerations. This course helped prepare both new participants to the planning process and returning team members and was interactive.

Planning Implementation and Grant Development Workshops (PIG-Ds), July 25-26, 2022. These workshops were offered in VDEM Region 4 for three PDCs: Cumberland Plateau, LENOWISCO, and Mount Rogers.

Hazard Mitigation Assistance Stakeholder Workshop, August 20, 2020. VDEM hosted a 3-hour virtual workshop. The objectives were to 1) provide stakeholders with the grant overview and grant evaluation process; 2) conduct open discussion of grant topics; and 3) refine project peer review scoring criteria. Approximately 62 participants representing multi-disciplinary stakeholders across the Commonwealth attended the workshop. Invited participants included at least two emergency managers, two non-emergency managers, one planning district commission, and one VDEM planner from each region. The results of the workshop reflect the values, judgment and experience of the stakeholders and was marked by energetic and engaged input from the participants.

6.5.3 State Review of Local and Tribal Hazard Mitigation Plans

VDEM all hazards regional planners continue to assist with regular updates of the local, DRU and tribal hazard mitigation plans, serving as a technical reviewer for plans that must go to FEMA for review and approval. VDEM policy does not allow planners to approve or submit a plan to FEMA for review and approval unless they have determined that the plan and all attachments meet the FEMA and VDEM local hazard mitigation planning requirements.

Early in the planning process, VDEM regional planners request a minimum of 30 days be built into the project schedule to accommodate their review of local or tribal hazard mitigation plans and provide comments. Once the draft is complete, PDCs, universities or tribes submit their plan to VDEM along with a request for review and approval, and subsequent submittal to FEMA. The VDEM regional planners then use the FEMA Plan Review Tool as a guide for their review. Some comments may require revisions and the project schedule should allot at least a week for this. Planners will usually meet with or have a call with the PDC, tribe or university to discuss the required revisions on the plan review tool, and any suggestions that are not required. Suggested revisions may include grammatical changes or suggestions to consider for the next plan update in 5 years.

Once the planners determine the plan meets the requisite standards, they will prepare it for submittal to FEMA. These reviewers provide one electronic copy, one hard copy, and a copy of the plan review tool to FEMA, and include a letter of endorsement from the State Hazard Mitigation Officer to the FEMA Regional 3 Regional Administrator.

VDEM has specific quality control internal requirements for all local and VDEM-involved tribal hazard mitigation plans. In order to be approved by VDEM, the plans must meet all local plan requirements of DMA 2K and specifically must include:

- current floodplain maps for the study area;
- maps showing geographic variability in risk for any hazard ranked “high”;
- a local capability assessment; and,
- a repetitive flood loss strategy for any areas that have repetitive flood losses.

6.5.4 Tribal Capabilities

Table 6-4 provides a summary of tribal hazard mitigation capabilities for State- and federally-recognized tribes in Virginia. The status of individual tribes’ emergency management and hazard mitigation programs is generally unknown to VDEM and other State representatives. In some cases, it is not very well understood. The table was created from a VDEM survey sent to VDEM Regional Staff as part of the planning process; tribes not shown in Table 6-4 have no known mitigation capabilities and almost no communications with VDEM to date.

Communications with tribal representatives and their leaders have typically focused on publication distribution, invitations to participate in jurisdictional hazard mitigation and planning activities/training, and requests for assistance or guidance from VDEM. At this time, working relationships between the tribes and VDEM regional staff are not as effective as they will be in the future. Local Emergency Managers from jurisdictions adjacent to the tribal lands have, in some cases, taken responsibility for coordinating with the tribes within their jurisdictional footprint on response and mitigation efforts. Some VDEM regional planners rely on these relationships for information and updates they receive regarding tribal capabilities.

Table 6-4 - Virginia's Tribal Hazard Mitigation Capabilities

Tribe	Mitigation Capabilities	Effectiveness of Existing Capabilities	Capability Shortfalls	Process/Timeframe for Submitting HMP to VDEM & FEMA	Frequency of Tribal Communications	Additional Notes
Patawomeck	Undetermined	Undetermined	No working relationship between tribe and VDEM Region 7 staff	No tribal plans have been submitted to date.	Never	VDEM is exploring possibility of coordinating with Stafford County OEM to establish communication pathways based on any previous contact or working relationships at the local level.
Nansemond	Current job posting for Environmental Coordinator	Undetermined	No hazard mitigation plan for tribe	No tribal plans have been submitted to date.	Undetermined	Job posting description includes activities that align with hazard mitigation concepts
Nottaway	Undetermined	Undetermined	No hazard mitigation plan for tribe	No tribal plans have been submitted to date.	Undetermined	Tribal lands are 263 acres, including border along US 58 and a small waterway.
Pamunkey, Headwaters Casino in Norfolk	Undetermined	Undetermined	Unknown hazard planning for HeadWaters Casino	No tribal plans have been submitted to date.	As needed	Tribal leaders receive a weekly newsletter from VDEM Region I staff and reach out for assistance as needed. Casino is due to open their interim location in March 2023.
Pamunkey	Undetermined	Undetermined	Undetermined	The Pamunkey Tribe's Addendum to the Middle Peninsula Planning District Commission's Regional All-Hazards Mitigation Plan was reviewed and approved by VDEM Regional Planners and FEMA	Weekly and as needed	Tribal leaders receive a weekly newsletter from VDEM Region I staff and reach out for assistance as needed.
Upper Mattaponi	Full-time Emergency Coordinator	Undetermined	Undetermined	The Upper Mattaponi Indian Tribe's participation in the Middle Peninsula Planning District Commission's Regional All-Hazards Mitigation Plan was reviewed and approved by VDEM Regional Planners and FEMA	Weekly, and as needed	Tribal leaders receive a weekly newsletter from VDEM Region I, attend some regional meetings and reach out for assistance as needed.
Chickahominy	Hired a contractor to write some disaster-related plan, including HM plan	Undetermined	Undetermined	Plan was reviewed & approved by VDEM Region 1's All-Hazards Planner and FEMA in 2022.	Weekly, and as needed	Tribal leaders receive a weekly newsletter from VDEM Region I staff and reach out for assistance as needed.

Chickahominy Tribe – Eastern Division	Undetermined	Undetermined	Undetermined	No tribal plans have been submitted to date.	Weekly, and as needed	Tribal leaders receive a weekly newsletter from VDEM Region I staff and reach out for assistance as needed.
Rappahannock	Have a full-time Emergency Coordinator and a Tribal Center that may be used as a shelter.	Undetermined	Communications with local EOCs with tribal members reside, and a lack of staffing support	The Rappahannock Tribe's participation in the Middle Peninsula Planning District Commission's Regional All-Hazards Mitigation Plan was reviewed and approved by VDEM Regional Planners and FEMA	Weekly, and as needed	Tribal leaders receive a weekly newsletter from VDEM Region I, attend some regional meetings and reach out for assistance as needed.

In recognition of these and other equity challenges in the Commonwealth, in 2021 VDEM created and staffed an Office of Diversity, Opportunity, and Inclusion (ODOI) to thread diversity, inclusion, and accessibility principles into communications, interactions and other interfaces with vulnerable communities that are disproportionately impacted during disasters, including tribes. The ODOI serves two functions within the agency: 1) assist VDEM regions and localities in providing access and resources to every individual, regardless of possible barriers to access or ability; and 2) internally assist the agency to build diversity, inclusion, and accessibility principles throughout every function of the agency.

ODOI serves the Commonwealth's vulnerable communities and tribes throughout all five phases of emergency management. Using a data-driven approach, the office connects with external stakeholders to aid the work of agency partners at the federal, state, tribal, and regional levels. This is demonstrated in ODOI's emphasis on regional staff and the work of local and tribal Emergency Managers. Special emphasis is placed by the agency on sharing resources, and information, with federally recognized tribes. Additionally, ODOI acts as an agency representative when invited into the spaces of disproportionately impacted communities, such as the Sovereign Nations of Virginia Conference and the NAACP Hurricane Presentation. VDEM Regional Staff support ODOI's efforts and outreach through the annual Sovereign Nations of Virginia Conference.

VDEM recognizes that there are areas for improvement in the agency's understanding and knowledge of tribal capabilities and expects ODOI, in conjunction with VDEM Regional Staff, to be able to facilitate appropriate communications, training opportunities, planning assistance, and mitigation project assistance to the tribes throughout Virginia as our relationships mature. The process of improving the relationship between VDEM and the tribes must be approached thoughtfully, with the tribes' best interests, concerns, and consultation as a high priority. Thus, ODOI, in conjunction with VDEM Regional Staff, will continue to purposefully work to develop trust, understanding, knowledge and capacity among tribal leaders with regard to mitigation capabilities over the coming months and years. Mitigation Action MH-29 provides additional information regarding how the VHMWG and other stakeholders expect to address these capability gaps.

Endnotes

[i] Thomas, Dave. FEMA Region III, personal communication, July 8, 2003.

Contents

7.1 2023 Update

This section was updated to reflect and document current VDEM programmatic standards reflective of the Enhanced Plan requirements at 44 CFR 201.5(b). New data resulting from a 2022 Loss Avoidance Study was included. Some subsections were reorganized.

7.2 Compliance with Standard Plan Requirements

The *2023 Commonwealth of Virginia Hazard Mitigation Plan* meets all the Standard State Mitigation Plan requirements as set forth in 44 CFR 201.4. The enhanced pre-disaster planning efforts documented in this chapter directly support state and local governments' efforts to articulate accurate, targeted, and prioritized needs for hazard mitigation that will reduce exposure to natural and human-caused hazards. These planning efforts will result in timely allocation of funding and more effective risk reduction strategies and projects.

7.3 Integrated Planning (201.5(b)(1))

A comprehensive hazard mitigation program at the state level is more effective if it has been integrated into the multiple arenas of state government planning. The state hazard mitigation program has been integrated into and throughout other state planning processes through the following:

- All 20 multi-jurisdictional hazard mitigation plans in the Commonwealth were integrated into this update including the HIRA, capability assessment, goals, and strategies. Furthermore, VDEM verifies that each of these plans incorporates other local and regional planning processes into their planning efforts, including comprehensive plans, capital improvement plans, emergency operations plan, regional transportation plans, and others.
- Several local Emergency Managers and hazard planners were invited to participate in the Commonwealth's hazard mitigation planning through the VHMAC and VHMWG.
- VDEM staff sit on the Chowan River Basin Technical Advisory Committee, which was set up through the USACE to improve the warning capabilities and data collection for flooding events within the river basin. Flooding within this basin was responsible for the severe damages in the City of Franklin and elsewhere after Hurricane Floyd (VA-DR-1293).
- The VDEM State Hazard Mitigation Officer and Flood Mitigation and Resilience Coordinator serve on the Virginia Silver Jackets Team.
- Localities involved in hazard mitigation planning, emergency operation planning, COOP planning, and disaster recovery planning are assisted by VDEM planners in order to ensure integration of hazard mitigation plan risk assessment results into local plans.
- This updated hazard mitigation plan and data produced from the risk assessment will be made available for integration into other state plans as well as local hazard mitigation plan updates.
- VDEM staff collaborate with state, local, and federal disability partners to form the Access and Functional Needs Advisory Committee. This committee was created to ensure state planning efforts meet the needs of individuals with disabilities and access and functional needs during disasters. The committee uses lessons learned from disasters in other states to improve Virginia's plans.

- The scenarios included in the state Threat Hazard Identification and Risk Assessment (THIRA) and Commonwealth THIRA (C-THIRA) are derived from the HIRA in Chapter 3 of this document. Similarly, the threats identified in Appendix D reflect updates and changes to the THIRA and C-THIRA in intervening years.
- Recent collaborative efforts including the VEST, the Fusion Center, the Virginia Coastal Policy Team, and the *Virginia Coastal Resilience Master Plan*, as described in Chapter 4, represent efforts that cross agency lines to maximize the strengths of individual agencies in working together to realize mutually beneficial multi-hazard mitigation initiatives.

7.4 Project Implementation Capability (201.5(b)(2))

FEMA's HMA program is comprised of three programs that provide funding and assistance to eligible natural hazard mitigation projects and planning efforts: BRIC (previously PDM), FMA, and the post-disaster HMGP. These programs are governed by criteria described in FEMA's *Unified Hazard Mitigation Program Guidance,* which is published and maintained by FEMA. The guidance describes the requirements for feasibility, benefit-cost analysis, and the environmental and historic preservation review process, as well as other eligibility criteria.

Proposed hazard mitigation project applications are submitted to the Commonwealth and FEMA based on the process established in VDEM's Administrative Plan, included in Appendix H. The following detailed procedures supplement the plan and indicate an adherence to regulations and successful implementation.

7.4.1 Pre-Application Procedures

Potential applicants must submit a grant pre-application within the designated timeframe determined by the State Hazard Mitigation Officer. The pre-application notifies VDEM of the applicant's interest, and identifies the primary and authorized contacts to administer the grant program. The deadline for notification of interest will be set by the SHMO and published at the briefing. The applicants must submit a completed HMGP pre-application form as notification. The time limitation may be extended by the SHMO when justified and requested in writing by the applicant.

Upon receipt of the above-mentioned forms, the SHMO, in coordination with VDEM Hazard Mitigation Grant Administrators (GAs), will perform eligibility reviews and will notify potential applicants in writing of their eligibility findings. Applicants whose pre-applications were deemed eligible receive a notification of eligibility with instructions on how to apply, with other pertinent application requirements. Applicants whose pre-applications were determined ineligible are offered technical assistance/advice regarding how to achieve program eligibility (if applicable).

7.4.2 Application Procedures

Below are the application procedures VDEM follows for each funding cycle or opportunity:

1. The SHMO has the primary responsibility for ensuring that all applications are properly completed.
2. The date for submission of the application is established by the SHMO. Applicants have at least 60 days following receipt of the SHMO stating their eligibility. The SHMO may give extensions upon written request.
3. Upon receipt of a project application, the SHMO and Hazard Mitigation GAs assign a Project Identification Number (PIN) to each application. The PIN consists of the FEMA disaster number, the Federal Identification Processing System (FIPS) Code, and a project number.
4. The SHMO consults with appropriate state agency representatives on the State Hazard Mitigation Advisory Committee to review each application for eligibility in accordance with applicable regulations of the funding program. The SHMO and Hazard Mitigation GAs are responsible for requesting any additional information necessary to make the determination and for notifying applicants of ineligible projects or proposed project status. An example of this would be to consult with VDOT to ensure that no future development is planned for a property that is being acquired and demolished.
5. When several eligible projects compete for limited funding, applications submitted to FEMA will be made in accordance with priorities established in the Mitigation Strategy and by the VHMAC.
6. A stakeholder engagement process was introduced in 2017 for the PDM/FMA and HMGP 4291 grant cycles. Stakeholders help assign weights to scoring criteria for the established priorities. This is followed by a peer review process, which will continue for future funding cycles.
7. The SHMO is responsible for preparing a complete application, signed by the GAR, which must include a Standard Form (SF) 424, Application for Federal Assistance, and SF 424D, Assurances for Construction Programs (if appropriate), and a narrative statement to support the package transmitted to FEMA.
8. The application may be amended by VDEM to include measures identified after the initial application. All supplements identifying new mitigation measures to the application must be made within 90 days of FEMA approval of the Section 322 Mitigation Plan and must contain information as noted in section H.1 of the Administrative Plan.
9. The SHMO and GAs will establish contact with all Sub-recipient's Authorized Representatives and provide technical assistance and project management overview to the Sub-recipients for the duration of the project. Technical expertise and guidance can be

obtained through the SHMO, State Hazard Mitigation Committee, and Hazard Mitigation GAs.

10. Time limitations on applications may be extended by the FEMA Regional Administrator when justified and requested in writing by the GAR.
11. The SHMO will notify the applicants and other appropriate parties of funding requests.

7.4.3 Eligibility Determination Criteria for Multi-Hazard Mitigation Measures (201.5(b)(2)(i))

The SHMO and GAs will determine eligibility of the applicant and verify that minimum program requirements are met by ensuring that each application contains:

1. A reference to the specific section of the Commonwealth's Hazard Mitigation Plan to which the proposed project relates.
2. A narrative describing how the project benefits the designated disaster area (HMGP Only), or how the project reduces risk to future hazards.
3. A completed environmental and historic review as required by FEMA (per 44 CFR, 206.437 (b) (4)(iv)), using guidelines and input established by FEMA, EPA, Virginia DHR, Virginia DEQ, and other agencies as appropriate, and in all cases of mitigation of structures more than 50 years of age.
4. NFIP participation requirement and compliance with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands.
5. Information sufficient to determine the extent to which the project will solve the problem it is intended to address and the status of any associated dependent or supporting projects.
6. Applicant should document compliance with all applicable federal, state, and local codes, including:
   i. A brief history of previous occurrences of the problem the project addresses, including dates and impact of each occurrence or an analysis of projected potential damages if the hazard is not addressed.
   ii. Documentation comparing the proposed project and a listing of influencing factors.
   iii. An estimate of the effective life of the project and a listing of influencing factors.
   iv. An analysis of any pertinent demographic and physical changes to the area or facility to be protected by the project and description of any future maintenance or modifications the project may involve.
   v. A cost analysis to determine whether the benefits to be gained are at least equal to if not greater than the cost of the project, as well as the following points:
      1. Addresses a problem that has been repetitive or one that poses a significant risk to the community if left unresolved

2. Will not cost more than the anticipated value of the reduction in both direct damages and subsequent negative impacts to the area if future disasters were to occur.
3. Is the most practical, effective, and environmentally sound alternative after consideration of a range of alternatives and has the greatest potential impact on reducing future disaster losses.
4. Contributes to a permanent or long-term solution to the problem it is intended to address.
5. Solves a problem independently or constitutes a functional portion of the solution where there is assurance that the project, as a whole, will be completed.

7.4.4 Project Selection Criteria (201.5(b)(2)(i))

If it is necessary to select from a range of projects due to funding or other constraints, the SHMO, in consultation with the VHMAC using the Commonwealth's Hazard Mitigation Plan, will evaluate and prioritize all eligible applications. A stakeholder group with representation of all VDEM regions will be convened to assign weights to scoring criteria to meet the priorities. For HMGP, this ranking will be in accordance with the mitigation strategy established for the disaster and criteria in 44 CFR Sections 206.434(b) and 206.435(b) and (c) as follows:

1. Measures that best fit within an overall plan for development and/or hazard mitigation in the community, disaster area, or state.
2. Measures that, if not taken, will have a detrimental impact on the applicant, such as potential loss of life, loss of essential services, damage to critical facilities, or economic hardship on the community.
3. Measures that have the greatest potential impact on reducing future disaster losses.
4. Measures that are designed to accomplish multiple objectives, including damage reduction, environmental enhancement, and economic recovery.

The SHMO and VHMAC will take into consideration optimizing the total amount of funding available, including overmatching of federal funds with nonfederal funds, when developing this ranking. The SHMO and VHMAC will also consider the level of interest and demonstrated degree of commitment of each applicant when making final project funding selections.

7.4.5 Benefit Cost Analysis for Hazard Mitigation Projects (201.5(b)(2)(ii))

A project must not cost more than the anticipated value of the reduction in both direct damages and subsequent negative impacts to the area if future disasters were to occur. FEMA's Benefit-Cost Analysis (BCA) software program is used to determine the cost-effectiveness of proposed mitigation projects for FEMA's mitigation grant programs. A BCA evaluates the future benefits (projected losses avoided) of a project in relation to its cost. The BCA evaluation results in a benefit-cost ratio (BCR). If the future benefits are equal to or greater than the project cost, then the BCR is equal to or greater than 1.0 and the proposed project is considered cost effective. If the benefits are less than the cost, then the BCR is less than 1.0, and the proposed project is not considered cost effective. Only projects that demonstrate a BCR of 1.0 or greater are considered for HMA funding.

OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* is the basis for the FEMA BCA. The goal of this Circular is to promote efficient resource allocation through well-informed decision-making by the Federal Government. It provides general guidance for conducting benefit-cost and cost-effectiveness analyses. It also provides specific guidance on the discount rates to be used in evaluating Federal programs whose benefits and costs are distributed over time. The general guidance serves as a checklist of whether an agency has considered and properly dealt with all the elements for sound benefit-cost and cost-effectiveness analyses.[1]

FEMA has developed software, written materials, and training to support the effort and assist with estimating the expected future benefits over the useful life of a retrofit project. The current version is FEMA BCA V6.0, available online for download at: https://www.fema.gov/grants/tools/benefit-cost-analysis.

Eligible applicants must submit a BCA with the project application. The BCA must be accompanied by supporting documentation and a completed data documentation template. The data needed to complete the BCA will vary with the project type and the module selected, but each BCA requires the following general data points:

- Type of mitigation to be implemented;
- Project cost;
- Maintenance cost; and
- Useful life of the project.

In 2013, FEMA released the Environmental Benefits Policy regarding BCAs. FEMA allowed for the use of environmental benefits in acquisition projects only and if the project had a 0.75 benefit cost ratio (BCR) prior to the use of the benefits. In 2016, FEMA released an expanded policy clarification changing the name environmental benefits to ecosystem service benefits and those benefits could be used for all risk reduction projects that enhanced the natural environment. The mitigation project was still required to have a BCR of 0.75 or greater before ecosystem benefits could be included. The ecosystem benefits supported risk reduction through erosion control, air quality, recreation space, and water filtration. In September 2020, FEMA released an updated policy that removed the BCR threshold of 0.75 and listed all HMA grant programs as eligible programs to use the ecosystem benefits.

FEMA also released streamlined BCA guidance for projects that acquire or elevate private property within the SFHA. FEMA's Risk Reduction Division completed an analysis of 11,000 elevation and acquisition projects and determined that the average benefits for each type of project were $175,000 and $276,000, respectively. FEMA also determined that acquisition or elevation of a structure located in an SFHA (as delineated on the FIRM or based on best available data) that costs less than or equal to these amounts can be considered cost-effective with no further analysis required. In a memorandum dated September 29, 2021, those benefit values were updated to $323,000 per structure for acquisitions and $205,000 per structure for elevations and mitigation reconstruction.[2]

The SHMO and Hazard Mitigation GAs are experienced and skilled at performing BCAs for hundreds of residential acquisition and demolition, elevation, and mitigation reconstruction projects. In addition, BCAs have been performed for successfully funded projects related to drainage improvement and soil stabilization projects.

7.5 Mitigation Program Management Capability (201.5(b)(2)(iii))

All program management is handled by VDEM. The Commonwealth, as the Recipient, has primary responsibility for management and accountability of funds as indicated in 2 CFR 200 and for ensuring that all program and administrative requirements are met as indicated in 2 CFR 200, 44 CFR Part 206 and the *HMA Unified Guidance* as applicable to HMA projects.

7.5.1 Payments and Performance Period

Payment of funds to the Recipient or Sub-recipient for any HMA grant is through a reimbursement process, with the rare and occasional exception of advance payments (as allowed under 2 CFR 200.3 and per 44 CFR 206.437(b)(4)(vi), when determined to be required and necessary for the project to proceed). All reimbursement requests will be handled in a timely and effective manner in accordance with 2 CFR 200.305.

The initial Period of Performance for all HMA Grants is typically no more than three years. VDEM Hazard Mitigation GAs will notify the sub-recipients in writing within 90 days in advance of the period of performance end date. If an extension is required, requests must be received in writing by VDEM within 75 days of project termination date with reasons for requested time of performance extension and a revised milestone table. The request must include:

1. Federal Project Identification Number;
2. Reason(s) for the delay;

3. Original scheduled completion date;
4. New scheduled completion date, including milestones; and
5. Dates and provisions of any previous extensions.

Requests for extensions will be forwarded to FEMA, along with the GAR's recommendation, at least 60 days prior to the end of the project performance period. If an additional extension is required, a request will be forwarded to FEMA along with the GAR's recommendation at least 60 days prior to the end of the extended period of performance period.

7.5.2 Progress Reports

The Sub-recipient will provide VDEM with quarterly reports and a final report on the progress of work set forth in the Scope of Work. The quarterly reports and final report shall contain the following components:

1. A narrative describing in detail the progress of the Sub-recipient in fulfilling the provisions of the Scope of Work;
2. Reimbursement requests (per 206.437(b)(4)) as needed which itemize the expenses incurred by the Sub-recipient, including separate columns for the federal, state and the Sub-recipient's matching contribution to the total cost of services as reflected in the approved project budget; and
3. The schedule of specific project tasks with target completion dates and actual completion dates. The first quarterly report is due to VDEM at the end of the first complete quarter following the award of the grant.

Sub-recipients must submit quarterly reports to VDEM on the following schedule:

- Quarter 1 (October 01-December 31) – no later than January 15th
- Quarter 2 (January 01-March 31) – no later than April15th
- Quarter 3 (April 01-June 30) – no later than July 15th
- Quarter 4 (July 01-September 30) – no later than October 15th

Sub-recipient quarterly reports for all active, approved projects will be used by VDEM to compile the required progress reports for FEMA. This report will be submitted to the FEMA Project Officer no later than the last day of the month immediately following each federal fiscal quarter, in compliance with the federal audit requirements described in 2 CFR 200.328.

7.5.3 Scope of Work Changes

The Sub-recipient must notify the GAR of any perceived changes to the original scope of work. The written notification must include:

1. Federal HMGP Project Identification Number;
2. Reason(s) for the change with appropriate justification and any relevant documentation: e.g., photographs, standards, etc.;
3. Estimate of the change in cost and referencing the original budget;
4. Original schedule and completion date; and
5. New projected schedule and completion date.

The GAR will evaluate the proposed change(s) and, if necessary, ask FEMA to perform a technical engineering review. The change request and GAR's recommendation will be submitted to FEMA after evaluation of all available information. If FEMA's engineering expertise is required, the GAR will defer recommendation to that agency.

7.5.4 Cost Overruns

When the actual cost of a project exceeds the estimated project cost approved in the application, the Sub-recipient may request additional funding to cover the cost overrun. This request must be submitted to the GAR in writing and must provide justification for the increased funding.

Cost overrun requests are evaluated by the GAR. Those cost overruns that can be met with available federal funds, or that can be met by offsetting cost under runs on other projects (HMGP only), may require approval of FEMA if the full scope of work on all affected projects can still be accomplished. Requests that are not justified will be denied by the GAR.

For justified cost overrun that exceed previous federal obligations and require additional federal funds, the GAR will submit a request with a recommendation to the FEMA Region III Administrator for a determination. The Sub-recipient's request and justification will accompany the GAR's request. Cost overruns require a new BCA to demonstrate that the project remains cost-effective at the increased price. All cost overruns must be recorded on the quarterly report.

7.5.5 Duplication of Benefits

VDEM Mitigation staff will work with both FEMA and Sub-recipients to identify and document any possible duplication of benefits concerns. If any are discovered, care will be taken to ensure that there are no inappropriate reimbursements that will create a situation where funds must be returned. If duplication is discovered after a project is completed, VDEM will work with FEMA to recover those funds.

7.5.6 Appeals

The Recipient may appeal any determination made related to federal assistance. Sub-recipients may file, with the Recipient, an appeal of any determination made related to federal assistance. Appeals file by Sub-recipients must be in writing and supported by sufficient documentation (new and compelling information), providing a justification to allow the GAR to make a validity determination on the first appeal. If the Sub-recipient's appeal is found valid after review by the SHMO and the GAR, the appeal will be processed and forwarded to FEMA for review and determination.

If the SHMO, GAR, or FEMA deny the appeal, the actions outlined above apply to any second appeal filed. The second appeal must include new or expanded information to support the need for a second appeal. The second appeal must be made within 60 days of the decisions being appealed. The decision on the second appeal, whether made by the SHMO, GAR, or FEMA, is final.

7.5.7 Compliance Monitoring

As projects are identified 'complete' either through contact with the Sub-recipient, review of quarterly reports, or site visits, VDEM Mitigation GAs prepare a Local Financial Reconciliation Form to help the Sub-recipient prepare for the state's final site visit. Within this form, the Sub-recipient is asked to verify receipt of funds and expenditure of non-federal match. Concurrent with sending out the Local Financial Reconciliation Form, VDEM schedules the final site visit with the locality.

The site visit includes a site inspection for mitigation program compliance, a review of financial records, and a review of programmatic records. VDEM staff take digital pictures of each mitigation project structure during the visit and any other relevant areas that will be benefited by the mitigation project. Documents gathered during the site visit, if not previously submitted to VDEM, include:

1. Digital photographs of mitigated structures, infrastructure, affected area;
2. Signed verification of financial reconciliation between VDEM and the Sub-recipient;
3. Latitude and longitude of the project area;
4. Documents produced as defined within the Scope of Work;
5. National Flood Insurance Program policy verification;
6. Elevation certificate(s);
7. Copies of deeds and restrictions on those deeds; and
8. Other pertinent documents or information.

All acquisition projects will be monitored every three (3) years to ensure the integrity of the 'open space in perpetuity' provisions of 44 CFR, Part 80.19.

7.6 Effective Use of Available Mitigation Funding (201.5(b)(3))

Funds to implement mitigation projects may come from a variety of sources – federal and state governments, private sector, foundations, insurance, and property owners. The funding is often in the form of grants but may be loans or in-kind contributions. Most mitigation funds used in the Commonwealth originate with FEMA's mitigation assistance programs – BRIC, PDM, FMA, and HMGP. Table 7-1 provides an overview of the amount and status of funding provided to the Commonwealth by FEMA or by the Commonwealth to local partners between 2011 and 2022. The table also provides the amount of funding the local sub-recipient and the Commonwealth contributed to the projects. When funding is available, the Commonwealth – through VDEM – contributes up to 20% of the non-federal portion of the project's cost under the HMGP program, resulting in a local cost share of approximately 5% of the total project cost.

Table 7-1 - Mitigation Spending in Virginia (2011-2022)

Funding Source	Project Type	Federal Obligated	State Obligated	Local Obligated	Total Obligated
HMGP (DR-1874, December 2009 Winter Storm)	Structural elevations, planning, drainage improvements, generators Elevation, Acquisition, Drainage Improvements, Planning, and Generators	$4,433,630	$1,142,661	$335,214	$5,911,505
HMGP (DR-1905, February 2010 Winter Storm)	Elevation, Acquisition, Drainage Improvements, Planning, and Generators	$4,181,065	$1,043,525	$404,408	$5,628,998
HMGP (DR-4024, August 2011 Hurricane Irene)	Elevation, Acquisitions, Drainage Improvements, Outreach, Planning, and Generators	$6,324,377	$1,691,532	$661,071	$8,676,980
HMGP (DR-4042, August 2011 Earthquake)	Elevation, Acquisition, Drainage Improvements, Warning Sirens, Planning, and Generators	$6,372,244	$1,584,531	$544,209	$8,500,985
HMGP (DR-4045, August 2011 Tropical Storm Lee)	Elevation	$842,149	$224,573	$56,143	$1,122,865
HMGP (DR-4072, June 2011 Derecho)	Elevation, Generators, Warning Systems	$2,329,986	$621,330	$155,332	$3,106,648
HMGP (DR-4092, October 2012 Hurricane Sandy)	Elevation, Acquisition, and Generators	$1,483,214	$395,524	$98,881	$1,977,618
SRL 2011	Mitigation reconstruction	$110,450	--	$11,045	$121,495
SRL 2011	Mitigation reconstruction	$110,450	--	$11,045	$121,495
FMA 2013	Elevation and Acquisition	$7,153,937	$0	$49,739	$7,203,676
PDM 2013	Planning	$175,310	$0	$58,437	$233,746
FMA 2014	Elevation and Acquisition	$2,346,773	$0	$18,153	$2,364,926
PDM 2014	Acquisition and Planning	$588,803	$0	$101,244	$683,576
FMA 2015	Elevation and Acquisition	$2,824,306	$0	$0	$2,824,306
PDM 2015	Elevation and Generators	$845,947	$37,500	$246,328	$1,129,774
FMA 2016	Elevation and Acquisition	$8,270,835	$16,667	$94,550	$8,382,052
PDM 2016	Planning	$490,256	$62,500	$100,919	$653,675
PDM 2017	Planning and Elevation	$640,649	$0	$584,900	$1,225,548
FMA 2017	Elevation and Acquisition	$1,756,940	$0	$40,698	$1,797,638
PDM 2018	Planning and Stream Restoration for a Pump Station	$9,109,772	$0	$3,036,591	$12,146,362
FMA 2018	Elevation, Mitigation Reconstruction, Acquisition, and Planning	$6,059,945	$12,500	$505,809	$6,578,254
PDM 2019	Acquisition, Planning, Stormwater Management, Water Storage, and Generators	$20,401,174	$75,000	$73,617,790	$94,093,964
FMA 2019	Elevation, Mitigation Reconstruction, Acquisition, and Drainage for a Pump Station	$12,625,276	$0	$2,741,320	$15,366,596
FMA 2020	Elevation, Acquisition, and Scoping	$2,866,180	$0	$199,823	$3,066,003
PDM 2022 – Congressional Directive	Planning and Stormwater Management	$1,700,000	$0	$566,667	$2,266,667

Funding Source	Project Type	Federal Obligated	State Obligated	Local Obligated	Total Obligated
BRIC 2020	Planning	$234,069	$0	$78,023	$312,092
BRIC 2020	Capacity and Capability Projects	$600,000	$26,880	$147,780	$774,660
HMGP (DR-4262, 2016 Winter Snow Storms)	Elevation, Acquisition, Soil Stabilization, Planning, and Generators	$7,440,330	$1,993,088	$487,020	$9,920,438
HMGP (DR-4291, 2016 Hurricane Matthew)	Elevation, Acquisition, Planning and Generators	$3,624,940	$972,038	$269,327	$4,866,305
HMGP (DR-4401, 2018 Hurricane Florence)	Elevation, Acquisition, Planning and Generators	$3,926,216	$1,046,991	$487,745	$5,460,951
HMGP (DR-4411, 2018 Tropical Storm Michael)	Elevation, Acquisition, Planning, Stormwater Management, and Generators	$4,200,374	$974,100	$485,393	$5,659,867
HMGP (DR-4602, February 2021 Winter Storm)	Advanced Assistance	$93,750	$0	$31,250	$125,000
HMGP (DR-4512, COVID-19)	Acquisition	$828,216	$92,024	$0	$920,240
HHPD 2019	HHPD – Harwood Mill Dam	$95,744	$177,810	$0	$273,554
HHPD 2020	HHPD – Harwood Mill Dam	$87,987	$163,402	$0	$251,389
Dam Safety, Flood Prevention and Protection Assistance Fund (DSFPPAF) 2017	Dam Safety, Flood Prevention	$0	$4,732,251	$2,366,126*	$25,732,818
DSFPPAF 2018	Dam Safety, Flood Prevention	$0	$1,086,768	$543,384*	$5,363,822
DSFPPAF 2019	Dam Safety, Flood Prevention	$0	$5,668,615	$284,308*	$18,989,847
DSFPPAF 2020	Dam Safety, Flood Prevention	$0	$530,130	$265,065*	$1,291,381
DSFPPAF 2021	Dam Safety, Flood Prevention	$0	$402,007	$201,004*	$1,356,354
Community Flood Preparedness Fund (CFPF) 2021 - Round 1	Flood prevention and protection, planning, capacity building, hybrid	$0	$7,737,865	$4,114,815	$11,852,680
CFPF 2021 - Round 2	Flood prevention and protection, planning, capacity building, hybrid	$0	$24,731,923	$8,846,361	$33,578,283
				Total (2011-2022):	**$321,915,033**

* Additional funding beyond state grant and local match was required for these projects.

Table 7-2 provides a summary of the types of mitigation projects that have been funded between 2010 and 2021 through HMA grants. Clearly, the Commonwealth has placed a high priority on mitigating flood hazards through structure elevation and acquisition.

Table 7-2 – Hazard Mitigation Assistance Grants by Project Type, 1990-2021

Hazard Mitigation Assistance Project Type	Amount Allocated
Elevation	$65,558,053
Acquisition	$65,052,415
Infrastructure Protective Measures	$21,542,612
Hazard Mitigation Plan	$12,549,092
Management Costs	$12,163,922
Stormwater Management	$4,498,605
Generators	$3,828,450
Flood Control - Dam	$2,510,440
Shoreline Stabilization	$2,328,770
Other Equipment Purchase and Installation	$1,748,805
Miscellaneous	$1,680,426
Other Non-Construction	$1,358,447
Warning Systems	$1,179,492
Retrofitting - Wind	$1,023,034
Public Awareness and Education	$965,089
Water & Sanitary Sewer System Protective Measures	$734,432
Advanced Assistance	$642,082
Dry Floodproofing	$622,036
Landslide Stabilization	$516,994
Mitigation Reconstruction	$502,221
Feasibility, Engineering and Design Studies	$461,076
Utility Protective Measures	$370,389
(blank)	$335,335
Relocation	$151,079
Codes, Standards, Ordinances and Regulations	$118,712
Technical Assistance	$116,666
Planning	$66,920
Total	**$202,625,595**

7.6.1 Virginia Disaster Relief Fund

Established in 1995, the Virginia Disaster Relief Fund (VDRF) provides grants to established private non-profit entities to support organizations active in disaster relief and recovery in their missions to assist residents and communities impacted by disasters. Since 2011, the VDRF has provided more than $2.3 million in grants to eligible organizations as shown in Table 7-3.

Table 7-3 - VDRF Grants Awarded, 2011-2022

Disaster	Total Awarded	Number of Grants	Average Award
152 - Pulaski Tornado	$242,384.00	18	$13,465.78
153 - Other Area Tornados	$89,940.57	10	$8,994.06
154 - Washington Tornado	$713,760.82	124	$5,756.14
155 - Hurricane Irene	$81,974.00	8	$10,246.75
156 - Earthquake	$61,945.00	6	$10,324.17
157 - Tropical Storm Lee	$702,955.00	105	$6,694.81
158 - Derecho	$9,617.00	1	$9,617
159 - Newport News Floods	$75,212.49	32	$2,350.39
160 - Hurricane Sandy	$229,856.99	57	$4,032.58
163 - SWVA Winter Storms	$160,712.45	18	$8,928.47
All Disasters	**$2,368,358.32**	**379**	**$6,248.97**

7.6.2 Grants Management Summary

VDEM provides timely and accurate performance and financial reports to FEMA regarding mitigation grants. To meet their reporting requirements to FEMA, VDEM requires Sub-recipients to submit their individual sub-grant reports to VDEM by the 15th of the month following the close of the quarter. VDEM submits their required report to FEMA by the end of the same month.

7.7 Mitigation Action Assessment (201.5(b)(2)(iv))

To document and evaluate the impact of mitigation funding, VDEM examined a selection of completed mitigation projects and estimated the real-world losses avoided by those projects. Project methodology and sample results of the Loss Avoidance Studies (LAS) conducted to date are summarized below; however, these studies are available in their entirety upon request to the Hazard Mitigation Planner at VDEM. This long-term strategy of conducting LAS and assessing impacts of completed mitigation actions is expected to increase public acceptance of mitigation programming, provide case studies for mitigation practitioners throughout the Commonwealth, and document the effectiveness of mitigation spending. The ability to assess the economic performance of mitigation projects over time is important to encourage future funding and continued high level support of mitigation projects, activities, and programs.

7.7.1 Project Methodology

The overarching goal of mitigation funding is to fund the implementation of measures that avoid or reduce future losses from natural hazards. By documenting project costs and post-implementation losses avoided, it is possible to measure the effectiveness of mitigation programs or actions.

Damage-induced losses avoided because of mitigation measure(s) are determined by comparing the damage that would have been caused by a subsequent event had the projects not been implemented. Mitigation projects studied through these LASs must be fully completed prior to the damage event(s) analyzed.

Calculating losses avoided requires both pre-mitigation data and post-mitigation data. These data sets can be analyzed in a process similar to a BCA. Project closeout assessments provide information for project successes or failures and provide data for further loss avoidance studies. Therefore, maintaining detailed cost accounting of mitigation projects during and after implementation is essential. When mitigation project costs can be evaluated after implementation, the overall effectiveness of both the project and the Commonwealth's mitigation program can be evaluated more fully.

The first LAS conducted in 2017 examined previously completed private property mitigation activities in the Cities of Poquoson and Roanoke in an effort to determine the extent of damages the subject structures would have sustained had they not been acquired or elevated. An array of data points was collected, including:

- Original finished floor elevations (pre-mitigation);
- Post-mitigation finished flood elevations;
- Base Flood Elevations;
- Square footage of the structures;
- Structure type;
- Cost of the mitigation measure;
- Value of the structure;
- Value of the structure's contents; and,
- Depth of flooding in project area (post-mitigation).

For both study areas, a review of the mitigated properties was conducted. The review included grant documents provided by VDEM, NFIP claims data for the community, and flood history data from both the community and the NWS. After review of these data, specific properties were identified within each study area that had the most complete data sets.

The structures studied in Poquoson were all elevated to a minimum of one foot above the effective BFE, consistent with local ordinance requirements at the time. The selected properties were all elevated after Hurricane Isabel (2003) and are in areas that have an ongoing risk of flooding. The LAS team used a depth-damage calculation that determined the dollar value of losses avoided based on the likely depth of inundation the structure would have experienced without mitigation. This calculation was then compared to the project cost to elevate each structure to determine the cost-effectiveness of the mitigation project.

The subject structures in the City of Roanoke were all acquired and demolished, with the remaining land converted to greenspace in perpetuity. Eleven of the structures were acquired in approximately 1996, with four acquired approximately ten years later. In the two decades since the original structures were acquired, the city has undertaken an array of other flood mitigation measures, including the creation of a greenway, the Peters Creek project, and the Roanoke River project.

While flooding has occurred in the city since these structures were acquired, there has been little flooding in the areas where the subject structures were previously located. This is likely due to a combination of factors, including other mitigation activities in the watersheds. A review of rainfall data in the watershed does not show a decrease in rainfall during the study period, thus the lack of flooding does not appear to be due to a natural decrease in precipitation.

7.7.2 Losses Avoided Through Mitigation

In the City of Poquoson, losses avoided were calculated for both the 2009 nor'easter and a 2011 storm. Aggregate losses avoided for the City of Poquoson projects are presented Table 7-4. As shown in the results, the private property elevation projects implemented in Poquoson were cost beneficial. While not every structure examined has delivered a positive return on the initial investment to date, the project has resulted in at least $2.22 in avoided losses for every dollar spent on mitigation for the studied properties.

The City of Roanoke provided documentation and anecdotal information regarding other flood control and mitigation measures enacted in the city over the previous two decades, and other local information and insight. City staff confirmed that while there have been floods in the City since these properties were acquired, no flooding has occurred in the project areas since the properties were acquired. A review of the available, documented flood history of the city confirmed this finding.

As there have been no documented flood events in the study area since the properties were acquired and the land returned to greenspace, actual losses avoided cannot be calculated, as there are no post-mitigation damages in the project area to use in the calculation. Based on interviews and documentation, the other mitigation and flood control measures enacted appear to have reduced the flood risk in the area, though this cannot be confirmed without a detailed hydrology and hydrological study, which is outside of the scope of the LAS.

Table 7-4 - Aggregate Flood Losses Avoided for Subject Properties, City of Poquoson

Property ID	Year Built	Number of Stories	Finished Floor Elevation (pre-mitigation)	Finished Floor Elevation (post-mitigation)	Cost of Mitigation	Structure Value	2009 Losses Avoided (Total)	2011 Losses Avoided (Total)	Aggregate Losses Avoided	Aggregate Benefit-Cost Ratio
7	1949	2	3.6 feet	10 feet	$31,850	$65,900	$32,885	$32,884	$65,768	2.06
31	1939	1	4.0 feet	11 feet	$28,150	$63,000	$45,864	$45,864	$91,728	3.23
12	1957	1	4.1 feet	11 feet	$44,350	$86,000	$62,608	$53,406	$116,014	2.61
18	1949	1	4.4 feet	11 feet	$28,150	$51,300	$31,857	$31,857	$63,715	2.26
10	1949	1	4.5 feet	11 feet	$44,350	$73,300	$45,519	$45,519	$91,039	2.05
6	1948	1	4.8 feet	10 feet	$43,150	$94,300	$58,560	$58,560	$117,121	2.71
4	1958	1	5.0 feet	10 feet	$43,150	$105,800	$65,702	$65,702	$131,404	3.04
2	1949	1	5.3 feet	10 feet	$43,250	$95,900	$47,950	$47,950	$95,900	2.21
9	1965	1	5.5 feet	10 feet	$49,350	$75,900	$37,950	$37,950	$75,900	1.53
11	1965	1	5.9 feet	10 feet	$43,150	$97,000	$48,500	$48,500	$97,000	2.23
5[3]	1949	2	4.6 feet	11 feet	$43,450	$113,500	$47,444	$47,443	$94,886	2.18
15	1949	2	5.0 feet	10 feet	$39,250	$99,100	$41,424	$41,424	$82,848	2.11
16	1949	2	5.0 feet	11 feet	$43,450	$97,600	$40,797	$40,797	$81,594	1.87
24	1955	1	5.0 feet	10 feet	$38,170	$101,800	$63,218	$63,218	$126,436	3.31
14	1949	2	5.3 feet	10 feet	$58,150	$78,000	$25,818	$25,818	$51,636	088
23	1949	1	5.5 feet	10 feet	$56,050	$106,500	$53,251	$53,250	$106,500	1.90
25	1970	1	5.8 feet	10 feet	$74,950	$185,700	$92,850	$92,850	$185,700	2.47
			4.9 feet (Average)	**10.35 feet (Average)**	**$752,370 (Total)**	**$1,590,600 (Total)**	**$842,194 (Total)**	**$832,992 (Total)**	**$1,675,186 (Total)**	**2.22 (Aggregate)**

7.7.3 Additional Loss Avoidance Studies

Prior to the *2018 Commonwealth of Virginia Hazard Mitigation Plan*, VDEM conducted loss avoidance studies in Gloucester County, Southampton County, and the City of Franklin. Those studies documented that in less than 7 years after the mitigation activity, there was already a significant savings in post-project flood damages. Concurrent with the writing of this plan in 2022, there are 5 elevation properties in two jurisdictions, Lottsburg in Northumberland County and the City of Chesapeake, that are undergoing study to determine losses avoided.

In 2022, VDEM and VMASC conducted an LAS for a 2016 acquisition/demolition project in the Town of Cleveland in Russell County. Cleveland sits in the 100-year floodplain and has had major flooding in the past that had damaged the subject buildings beyond a cost-effective repair strategy. Because the subject buildings were not habitable because of flood damage, they posed a persistent maintenance and health threat to the residents of the community. The lack of structural integrity posed a risk of building collapse into public roadways and powerlines. They posed a fire risk and contained asbestos.

All these factors contributed to a significant threat to the ecologically sensitive Clinch River, which is one of the most biologically diverse rivers of native species in North America. One sensitive concentration of mussels lies just downstream of Cleveland at Cleveland Island and is recognized by the Nature Conservancy and Virginia's Department of Game and Inland Fisheries as a high priority conservation area. The controlled demolition and removal of the structures would further enhance not only the quality of life of Cleveland residents, but also, the ecological health and financial impacts of flood mitigation.

The flooding event that occurred post-mitigation was a February 2020 rain event. On February 4, 2020, the NWS issued a Flash Flood Watch for southwest Virginia for a strong storm system moving through the area, with 2 to 4 inches of heavy rainfall. On February 6, the Emergency Management Assistant Director for Russell County declared a local emergency due to a record amount of rainfall and flash flooding, rock/mud slides, and high water on roadways. An estimated $244,124 of damage occurred to private property, and $348,825 to public property, totaling $592,949 in damages. A remaining structure adjacent to the previously mitigated properties sustained $4,850 in damages.

The following calculations were performed to support the avoided loss estimate from the February 2020 post-mitigation storm event:

- Stream discharge;
- Flood depth elevations;
- Residential building depth-damage curve;
- Residential building contents depth-damage curve;

- Displacement Costs; and,
- Expected annual ecosystem services benefit from reverting the properties to open green space.

Losses avoided and the BCR are reported in Tables 7-5 and 7-6 below. Both tables report the property (structure) ID, total project cost, estimated depth of flooding from the February 2020 storm event, value of damage to the building and contents, and displacement costs. Table 7-5 reports the benefit-cost ratio independent of the added benefit to ecosystem services obtained from reverting the properties to open green space. Table 7-6 reports the losses avoided plus the added ecosystems services benefit and the adjusted benefit-cost ratio. While not all properties are estimated to have incurred damages under this scenario, five of the six structures would have experienced some degree of inundation. When considering the benefit of acquisition green space, the aggregate benefit-cost ratio proves cost effectiveness of the mitigation measures. Losses avoided were returned far in advance of the project useful life of 100 years. The properties were purchased and demolished in 2016, and exceeded the desired costs saved in an approximate 3.5-year period.

Table 7-5 - Losses avoided and BCR without ecosystems services benefit

ID	Total Project Costs	Flood Depth	Building Damage Value	Contents Damage Value	Displacement Damage Value	Total Damage Losses Avoided w/out Eco Benefit	Benefit-Cost Ratio w/out Eco Benefit
1	$32,566	3.98	$25,371	$21,646	$1,065	$48,083	1.48
2	$32,566	3.98	$33,793	$55,145	$9,054	$97,992	3.01
3	$90,570	3.06	$109,325	$19,754	$38,245	$167,325	1.85
4	$73,471	0.04	$3,917	$0	$0	$3,917	0.05
5	$61,523	-0.45	$1,151	$0	$0	$1,151	0.02
6	$100,981	0.58	$26,661	$5,631	$6,442	$38,734	0.38
	$391,677		**$200,219**	**$102,177**	**$54,806**	**$357,202**	**0.91**

Table 7-6 - Losses avoided and BCR with ecosystem services benefit

ID	Total Project Costs	Flood Depth	Building Damage Value	Contents Damage Value	Displacement Damage Value	Total Damage Costs Losses Avoided + Eco Benefit	Benefit-Cost Ratio w/ Eco Benefit
1	$32,566	3.98	$25,371	$21,646	$1,065	$54,782	1.68
2	$32,566	3.98	$33,793	$55,145	$9,054	$102,829	3.16
3	$90,570	3.06	$109,325	$19,754	$38,245	$174,395	1.93
4	$73,471	0.04	$3,917	$0	$0	$29,593	0.40
5	$61,523	-0.45	$1,151	$0	$0	$11,571	0.19
6	$100,981	0.58	$26,661	$5,631	$6,442	$48,408	0.48
	$391,677		**$200,219**	**$102,177**	**$54,806**	**$421,578**	**1.08**

VDEM lacks the resources to systematically track potential losses avoided for every mitigation project implemented. The agency does, however, routinely collect and maintain information and documentation of mitigation success stories and best practices.

Going forward, VDEM will capitalize on opportunities to collect and record data regarding the real-world effectiveness of successful mitigation projects implemented and the losses avoided.

This effort may include such actions as evaluating previous flood loss properties following successful mitigation to determine what damages were avoided by the implementation of the mitigation measure, and including periodic, post-mitigation reports from communities that successfully implement mitigation measures. The agency will also seek out opportunities to do LAS investigations for non-flood related hazards such as hurricane and soil stabilization.

7.8 Commitment to a Comprehensive Mitigation Program (201.5(b)(4)(i-vi))

As provided earlier in Chapters 4 (Capability Assessment), 5 (Mitigation Strategy), and 6 (Local Plan Coordination), the Commonwealth has a demonstrated commitment to achieving its published mitigation goals and to building multi-hazard mitigation capacity and capability throughout the Commonwealth. The goals are implemented through a range of active mitigation programs shared among several state agencies, regional planning partners, and local stakeholders.

7.8.1 Capacity Building

To build and maintain capacity throughout the Commonwealth, VDEM and other state agencies and entities support an array of activities, including planning, technical assistance, and training. These opportunities are provided to communities, tribes, institutes of higher education, organizations and businesses, property owners and visitors in Virginia.

All jurisdictions in the Commonwealth are part of a local hazard mitigation plan. VDEM provides and encourages communities to apply for funding as it becomes available. Details of the local plan coordination can be found in Chapter 6 of this plan.

In addition, VDEM provides or organizes planning and project training throughout the Commonwealth on a regular basis. Training is also available online through FEMA to any community resident. These valuable training opportunities provide communities, first responders, and other emergency management personnel with opportunities to build their own local capacity, which in turn builds capacity throughout the Commonwealth.

Due to the number of disasters in 2016 and 2017, annual HMA grant workshops were not held, and the 2020 COVID-19 Pandemic derailed in person training for almost 2 years. However, VDEM grants staff undertook a stakeholder engagement and peer review process beginning in 2017 that was the focus of the agency’s HMA outreach strategy. Annual G393 workshops were held in 2018, as were HMA application process webinars. These workshops are geared towards helping local governments understand the HMA programs and benefits to be derived from participation. VDEM has re-vamped their application process to move from paper applications to a grants management portal. Additional workshops and webinars in the past 10 years are described in Chapter 6 in additional detail.

According to the Association of State Floodplain Managers, there are now 446 Certified Floodplain Managers™ in the Commonwealth of Virginia[4], an increase of 34 since 2017. Given the serious risk that flooding poses to communities throughout Virginia, having this many trained, qualified, and certified floodplain managers in the Commonwealth is a valuable resource, at both the state and local levels.

7.8.2 Local Challenges

Many local jurisdictions and counties are faced with challenges when it comes to development and project management of HMA grant applications. Most of these challenges are related to the amount of time employees can allot to project development and management of the grants. Many local employees are charged with numerous program responsibilities and cannot contribute the additional necessary time, especially when unfamiliar with the mitigation application process and requirements.

The benefit cost analysis is usually the most challenging part of the application process, and as discussed in Chapter 4, can be more difficult for non-residential projects. Local officials have expressed that more training and tools to address flood mitigation projects would be helpful.

HMA grants can be difficult to manage locally, especially for residential projects. Some communities have experienced challenges when initially approvable HMA projects cannot continue because property owners cannot contribute the non-federal and non-state share of the project. As discussed in Chapter 4, VDEM has tried to identify more private contributions moving forward, which may help address this issue.

7.9 Executive Actions (201.5(b)(4)(i-vi))

The *Code of Virginia* §44-146.17 allows the Governor to appoint an Emergency Coordinator to carry out all provisions of the Code of Virginia related to emergency preparedness, response, and recovery. The *Code of Virginia* §11-146.22 specifically authorizes the Governor to consider hazard mitigation measures to prevent or reduce the harmful consequences of disaster. The Governor is expected to make recommendations to the Virginia General Assembly, local governments, and appropriate public and private entities.

Through VDEM, the Commonwealth has two standing mitigation councils: the VHMAC and the VHMWG. As discussed in Chapters 2 (Planning Process) and 8 (Plan Implementation and Maintenance), these groups are essential to providing direction and information to the mitigation planning process in the Commonwealth, both during and between updates. Some of the

Commonwealth's other critical legislation or executive actions related to hazard mitigation are discussed below.

7.9.1 Building Codes

Through the DHCD, Virginia has adopted and publishes the USBC, which contains building regulations that must be adhered to when constructing new buildings, structures, or additions to existing structures, and when maintaining or repairing an existing building or renovating or changing the use of a building or structure. The Board of Housing and Community Development formally adopts and amends the USBC. The Board bases the technical requirements of the code on nationally accepted model codes and standards and makes as few amendments as possible. Enforcement of the USBC is the responsibility of local governments. The local government may charge fees to defray the costs of enforcement and appeals arising from the application of the code.

As discussed in Chapter 4, during the 2018 Code Development Cycle, a Resiliency Sub-Workgroup was convened to focus on resiliency, and a Resiliency Impact Analysis of the codes was conducted. The group met most recently during the 2021 Code Development Cycle to develop proposals for Virginia's codes to increase resiliency, as well as review the resiliency impact of proposals submitted by others throughout the review cycle. Most notably, the group brought forward a code proposal from the 2024 model codes that incorporates considerations for tornado loads on structures and updates the ASCE standard to the most recent standard.

7.9.2 Floodplain Management Design Requirements

DCR is responsible for floodplain management in Virginia and serves as the NFIP State Coordinating Office. While community participation in FEMA's NFIP is voluntary, any community that elects to join the program is required to adopt and enforce minimum floodplain management standards. In return, FEMA makes flood insurance available for purchase to residents of those communities. DCR provides communities with a state model ordinance that communities may use to develop their own ordinance, and DCR aids communities that may want to strengthen their ordinance to provide additional protection for future construction.

Governor Northam signed Executive Order (EO) 45 in 2019, creating the Virginia Flood Risk Management Standard. A first of its kind for any state, the Virginia Flood Risk Management Standard improves flood protection in coastal areas by discouraging building in floodplains and incorporating sea level rise projections that have been developed based on the best available science and adopted by NOAA. In addition, EO45 establishes a "freeboard" standard that increases protection of state-owned buildings in both coastal and riverine floodplains by requiring that they be built to elevation standards that will protect them from flooding.

This initiative is the result of EO-24 (2018) to improve resilience and protect people and property from natural catastrophes. EO 24 required the issuance of state-wide or regional freeboard and sea-level rise projections. The Virginia Flood Risk Management Standard satisfies those requirements by setting standards for coastal and riverine flood prone areas. Flood prone areas includes sea level rise inundation areas, as well 100- and 500-year floodplains mapped by FEMA. As part of EO-24 (2018) , the Commonwealth is charged with developing a Coastal Resilience Master Plan. This plan is discussed in detail in Chapter 4 (Capability Assessment)

Developed in the early 1990s and adopted after Hurricane Fran in 1996, Executive Memorandum 2-97, Floodplain Management for State Agencies, clarifies the Governor's intent that all state agencies have some responsibility in managing flood hazards and impacts through avoidance, promotion, and coordination activities. Additional details are provided in Chapter 4, as well.

7.9.3 Critical and Essential Facilities

Every incarnation of the Commonwealth's Hazard Mitigation Plan has identified assets throughout the state that are critical and essential to the Commonwealth for post-disaster response and recovery. Every local hazard mitigation plan identifies critical and essential assets for each community's post-disaster response and recovery efforts. Both the Commonwealth and the local plans identify mitigation goals, actions, and strategies to further protect, strengthen, and/or harden these critical and essential facilities to ensure the availability of necessary resources following a disaster event.

7.9.4 Integration with Post-Disaster Recovery Operations

Through the management and implementation of the HMGP, the Commonwealth and its communities successfully integrate mitigation into post-disaster recovery operations. Through VDEM's administration, oversight and assistance, communities can apply for and receive additional funding to enact mitigation measures during the repair/rebuilding process that follows any disaster. Mitigation measures will be at the forefront of any future disaster, with both public assistance and hazard mitigation grants fully integrated into the Finance and Grants Division.

As evidence of this commitment, VDEM is hiring a technical assistance coordinator, and one of their primary tasks will be to ensure that mitigation projects, plans, methods and ideas get discussed early and often at the state, tribal and local levels. VDEM hired Recovery and Mitigation Specialists in each of the agency's 7 regions to identify mitigation opportunities as early as the preliminary damage assessment stage of significant disasters. Hazard mitigation is also actively encouraged through the Public Assistance program.

Endnotes

[1] OMB. Circular A-94, Guidelines and Discount Rates for Benefit Cost Analysis for Federal Programs. Retrieved 07.07.17 from, https://obamawhitehouse.archives.gov/omb/circulars_a094
[2] FEMA Memorandum for Regional Administrators, dated 9/29/2021. Retrieved 2/21/23 from https://www.fema.gov/sites/default/files/documents/fema_acquisition-elevation-precalculated-benefits-memo_092021.pdf
[3] Properties 5, 15, 16, 24, 14, 23, and 25 were funded using CDBG rather than HMGP funds, though they were originally included in the HMGP project application.
[4] Association of State Floodplain Managers, List of Certified Floodplain Managers, 2022. Retrieved 10/28/2022 from http://floods.org/index.asp?menuID=811&firstlevelmenuID=180&siteID=1#VA

Contents

8.1 2023 Updates

This section was revised to organize the sections more clearly. A section on mitigation project closeout procedures was deleted because it restated FEMA policy and VDEM grant administrative procedures outlined in Appendix H and did not pertain directly to implementation and maintenance of the plan. Implementation, monitoring and maintenance procedures were clarified, and the Plan Integration subsection was added to show how the plan will be integrated into other planning mechanisms across the Commonwealth's other agencies. EMAP and Enhanced Plan processes for 2025 were appended to Table 8-1, which was updated with dates pertaining to the subsequent 5 year period.

8.2 Introduction

This *Commonwealth of Virginia Hazard Mitigation Plan* is intended to be a living document, one that is operationalized through the continuous implementation of the actions identified in Chapter 5 and ongoing dialog with stakeholders. It is also intended to be dynamic – changing and improving as needed through routine maintenance procedures that help to ensure the plan is reviewed, revised, and updated as conditions and information change, and with input from stakeholders. This chapter outlines more specifically how the plan will be implemented and maintained by the Commonwealth, and it describes how stakeholders will continue to be involved in the process.

8.3 Plan Implementation

The most critical outcome of the planning process is the effective implementation of specific hazard mitigation actions, which will ensure that the Commonwealth can achieve the plan's vision, goals, and objectives. Plan implementation will be accomplished by designing implementation strategies and establishing detailed timelines for priority actions, and by continuing to monitor, evaluate, update, and develop actions as new information and experiences become available.

The state agency with primary responsibility for implementing, maintaining, monitoring, evaluating, enhancing, and updating the plan is VDEM. Although VDEM is tasked with general monitoring and reporting on plan implementation, proposed actions have been assigned to a specific lead agency with overall responsibility and accountability for carrying the action out. Therefore, the ultimate responsibility for plan implementation falls on many state agencies, as well as state and local stakeholders. Actions that are crosscutting have also been identified and many need to be implemented across State government, with a specific agency lead. These actions will be particularly important for VDEM to track to ensure this plan's objectives are being met in conjunction and alignment with other agencies' planning priorities.

Specific implementation details for each action proposed in this plan, such as the lead agency, potential partners, timeline for completion, funding source(s), and agency priority level are identified in Chapter 5. Although it is the responsibility of each lead agency to determine additional implementation needs beyond those listed in this plan, each action has been developed to be measurable and time-bounded, making these actions the most useful indicators for tracking progress in overall plan implementation. Where individual lead agencies find that the original prioritization framework did not provide sufficient benefit analysis to accurately prioritize certain agency-specific missions, such as impact on socially vulnerable populations, additional benefit analysis considering co-benefits should be conducted to reassess the action priority for that agency.

8.3.1 Plan Adoption

As discussed in Chapter 1, this plan has been formally adopted by the Governor of Virginia as shown by the letter provided in Appendix I. The *Code of Virginia* at §44-146.22 specifically authorizes the Governor to consider hazard mitigation measures to prevent or reduce the harmful consequences of disasters. The Governor is expected to make recommendations to the General Assembly, local governments, and appropriate public and private entities as part of the Commonwealth's ongoing implementation of this plan. Appendix J includes the final letter of FEMA approval for this plan.

8.3.2 Review of Mitigation Initiatives

Bi-annually and following large-scale disasters in the Commonwealth, the VHMAC and the VHMWG will meet to discuss ongoing mitigation initiatives. These meetings will have pre-identified topics of discussion and agendas that will focus on changes in policy or regulations, recent events, and mitigation activities identified in the plan, particularly those identified as high priority. Subject matter experts may be called in to present on topics related to specific programs including, for example, mitigation programs in other states, or ongoing projects in Virginia. Periodically, the groups will self-assess the overall effectiveness of their meetings and adjust the vision, purpose, and logistics, as needed.

Following a disaster, VDEM will gather specific information for presentation to these committees. VDEM will consult with affected PDCs and local Emergency Managers to identify mitigation activities and opportunities that they may have identified before, during or after the event. This information will be presented to the committee members prior to the next bi-annual meeting, so that the members have time to review and be prepared to discuss any recommended changes to the plan at the next bi-annual meeting.

8.3.3 Plan Integration

At the state level, the *Commonwealth of Virginia Hazard Mitigation Plan* serves as the Commonwealth's primary risk assessment and risk reduction strategy for natural hazards. As a result, it serves as a key document for state agencies to routinely reference, and as applicable, to integrate into their own plans, budgets, policies, assessments, or strategies. Such integration will continue to be encouraged by members of the VHMAC as specific opportunities are identified. Plan integration will also be a discussion topic during regularly scheduled plan reviews, as described in Section 8.3.1.

More specifically, this plan and the mitigation vision, goals, objectives, and actions will continue to be integrated to the maximum extent practical with state plans or programs that have already been determined to be mutually supportive and at a minimum, in need of cross-referencing. These include, but are not limited to, the following:

- Virginia Department of Planning & Budget Six Year Capital Plan
- DCR's Floodplain Management & Dam Safety Programs
- Virginia Dam Safety, Flood Prevention and Protection Assistance Fund
- Virginia Community Flood Preparedness Fund
- Virginia Coastal Resilience Master Plan
- Floodplain Management Plan for the Commonwealth of Virginia, 2022 pending update
- Scenic Rivers Program
- Virginia Outdoors Fund
- Virginia Agricultural Cost Share Program

- Virginia Natural Heritage Karst Program
- Conservation Reserve and Enhancement Program
- Commonwealth of Virginia Emergency Operations Plan, 2021
- VDEM HMA Programs
- VDEM THIRA
- Virginia Energy Plan
- VDEM Continuity of Operations Plan
- Virginia Uniform Statewide Building Code Resiliency Sub-Workgroup
- Hazardous Material Emergency Response Program
- Virginia Weatherization Assistance Program
- Virginia Behavioral Risk Factor Surveillance System
- Virginia Transportation Research Council
- VDOT Office of Transportation Sustainability
- Virginia Property System
- Virginia Coastal Zone Management Program and Coastal Policy Team
- Virginia Drought Monitoring Task Force
- All agencies grant programs and capital spending requests

The *Commonwealth of Virginia Hazard Mitigation Plan, 2023* will reside on VDEM's Planning Division page (https://www.vaemergency.gov/divisions/planning/), which serves as a gateway to data and information relevant to natural hazard mitigation across the state. The site will be the home for the online version of the 2023 plan, as well as future updates to the plan; and will enable dynamic interaction with the general public, local communities, state agencies, and other stakeholders over the life of the plan. At a more local level, many state agencies routinely coordinate with municipalities and other jurisdictions, and through direct outreach and interaction with the VDEM regional staff will help to ensure the plan is incorporated into other relevant plans such as local or regional hazard mitigation plans. It is expected that both state and local level planning initiatives will benefit from this coordination because state agency staff will also be able to more easily identify ways to improve the ability of the state plan components to support local plans.

At a national level, the Commonwealth plans to revise specific plan components in order to participate and receive accreditation in the Emergency Management Accreditation Program in 2025, which will help ensure that the plan is adequately in compliance with national standards for risk assessment, risk reduction, and other emergency or disaster management programs.

The plan will also be updated in 2025 to submit for an off-cycle review for FEMA's Enhanced Plan status documenting a proven commitment to long-term risk reduction. Being enhanced recognizes a state's ongoing and coordinated work to reduce losses from natural hazards, protect life and property, and create more resilient communities. VDEM understands that one year prior to submittal for enhanced status, they must notify FEMA and jointly develop a detailed submission and review schedule for that process. VDEM's most recent four quarters of grant performance data must also be submitted for the HMA pre-qualification. The initial coordination is shown in the schedule for plan maintenance shown in subsection 8.8.1 below.

Enhanced states' mitigation plans go beyond the minimum requirements. These states' plans represent holistic mitigation programs integrated across partners, staff, and offices. The commitment to mitigation is demonstrated both in the plan and in day to day operations. Enhanced states have the capacity, resources, and/or skills to build resilience for communities across the state.

Enhanced states receive an additional 5% in HMGP funds after a disaster. This means they receive 20% of estimated eligible Stafford Act assistance instead of 15%. Enhanced states share the responsibility for reducing risk across state agencies and departments. This "sharing the load" reduces risk more efficiently. It also connects the right resources with community needs.

The Commonwealth will also continue to seek opportunities to leverage or integrate other relevant national plans or standards with the plan as appropriate including, but not limited to, the National Climate Assessment, the Federal Emergency Management Agency's (FEMA) Strategic Plan, the National Mitigation Framework, and the National Disaster Recovery Framework.

8.4 Plan Monitoring

In order to monitor the plan's effectiveness, VDEM and the VHMAC must employ a system for evaluating implementation of individual strategies and projects. The Commonwealth's Mitigation Toolbox is offline and currently undergoing an update to make best use of current online technologies for collecting input from numerous agency representatives over time. The new action tracker will be a customized tool for reporting progress status updates on individual actions. The action tracker will be developed by VDEM in consultation with the VHMAC as soon as this plan is approved. The tracker will serve as the primary mechanism for reporting and tracking the status updates on each action, and will establish metrics to gauge effectiveness.

All agencies that have been assigned as the lead for an action in Chapter 5 will be required to provide annual implementation updates using the action tracker. Lead agencies will also be encouraged by the VDEM Hazard Mitigation Planner to maintain their progress tracking information for all actions on a more frequent basis. These action tracker updates include information on the specific status of the action (i.e., completed, partially completed, delayed, deferred, canceled), detailed costs and benefits, as well as narrative descriptions of progress made and accomplishments, funding acquired, changes in priority, delays incurred, problems faced, resources needed, or other details. Upon project completion, agencies can input project information regarding the number of structure and people protected, losses avoided and project relevancy to mitigation goals. The action tracker will help the lead agencies evaluate the appropriateness and/or feasibility of actions as currently designed or being pursued, and when necessary, take corrective steps or adjust actions to address current conditions.

The action tracker will be the primary tool for the VHMAC to routinely evaluate, monitor, and report on the overall implementation of this plan. Per the method and schedule for plan maintenance (described in subsection 8.8.1), the action tracker will be used in the completion of reporting procedures that are tied to annual due dates for lead agencies, in addition to an annual summary of implementation progress. It will also be a critical tool to assist the VHMAC in completing tasks associated with regularly scheduled plan review and update processes, reporting during bi-annual meetings and after large-scale disasters. VDEM will measure and show progress toward implementation by tracking and evaluating progress of specific actions.

8.5 Plan Maintenance

The *Commonwealth of Virginia Hazard Mitigation Plan* has been developed to be a living and public document that reflects the Commonwealth's continuing commitment to reducing risks from natural hazards and climate change. As noted above, the online version and future updates to the plan will reside on VDEM's Planning Division web site. This section describes how the plan will be actively maintained over time. It includes general procedures for regularly reviewing and making minor amendments, in addition to the comprehensive review, update, and adoption of the plan by the Commonwealth at least every 5 years. Modifications to specific actions or action plans will be revised more frequently as needed, including if the conditions under which this plan was adopted change—such as updates to critical underlying data or new study findings, new or revised state policies or federal regulations, lessons learned from implementing the plan, or a major disaster event.

8.5.1 Roles and Responsibilities

VDEM and the VHMAC, together with the lead agencies identified in the mitigation actions will oversee plan maintenance. This team will also lead the following ongoing activities:

- Help ensure the current version of the plan is made readily accessible to state agencies and the public, including an online version hosted on VDEM's Planning Division web site and in other formats as needed.
- Provide clear methods for state agencies and external stakeholders to review and provide comments on the plan and/or its effectiveness, especially during any scheduled plan reviews or updates.

- Work closely with other state agency staff to promote and support the plan in ways that continue to meet the needs of the Commonwealth and federal requirements for state hazard mitigation plans.
- Assist in interagency efforts for response, recovery, and hazard mitigation before and after major disaster events, including review and recommendation of Hazard Mitigation Grant Program projects.
- VDEM, working with VHMAC and VHMWG will be responsible for the plan's 5-year update, and establishing the plan update schedule, milestones, and federal requirements.

Numerous stakeholders from local, regional, state, and federal government agencies, private-sector organizations, and others will be engaged in the ongoing plan maintenance process. The primary method to engage these stakeholders is through the VHMAC. Additional methods for stakeholder engagement and coordination in support of plan maintenance are described in Section 8.8.3.

The VHMAC will continue to include representation from key state agencies. The committee composition is expected to remain similar to the group convened to update this plan, as summarized in Chapter 2. The VHMAC will be chaired by the VDEM Hazard Mitigation Planner. The role and responsibilities of the VHMAC members include, but are not limited to, the following:

- Conduct and attend bi-annual meetings, annual plan reviews, post-disaster reviews, and 5- year plan review and updates as scheduled.
- As necessary, coordinate with lead agencies and Cabinet Secretaries or upper level management to facilitate the completion of annual implementation updates as required for all actions included in Chapter 5 of the plan.
- Perform tasks necessary to support plan reviews and updates, and ensure that as new data become available, they will be incorporated into the plan. New data may include technical reports or scientific studies on hazard/climate risks; local hazard mitigation and climate adaptation plans; and completed or updated vulnerability assessments from state agencies, cities and towns, regional planning entities, private entities, educational institutions, and other sectors.
- Provide outreach, technical assistance, stakeholder engagement, and other educational services that increase general awareness and understanding of this plan.
- Help ensure the current version of the plan is well publicized and socialized in the member's own agency and area of subject matter expertise.
- Coordinate the continuous enhancement of the plan through collaborative partnerships and the active engagement of key stakeholders, including representatives from municipalities, planning districts, and others who play a role in supporting plan implementation through their own plans, policies, programs, or activities.
- Support incorporation into other state plans and programs.

8.5.2 Method and Schedule

The key components of the method and schedule for regularly maintaining the *Commonwealth of Virginia Hazard Mitigation Plan* include an annual plan review, a post-disaster plan review, and a 5-year plan review and update. Effective plan maintenance will also require additional routine or recurring activities that are not necessarily bound to specific methods or schedules, such as tracking and documenting new or best practices for hazard mitigation, or new policies or procedures that may affect how the plan is implemented. It is expected that many of these ongoing activities will continue to be performed by members of the VHMAC, and will be further discussed during the regularly scheduled plan reviews described below. These plan maintenance activities are distinguished from the bi-annual review of mitigation initiatives described in subsection 8.3.2 and the plan monitoring described in Section 8.4 by the focus of plan maintenance reviews on the status and accuracy of plan document components.

8.5.2.1 Annual Plan Review

This plan will be reviewed annually to evaluate the progress made on actions included in the hazard mitigation strategy, and to review and potentially amend the plan to reflect significant changes that took place during the preceding year. This annual review will take place in the third quarter of the year and be led by VDEM with VHMAC support and participation. The following tasks may be completed by the committee during the annual plan review:

- Evaluate overall progress on hazard mitigation actions, especially those identified as high priority actions. The most recent status updates provided by lead agencies in the action tracker (which will be updated on an annual basis by lead agencies) shall be reviewed and discussed to measure progress.
- Identify any problems or barriers associated with plan implementation (technical, administrative, financial, political, or legal), along with any required or recommended corrective actions.
- Examine any notable changes in the Commonwealth's risks or vulnerabilities related to natural hazards and climate change based on new data and information, updated climate change projections, or lessons learned through actual hazard occurrences. Special attention should be given to technical reports or scientific studies on hazard/climate risks, local hazard mitigation and climate adaptation plans, and completed or updated vulnerability assessments from state agencies, cities, counties and towns, planning districts, private entities, educational institutions, and other sectors.
- Identify any major changes to federal or state laws, authorities, regulations, funding, or other measures that may necessitate revisions or amendments to the plan.
- Prepare an internal summary of the results and findings of the above tasks, in addition to any other notable updates to the general status and implementation of the plan. The summary may also highlight any proposed additions, amendments, or improvements

required for the plan to increase its overall effectiveness. If determined necessary, the VHMAC may amend the plan to reflect significant changes in information. If not urgent to handle through interim/annual amendments to the plan, these changes may be documented and recommended for the next 5-year plan review and update process.

8.5.2.2 Post-Disaster Review

After each Presidential Disaster Declaration, the VHMAC and other stakeholders will convene as necessary to review specific hazard mitigation or climate adaptation needs and opportunities related to the disaster-affected area. This may be especially important in assisting with identifying any new hazard mitigation priorities for the Commonwealth, and expediting the integration of specific mitigation actions with recovery efforts in impacted areas. It will also allow the VHMAC to amend the plan to reflect lessons learned, or to address specific circumstances arising from the disaster event including, but not limited to, the prioritization of hazard mitigation actions. This post-disaster review may replace an annual plan review in any year that a major disaster occurs, if so determined by the State.

8.5.2.3 Five-Year Plan Review and Update

At least once every 5 years, this plan will undergo a comprehensive review, update, and readoption process as required by federal regulations for state hazard mitigation plans. The plan review and update process will be managed by VDEM. VDEM will manage the administrative details of the plan update process, including potentially securing external funding support through FEMA, contracting with outside consultants, coordination with FEMA, and plan submission. Upon completion, the updated plan will be submitted to the Governor for formal adoption, and to the FEMA Regional Administrator for final federal approval. At a minimum, the plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation or adaptation efforts, and changes in priorities. It must also incorporate information learned from implementing the plan and the experiences of state agencies, municipalities, and other partners or stakeholders in assessing and responding to natural hazard and climate change vulnerability. This includes, but is not limited to, plan amendments or updates that were identified during annual plan reviews, but not yet incorporated.

During the 5-year plan review and update, the following questions will be considered by the VHMAC as key factors for assessing the effectiveness of the plan, and for identifying the most critical improvements or enhancements to be made during the process. Additional questions may be added as appropriate:

- Are the plan’s goals and actions still representative of the Commonwealth’s priorities?
- Has there been meaningful progress toward achieving the goals and in implementing the actions? Has the completion of actions resulted in expected outcomes?

- If the action was completed, did it have the intended results? Did the action help achieve plan goals? What factors contributed to the action's success? Are there next steps that must be taken to ensure optimal outcomes?
- If the action was not completed, what were the barriers to implementation? Should the action remain in the strategy for the updated plan?
- How can lessons/outcomes from implementation of these actions inform development and implementation of future strategies and actions to reduce risk and vulnerability?
- Are the current capabilities and resources of state agencies adequate to implement the plan as scheduled? If not, what are the key gaps or shortfalls?
- Have there been any changes to Federal or State laws, authorities, regulations, funding, or other measures that necessitate specific revisions or amendments to the plan?
- Have the threats and hazards of concern as characterized in the risk assessment changed? Are there new data, techniques, or approaches that must be integrated into the risk assessment?
- Has there been significant new or improved development in areas susceptible or exposed to the impacts of natural hazards and/or climate change? Have the procedures to routinely monitor, evaluate, and enhance the plan between 5-year update cycles been effective at keeping it a living document?

The 5-year plan review and update process will entail a detailed and structured re-examination of all aspects of the original plan, followed by recommended updates. The recommendations will be presented to the VHMAC and VHMWG and other identified stakeholders for consideration and approval. On completion, the results and outcomes of the process will be summarized and incorporated into the relevant sections of the updated plan in accordance with the latest planning guidance or requirements from the Governor and FEMA. This includes a comprehensive description of the plan update process, in addition to any revisions or updates to existing plan chapters as required.

8.5.2.4 Annual Consultation with FEMA

In addition to the regularly scheduled plan reviews identified above, VDEM will coordinate with FEMA to host an annual collaborative meeting to help inform updates to the plan. Per FEMA's State Mitigation Program Consultation program, the agency provides technical assistance to states in reviewing activities, plans, and programs to help ensure hazard mitigation commitments are fulfilled. The agenda and specific scheduling arrangements will be done in coordination with FEMA, with the meeting scheduled as close to the Commonwealth's annual plan reviews as possible. After each year's consultation is completed, FEMA will prepare a State Mitigation Program Consultation summary to describe mitigation program strengths, specific challenges to advancing mitigation, and opportunities for improving mitigation capabilities.

8.5.3 2023-2028 Plan Maintenance Schedule

The plan maintenance methods outlined above will be conducted in accordance with the schedule in Table 8-1. The 60-month time frame will help to ensure that the 2028 plan update can be prepared, adopted, and published within the required 5-year period. The EMAP and Enhanced Plan modifications currently scheduled for 2025 will require a separate schedule for progress that will be executed within this schedule.

Table 8-1 – General Schedule for Plan Maintenance, 2023 - 2028

Task	Responsible Party	Anticipated Completion
Final Approval from FEMA	VDEM/FEMA	March 15, 2023
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Spring 2023
Debut new Action Tracker	VDEM	Summer 2023
Annual Consultation with FEMA	VDEM	Spring 2023
Request Status of Mitigation Actions from Agencies	VDEM/Agencies	Summer 2023
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Fall 2023
Annual Plan Review	VDEM/AC	Fall 2023
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Spring 2024
Annual Consultation with FEMA	VDEM	Spring 2024
Request Status of Mitigation Actions from Agencies	VDEM/Agencies	Summer 2024
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Fall 2024
Annual Plan Review	VDEM/AC	Fall 2024
Enhanced Plan Revisions	VDEM/AC/WG	Fall 2024 – Summer 2025
EMAP Revisions and Accreditation	VDEM	Fall 2024 – Summer 2025
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Spring 2025
Annual Consultation with FEMA	VDEM	Spring 2025
Request Status of Mitigation Actions from Agencies	VDEM/Agencies	Summer 2025
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Fall 2025
Annual Plan Review	VDEM/AC	Fall 2025
Secure Funding for 2028 Update	VDEM	Fall 2025
Annual Consultation with FEMA	VDEM	Spring 2026

Task	Responsible Party	Anticipated Completion
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Spring 2026
Secure Contractor for 2028 Update	VDEM	Spring 2026
Request Status of Mitigation Actions from Agencies	VDEM/Agencies	Summer 2026
Begin 2028 Plan Update	VDEM/AC/WG	Summer 2026
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Fall 2026
Annual Plan Review	VDEM/AC	Fall 2026
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Spring 2027
Annual Consultation with FEMA	VDEM	Spring 2027
Request Status of Mitigation Actions from Agencies	VDEM/Agencies	Summer 2027
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Fall 2027
Annual Plan Review	VDEM/AC	Fall 2027
Finalize 2028 Plan Update	VDEM/AC/WG	Fall 2027
Submit 2028 Plan Update to FEMA	VDEM/WG/AC	Winter 2027
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Spring 2028
Annual Consultation with FEMA	VDEM	Spring 2028
FEMA Final Approval of 2028 Plan Update	VDEM/FEMA	March 15, 2028
Request Status of Mitigation Actions from Agencies	VDEM/Agencies	Summer 2028
Advisory Committee/Working Group Bi-Annual Meeting	VDEM/AC/WG	Fall 2028
Annual Plan Review	VDEM/AC	Fall 2028

8.6 Stakeholder Engagement and Coordination

Active stakeholder engagement is an integral component to developing the Commonwealth of Virginia's Hazard Mitigation Plan, and will continue to be essential as this plan evolves and is updated over time.

The most appropriate and meaningful opportunities for stakeholders to be involved in the maintenance and implementation of the plan occur during the 5-year plan review and update process. Stakeholders play a role in helping to identify pathways for implementation of the plan, including opportunities for public-private partnerships, access to new data and techniques, and other catalysts that can speed implementation. Stakeholder engagement in this process will be solicited by members of the VHMAC and VHMWG through multiple means, and as similarly done for development of the plan, as resources permit. As demonstrated in Chapter 2, the Commonwealth has been proactive in seeking widespread stakeholder involvement throughout the process in ways that involve a cross-section of representatives from across the state. Future methods and opportunities to continue or enhance this engagement will be explored and determined by the VHMAC as part of the 5-year plan review.

In addition, while the 5-year plan review and update process represent the greatest opportunity for continued engagement, additional efforts to involve stakeholders in the plan maintenance process will continue to be developed and refined as necessary. These efforts may include, but are not limited to, the following:

- Leveraging External Affairs staff to engage the public and other stakeholders through targeted traditional and social media channels.
- Maintaining and publicizing the availability of the plan for review through multiple methods, including the ability to submit comments or questions regarding the plan at any time using the online plan platform on the VDEM web site. This site will make the plan available as a downloadable PDF, but is also expected to be enhanced over the next 5 years for a more dynamic user experience.
- Advertising regularly scheduled meetings of the VHMAC and VHMWG with the potential of accommodating additional guests, providing speaking or presentation opportunities, or other means of participation.
- Creating a VHMWG listserv for stakeholders who express an interest in keeping up with relevant news as it pertains to the implementation and maintenance of the plan.
- Delivering formal updates or presentations on the status of the plan at relevant professional conferences, seminars, or other forums of exchange.
- Developing active partnerships with municipalities, regional planning agencies, academic institutions, businesses, non-profit organizations, and other entities who share a mutual interest in advocating for and implementing effective hazard mitigation strategies.
- Branding the Bi-annual VHMAC and VHMWG to create an event that could be used to bring together a cross-section of representatives from various sectors to assist the VHMAC in identifying potential plan updates and enhancements. Attendance should be broad and inclusive to representatives from state agencies, municipalities, regional planning agencies, businesses, universities, non-profit organizations, FEMA, and other federal agencies. In addition to helping to improve the plan, such an event could benefit these other stakeholder organizations as their representatives return, and bring with them plan knowledge and tools to update their own related plans or activities.

In summary, although the *2023 Commonwealth of Virginia Hazard Mitigation Plan* will be submitted and adopted in the spring of 2023, the planning process is continuous and focused on plan implementation, maintenance, and iteration, which largely will occur in the period between March 2023 and the next 5-year plan update, due March 2028.

Appendix A:

Acronyms

%PGA	Percent Peak Ground Acceleration
AEL	Annualized Earthquake Losses
AELR	Annualized Earthquake Loss Ratio
APA	American Planning Association
ARC	Appalachian Regional Commission
ARC	American Red Cross
ARPA	American Rescue Plan Act
ASCE	American Society of Civil Engineers
ASPR	HHS Office of the Assistant Secretary for Preparedness and Response
ATL	Aid to Localities
AW-501	Repetitive Loss Update Certification
BCA	Benefit-Cost Analysis
BFE	Base Flood Elevation
BHCD	Board of Housing and Community Development
BMP	Best Management Practice(s)
BRIC	Building Resilient Infrastructure and Communities
CAP-SSSE	Community Assistance Program – State Support Services Element
CCALS	Commonwealth Center for Advanced Logistics Systems
CCI	Comprehensive Coastal Inventory Program
CDBG	Community Development Block Grant
CDC	Centers for Disease Control and Prevention
CFA	CDC Center for Forecasting and Outbreak Analytics
CFPF	Virginia Community Flood Preparedness Fund
CHEST	Center for Hardware and Embedded Systems Security and Trust
CMI	Crop Moisture Index
COOP	Continuity of Operations Plan
COOP Station	Cooperative Weather Stations
COV	Code of Virginia
COVEOP	Commonwealth of Virginia Emergency Operations Plan
COVID-19	Coronavirus Disease 2019
CRMES	Center for Risk Management of Engineering Systems
CRO	Chief Resilience Officer
CRS	Community Rating System
CWOP	Citizen Weather Observer Program
CWPP	Community Wildfire Protection Plan
CZM	Coastal Zone Management
DCR	Virginia Department of Conservation and Recreation
DEQ	Virginia Department of Environmental Quality

DFIRM	Digital Flood Insurance Rate Map
CFR	Code of Federal Regulations
D-SNAP	Disaster Supplemental Nutrition Assistance Program
DBHDS	Department of Behavioral Health and Developmental Services
DBIZ	Dam Break Inundation Zone
DC	District of Colombia
DCJS	Department of Criminal Justice Services
DGS	Virginia Department of General Services
DHCD	Virginia Department of Housing and Community Development
DHR	Virginia Department of Historic Resources
DHS	Department of Homeland Security
DMA2K	Disaster Mitigation Act of 2000
DMTF	Drought Management Task Force
DOC	Virginia Department of Corrections
DOD	United States Department of Defense
DOF	Virginia Department of Forestry
DOH	Virginia Department of Health
DRF	Virginia Disaster Relief Fund
DRM	Virginia Department of the Treasury Risk Management Division
DRU	Disaster Resistant University
DSE	Decadal Signal Extraction
DSFPM	DCR Division of Dam Safety and Floodplain Management
DSHMO	Deputy State Hazard Mitigation Officer
DSIS	Dam Safety Information System
DWR	Department of Wildlife Resources
EAP	Emergency Action Plan
EDA	US Department of Commerce, Economic Development Administration
EEE	Eastern Equine Encephalitis
EF [F0-F5]	Enhanced Fujita Scale
EMAC	Emergency Management Assistance Compact
EMP	Electromagnetic Pulse
EMPG	Emergency Management Performance Grants
EMS	Emergency Medical Services
EO	Executive Order
EOC	Emergency Operations Centers
EOP	Emergency Operations Plan
EPA	United States Environmental Protection Agency
EPP	Emergency Preparedness Plan
ESF	Emergency Support Function

EWP	Emergency Watershed Protection
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FDA	Food and Drug Administration
FHA	Federal Housing Administration
FIRM	Flood Insurance Rate Maps
FIT	FEMA Integration Team
FMA	Flood Mitigation Assistance
FNS	Food and Nutrition Service
FSA	Farm Service Agency
FTF	Fight the Flood
FY	Fiscal Year
GA	Grants Administrators
GE	Geographic Extent
GIC	Geomagnetic Induced Current
GIS	Geographic Information System
GMD	Geomagnetic Disturbance
GPS	Global Positioning System
GRCC	Green Rock Correctional Center
HAV	Hepatitis A Virus
HAZMAT	Hazardous Material(s)
HAZUS	FEMA Natural Hazard Analysis Tool
HEC-RAS	Hydrologic Engineering Center River Analysis System
HF	High Frequency
HHPD	High Hazard Potential Dam
HHS	United States Department of Health and Human Services
HIFLD	Homeland Infrastructure Foundation-Level Data
HIRA	Hazard Identification and Risk Assessment
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HMTAP	Hazard Mitigation Technical Assistance Program
HPP	Hospital Preparedness Program
HSGP	Homeland Security Grant Program
HSIP	Federal Homeland Security Infrastructure
HUD	United States Department of Housing and Urban Development
HVAC	Heating, Ventilation, and Air Conditioning
HVRI	Hazards and Vulnerability Research Institute

IA	Individual Assistance
ICAR	ODU Institute for Coastal Adaptation and Resilience
ICC	Increased Cost of Compliance Coverage
IDA	Initial Damage Assessment
IDF	Intensity-Duration-Frequency
IFLOWS	Integrated Flood Observing and Warning System
IPCC	Intergovernmental Panel on Climate Change
KM/HR	Kilometers per Hour
LCAR	Local Capabilities Assessment for Readiness
LFQ	Left Front Quadrant
LIDAR	Light Detection and Ranging
MAP	(FEMA's Risk) Mapping, Assessment, and Planning
MD	Maryland
MERS	Middle East Respiratory Syndrome
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MM	Moment Magnitude
mm/yr	Millimeters per year
MMS	Moment Magnitude Scale
MMSL	Monthly Mean Sea Level
MOM	Maximum of the Maximum
MPH	Miles per Hour
MRLC	Multi-resolution Land Characteristics Consortium
MVP	Mountain Valley Pipeline
NASA	National Aeronautics and Space Administration
NC	North Carolina
NCEI	National Centers for Environmental Information
NDSP	National Dam Safety Program
NEHRP	National Earthquake Hazard Reduction Program
NESIS	Northeast Snowfall Impact Scale
NFIA	National Flood Insurance Act
NFIF	National Flood Insurance Fund
NFIP	National Flood Insurance Program
NHP	National Hurricane Program
NIMS	National Incident Management System
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NOVA	Northern Virginia
NPMS	National Pipeline Mapping System

NPO	Nonprofit Organization
NRCS	United States Natural Resources Conservation Service
NRI	National Risk Index
NVRIC	Northern Virginia Regional Intelligence Center
NWI	National Wetlands Inventory
NWS	National Weather Service
UASI	Urban Area Security Initiative
ODU	Old Dominion University
OTS	Office of Transportation Sustainability
RC	Regional Commission
RNA	Rapid Needs Assessment
PA	Public Assistance
PAR	Population at Risk
PCA	Project Cooperation Agreement
PDA	Preliminary Damage Assessment
PDC	Planning District Commission
PDF	Portable Document Format
PDM	Pre-Disaster Mitigation
PDSI	Palmer Drought Severity Index
PE	Professional Engineer
PGA	Peak Ground Acceleration
PHEP	Public Health Emergency Preparedness
PHMSA	Pipeline and Hazardous Materials Safety Administration
PL	Public Law
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PPD-21	Presidential Policy Directive 21
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RAFT	Resilience Adaptation Feasibility Tool
RAMS	Recovery and Mitigation Specialists
RFQ	Right Front Quadrant
RGGI	Regional Greenhouse Gas Initiative
RL	Repetitive Loss
ROW	Right-of-Way
RPA	Resource Protection Area
RSI	Regional Snowfall Index
RSLR	Relative Sea Level Rise
SACAP	Special Assistant to the Governor for Coastal Adaptation and Protection
SBA	United States Small Business Administration

SC	South Carolina
SCC	Virginia State Corporation Commission
SDF	Spillway Design Flood
SE	Southeast
SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
SHMP	State Hazard Mitigation Plan
SHPO	State Historic Preservation Offices
SLFRF	State and Local Fiscal Recovery Fund
SLOSH	Sea, Land, and Overland Surges from Hurricanes
SLR	Sea Level Rise
SNAP	Supplemental Nutrition Assistance Program
SoVI	Social Vulnerability Index
SPC	National Weather Service Storm Prediction Center
SRL	Severe Repetitive Loss
SURE	Supplemental Revenue Assistance Payment Program
SVRGIS	Storm Prediction Center Severe Weather GIS
SSR	Shoreline Situation Reports
SW	Southwest
SWCB	Virginia Soil and Water Conservation Board
SWM	Stormwater Management
SWPC	Space Weather Prediction Center
SWPT	Sewell’s Point
TAC	Technical Assistance Coordinator
TBD	To Be Determined
TD	Tropical Depression
THIRA	Threat Hazard Identification and Risk Assessment
TN	Tennessee
TS	Tropical Storm
USACE	United States Army Corps of Engineers
USC	United States Code
USCG	United States Coast Guard
USBC	Virginia Uniform Statewide Building Code
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
VA	Virginia
VADOC	Virginia Department of Corrections
VAPS	Virginia Agency Property System

VASEM	Virginia Academy of Science, Engineering, and Medicine
VCPC	Virginia Coastal Policy Center
VDEM	Virginia Department of Emergency Management
VDFP	Virginia Department of Fire Programs
VDH	Virginia Department of Health
VDOF	Virginia Department of Forestry
VDOT	Virginia Department of Transportation
VEDSS	Virginia Electronic Disease Surveillance System
VEHTP	Virginia Environmental Health Tracking Program
VEOC	Virginia Emergency Operations Center
VEST	Virginia Emergency Support Team
VFC	Virginia Fusion Center
VFMA	Virginia Floodplain Management Association
VFRIS	Virginia Flood Risk Information System
VIMS	Virginia Institute of Marine Science
VITA	Virginia Information Technologies Agency
VMASC	Virginia Modeling, Analysis, and Simulation Center
VMRC	Virginia Marine Resources Commission
VOAD	Volunteer Organizations Active in Disaster
VRA	Virginia Resources Authority
VTSO	Virginia Tech Seismological Observatory
VWP	Virginia Water Protection Program
WAL	Wallops Island
WFO	Weather Forecasting Offices
WHP	Wildfire Hazard Potential
WHO	World Health Organization
WNV	West Nile Virus
WSR-88D	Weather Surveillance Radar, 1988, Doppler
WV	West Virginia

Acronyms for Chapter 5 – Mitigation Strategy, Only

E	Erosion
EH	Extreme Heat
FL	Flooding
G	Geologic
HC	Human-Caused
IF	Impoundment Failure
MH	Multi-Hazard
P	Pandemic
S	Space Weather
WF	Wildfire

Appendix B:

Authorities and References

Chapter 1

- *National Mitigation Framework, Second Edition*, June 2016
- 4 CFR §13.11
- *Commonwealth of Virginia Emergency Operations Plan*, October 2021
- Disaster Mitigation Act of 2000, found in Section 44, §201.4 of the Code of Federal Regulations (CFR). Commonly referred to as "DMA2K", Public Law 106-390 was signed into law October 10, 2000, and amends the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act
- *Code of Virginia* §44-146.17
- *Code of Virginia* §44-146.22

Chapter 3

- *Code of Virginia* §10.1-603
- *Code of Virginia* §10.1-604
- *Code of Virginia* §10.1-605
- *Code of Virginia* §10.1-608
- *Code of Virginia* §10.1-609
- *Code of Virginia*, Chapter 495, §§ 2.2-222.4, 10.1-602, 10.1-658, and 10.1-659
- *Virginia Administrative Code*, §4VAC50-20

Chapter 4

- *Code of Virginia* §15.2-2224
- *Code of Virginia* §15.2-2223 *et seq.*
- *Code of Virginia* §15.2-2283
- *Code of Virginia* §15.2-2241
- *Code of Virginia* §36-98
- *Code of Virginia* §44-146.19
- *Code of Virginia* §44-146.29
- *Code of Virginia* §44-146.30
- *Code of Virginia* §44-146.34
- *Code of Virginia* §44-146.38
- *Code of Virginia* §10.1-602
- *Code of Virginia* §55.1-708
- *Code of Virginia* Chapter 13, Title 10.1, Article 4, Section 10.1-603.24, and Section 10.1-603-25, and the provisions of §10.1-1330
- *Code of Virginia* § 62.1-44.15:24 et seq.
- *Code of Virginia* §62.1-44.15:51 et seq.

Chapter 7

- *Code of Virginia* §44-146.17
- *Code of Virginia* §11-146.22

Chapter 8

- *Code of Virginia* §44-146.22

Appendix C:

Meeting Documentation

Meeting Attendance

Meeting	Attendees	Organization
Kickoff Meeting		
3/25/2022	Stacy McKinley	VDEM
	Suzen Collins	VDEM
	Jennifer McKee	VDEM GIS
	Barry Ezell	ODU VMASC
	Jennifer Lindgens	ODU VMASC
	Jessica Whitehead	ODU LCAR
	Wie Yusef	ODU LCAR
	Jim Lambert	UVA CRMES
	Tom Polmateer	UVA CCAL
	Davis Loose	UVA CRMES
	Leigh Chapman	Salter's Creek Consulting, Inc.
	Allison Bryan	Moffat & Nichol
	Amy Mindick	Moffat & Nichol
	Brian Joyner	Moffat & Nichol
VHMAC Workshop #1		
4/26/2022	Stacy McKinley	VDEM
	Messmer, Debbie	VDEM
	McKee, Jennifer	VDEM
	Collins, Susan	VDEM
	Olajumoke Akinrimisi	VDEM
	Alexander Krupp	VDEM
	Archer Stark	VDEM
	Michelle Oblinsky	VDEM
	Archer Stark	VDEM
	Bob Coiner	VA Association of PDC
	Jessica Whitehead	ODU
	Jennifer Lindgens	ODU
	Wie Yusuf	ODU
	Barry Ezell	ODU
	Jim lambert	UVA
	Davis Loose	UVA
	Allison Bryan	UVA
	Tom Polmateer	UVA
	Ronnie Hill	UVA
	Allison Bryan	M&N
	Bryan Joyner	M&N

Meeting	Attendees	Organization
	Amy Mindick	M&N
	Sarah Hamm	M&N
	Rachel Baker	M&N
	Wendy Howard Cooper	DCR
	Angela Davis	DCR
	Marc Holma	DHR
	Megan Melinat	DHR
	Matt Dalon	DCR
	Kyle Flanders	DHCD
	Paul Messplayiv	DHCD
	Anne Witt	DOE
	Jason Braunstein	DOF
	Eric Seymour	NOAA
	William Isenberg	DEQ
	Branson Degraaf	DGS
	Hui-Shan Walker	Hampton
	Paul Hoyle	Grayson County
	Jessica Swinney	Wise County
	Leigh Morgan Chapman	Salter's Creek
	Johnathon Kiser	VDH
	Chris Patterson	VDH
	Matt Lott	VDOT
	John Scrivani	VDOT
	Ross Weaver	Wetlands Watch
	Afi Anuar	ODU
VHMWG Workshop #1		
6/22/2022	Stacy McKinley	VDEM
	Davis Loose	University of Virginia
	Harry Gruenspecht	Northern Virginia Emergency Response System
	Megan Melinat	Virginia Dept. of Historic Resources
	Chris Patterson	Virginia Department of Health
	Will Isenberg	DEQ - Coastal Zone Management Program
	Eddie Wells	Roanoke Valley-Alleghany Regional Commission
	Brian Mensing	DMAS
	Tracie Giles	Longwood University
	Shane Anderson	UVA Health

Meeting	Attendees	Organization
	Megan Cruz	Virginia Commonwealth University
	Robert Butler	Colonial Williamsburg Foundation
	Ashley Mills	Accomack-Northampton Planning District Commission
	Isabella O'Brien	Thomas Jefferson Planning District Commission
	Rebecca Joyce	Central Shenandoah Planning District Commission
	Chad Neese	Southside Planning District Commission
	Amy Howard	VSEM
	Matt Lott	VDOT
	Dan Shantler	UVA, Facilities Management
	Kristen Fagan	William & Mary
	Louise Salinas	VMASC/ODU
	Wendy Howard Cooper	DCR
	Thomas Lawson	LENOWISCO PDC
	Jim Redick	Norfolk Emergency Preparedness & Response
	Chris Shelton	Roanoke Higher Education Center
	Martin Chapman	Virginia Tech Geosciences Department
	Jason Burrow	Va Dept of Military Affairs
	Kelly Hitchcock	Central Virginia Planning District Commission
	Anne Witt	Virginia Department of Energy
	Sarah Hamm	Moffatt & Nichol
	Marc Holma	Department of Historic Resources
	Leigh Chapman	Salter's Creek Consulting
	Barry Ezell	ODU VMASC
	Laurie Perez	VDSS
	Angela Davis	VA DCR
	Maria Mutuc	Virginia Department of Transportation
	Jessica Whitehead	ODU ICAR
	Katherine Pitts	Colonial Williamsburg Foundation
	Liz Adams	VDEM
	Amy Mindick	Moffatt & Nichol
	Matthew Ettinger	Virginia Department of Health, Office of Radiological Health

Meeting	Attendees	Organization
VHMAC Workshop #2		
6/30/2022	Barry Ezell	VMASC
	Louise Salinas	VMASC
	Kyle Flanders	DHCD
	Paul Hoyle	Grayson County
	Stacy McKinley	VDEM
	Chris Patterson	Virginia Department of Health
	Leigh Chapman	Salter's Creek Consulting
	Suzen Collins	VDEM
	Jason Braunstein	Virginia Department of Forestry (VDOF)
	Davis Loose	UVA
	Matt Lott	VDOT
	Anne Witt	Virginia Dept of Energy
	Amy Mindick	Moffatt & Nichol
	Jessica Whitehead	ODU Institute for Coastal Adaptation and Resilience
	Wendy Howard-Cooper	DCR
	Debbie Messmer	VDEM, State Hazard Mitigation Officer
	Alex Krupp	VDEM
	Will Isenberg	Virginia CZM
VHMWG Workshop #2a		
7/12/2022	Barry Ezell	VMASC
	Stacy McKinley	VDEM
	Leigh Chapman	Salter's Creek
	Louise Salinas	VMASC
	Matt Doxey	VADOC
	Mari Radford	Community Planning Lead FEMA R3
	Matt Heller	Virginia Dept. of Energy
	Amy Hoffman	VDEM
	Ashley Mills	Accomack-Northampton Planning District Commission
	Anne Witt	Geohazards Geologist - Virginia Dept of Energy
	Phil Miskovic	DBHDS
	George Damon	Appalachian Natural Gas Company
	Jess Whitehead	ODU Institute for Coastal Adaptation and Resilience
	Dorette Sobolewski	Frontier Culture Museum

Meeting	Attendees	Organization
	Debbie Messmer	VDEM SHMO
	Chad Neese	Southside PDC
	Elliot Day	VDEM
	Davis Loose	UVA
	Amy Howard	VDEM
	Suzen Collins	VDEM
	Paul Messplay	Virginia Department of Housing and Community Development
	Jessica Swinney	County of Wise
	Griffin Kearns	VDEM Region 7
	Tracy Hanger	Hampton Office of Emergency Management
	Steve Pellei	VADOC
	Ross Weaver	Wetlands Watch
	Kristen Fagan	William & Mary
	Thomas Lawson	LENOWISCO PDC
	Kaleen Lawsure	VMASC/ODU
	Joseph Moore	VDEM - Regional Recovery & Mitigation Specialist, Region 4
	Kate Archie	VDSS
	Christopher Yeager	VADOC
	John Zelsnack	VDEM
	Emily Seigel	VDEM
	Patrick Mauney	Rappahannock-Rapidan Regional Commission
	Travis Perry	UVA Wise
	Liz Adams	VDEM
	JIm Redick	Norfolk Emergency Preparedness and Response
	Brandi Frazier Bestpitch	Energy Emergency Assurance Coordinator, Virginia Energy
	Rebecca Joyce Central	ShenandoahPDC
	Jumoke Akinrimisi	VDEM ODI
	Maria Mutuc	VDOT
	Laura Hahn	Upper Mattaponi Indian Tribe Emergency Management
	Amanda Weaver	VDEM Region 1
	Chris Bruce	VDEM Region 5 All-Hazards Planner
	Matt Lott	VDOT

Meeting	Attendees	Organization
	Chris Patterson	VDH
	Lucy Carter Smith	VDEM Region 3 DRRO
	David Eagle	VDEM Region 1
	John Bateman	NNPDC
	Alex Krupp	VDEM
VHMWG Workshop #2b		
7/14/2022	Liz Adams	VDEM
	Trina Addison	VDEM
	Ian Baxter	TJPDC
	Chris Bruce	VDEM
	Brandy Buford	DCR
	Leigh Chapman	Salter's Creek
	Suzen Collins	VDEM
	Mewgan Cruz	VCU
	Matt Dalon	DCR
	Angela Davis	DCR
	Matthew Doxey	DOC
	Timothy Eddy	UVA
	Barry Ezell	ODU VMASC
	Stacey Farinholt	DCR
	Darryl Glover	DCR
	Matt Heller	Virginia Energy
	Ronnie Hill	UVA
	Amy Howard	VDEM
	Sidney Huffman	DCR
	Jacob Hughes	VDEM
	Richard Jones	DOC
	Griffin Kearns	VDEM
	John Krik	DWR
	Davis Loose	UVA
	Stacy McKinley	VDEM
	Debbie Messmer	VDEM
	Thomas Meyer	DOC
	Michale Mulhare	VT EM
	Maria Mutuc	VDOT
	Isabella O'Brien	TJPDC
	Chris Patterson	VDH
	Tammie Purkey	DOC
	Mari Radford	FEMA R3
	Dan Shantler	UVA Facilities Mgmt

Meeting	Attendees	Organization
	Michael Smith	Virginia Natural Gas
	David Stroud	Wood Environment & Infrastructure Solutions
	Amanda Weaver	VDEM
	Anne Witt	Virginia Energy
	Christopher Yeager	DOC
	Joke Akinrimisi	VDEM

Meeting Agendas

Kickoff Meeting
3/25/2022

I. Welcome/Introductions (ODU, UVA, Salter's Creek, Moffatt & Nichol, VDEM)
II. Milestones
III. Mitigation Planning Team
IV. Plan of Action
V. Data Needs List Under Development
VI. Review of Existing Hazard List for Obvious Changes for New HIRA
VII. Immediate Next Steps

VHMAC Workshop #1
4/26/2022

I. Introductions and Opening Remarks – VDEM and ODU
II. Terminology Review
III. Mitigation Planning Cycle
IV. Composition of Committees
V. Project Milestones
VI. Plan of Action
VII. HIRA
   a. Data Needs
   b. Incorporating Climate Change
   c. Incorporating Social Vulnerability
   d. Capability Assessment & Gap Analysis
VIII. Existing Plan Goals
IX. Closing Remarks

VHMWG Workshop #1
6/22/2022

I. Welcome – Barry Ezell, ODU
   a. Introduce the Analysis Team
   b. Review Agenda for WG Meeting

    c. State HMP Timeline

II. Overview of the Planning Process – Leigh Chapman, Salter's Creek Consulting
    a. Participants & Committee Structure
    b. Four Phase FEMA Planning Process
    c. Current Progress

III. Hazard Identification and Risk Assessment Summary – Sarah Hamm, Moffatt & Nichol
    a. 2018 Hazard List vs. 2023 Hazard List
    b. Recent Disaster Declarations
    c. Data Sources Used in HIRA
    d. Select Hazard Reviews
        i. Flooding
            1. Recent Incidents
            2. Risk Description
            3. Climate Change Impacts
            4. Social Vulnerability
            5. Community Lifelines Impacts - INTERACTIVE
        ii. Hurricane
            1. Recent Incidents
            2. Risk Description
            3. Climate Change Impacts
            4. Social Vulnerability
            5. Community Lifelines Impacts - INTERACTIVE
        iii. Extreme Heat
            1. Recent Incidents
            2. Risk Description
            3. Climate Change Impacts
            4. Social Vulnerability
            5. Community Lifelines Impacts - INTERACTIVE
        iv. Tornado
            1. Recent Incidents
            2. Risk Description
            3. Climate Change Impacts
            4. Social Vulnerability
            5. Community Lifelines Impacts - INTERACTIVE
        v. Winter Weather
            1. Recent Incidents
            2. Risk Description
            3. Climate Change Impacts
            4. Social Vulnerability
            5. Community Lifelines Impacts – INTERACTIVE

IV. Appendix K Update Briefing - UVA

V. Hazard Ranking Exercise – INTERACTIVE – Barry Ezell, Sarah Hamm, and Leigh Chapman

VI. Next Steps – Barry Ezell, ODU
  a. HIRA Review
  b. July Working Group Meetings
    i. July 12, 2022 – Capability Assessment Review; Develop Goals & Objectives
    ii. July 14, 2022 – Mitigation Action Plan Development
  c. FEMA Deadlines

VHMAC Workshop #2
6/30/2022

I. Welcome, Barry Ezell, ODU
  a. Review today's agenda
  b. State HMP Timeline

II. Discuss July 12 agenda (Working Group Workshop #2a), Leigh Chapman, Salter's Creek
  a. Reviewing Capability Assessment , Leigh Chapman, Salter's Creek
  b. Reviewing Gap Analysis, Davis Loose, UVA
  c. Updating Goals and Objectives, Leigh Chapman, Salter's Creek
  d. Introduction to Mitigation Action Development, Leigh Chapman, Salter's Creek
    i. Possible video:
      FEMA future conditions mitigation planning: (just 0:51 – 1:15, total 24 minutes) https://www.youtube.com/watch?v=VHHGtCt7ZMM
    ii. Mitigation Action Categories
    iii. Examples
    iv. Prioritization Principles

III. Discuss July 14 agenda (Working Group Workshop #2b), Leigh Chapman, Salter's Creek
  a. Organization
    i. Tables organized by agency/Room Layout
    ii. Inclusion of Stakeholders
    iii. Nature of introductory materials
  b. Handouts
    i. Mitigation Action Categories
    ii. Gap Analysis and other ideas from previous meetings
    iii. Printing critical info from HIRA
      1. Maps of critical facilities, floodplain, state assets
      2. Other?
    iv. Mitigation Action Worksheets
  c. Facilitation
    i. Fostering agency partnerships
    ii. How to incorporate existing Mitigation Actions?

iii. Whiteboards

d. How Advisory Committee Can Help

i. Encourage multiple reps from agencies and programs

ii. In Person Attendance is Critical

1. Backup plan

IV. Next Steps, Barry Ezell, ODU

V. Conclude

VHMWG Workshop #2a
7/12/2022

I. Opening Remarks –VDEM

II. Welcome – Barry Ezell, ODU

a. Discuss Today's Agenda

b. State HMP Timeline

III. Preparing to Plan

a. Review Capability Assessment– Leigh Chapman, Salter's Creek

b. Review Gap Analysis – Davis Loose, UVA

c. Update Goals and Objectives

i. Review Other State/Regional Goals

ii. Update Virginia's Goals and Objectives – Leigh Chapman, Salter's Creek INTERACTIVE

IV. Short Break

V. Introduction to Mitigation Action Plan Development

a. Mitigation Action Categories and Examples - Leigh Chapman, Salter's Creek

i. Prevention of Future Risk

ii. Protection of the Built Environment

iii. Natural Resource Protection

iv. Hazard Modification through Construction

v. Emergency Services

vi. Public Education and Awareness

vii. Risk Analysis

b. Mitigation Action Prioritization Criteria and Methodology

c. Discuss Working Group Workshop #2b - Leigh Chapman, Salter's Creek and Barry Ezell, ODU

VI. Next Steps – Barry Ezell, ODU

VII. FEMA Video (optional) – *Future Conditions Mitigation Planning*

VHMWG Workshop #2b
7/14/2022

I. Opening Remarks

II. Welcome – Barry Ezell, ODU

III. Review Updated Goals & Objectives – Leigh Chapman, Salter's Creek

IV. Working with Breakout Group Templates - Leigh Chapman, Salter's Creek
   a. Evaluating existing mitigation actions
   b. Adding new mitigation actions
   Reminder – MITIGATION versus RESPONSE
V. Next Steps – Barry Ezell, ODU

Appendix D:

Threats

This Appendix reports technological and human-caused hazards from the Commonwealth of Virginia Threat and Hazard Identification and Risk Assessment (C-THIRA). The hazards identified as primary concerns are low probability, high consequence events that would have significant life, property, and social impacts and span multiple sectors. These hazards were identified as relevant to Virginia using several criteria, including: historical occurrence, economic impact, social vulnerabilities, geographical location, health considerations, and impacts on critical infrastructure and key resources. These threats were further validated by directly contacting state agencies and reviewing the work done be the UASI regions and localities to identify events of importance to them and by direct contact with state agencies (2018 C-THIRA).

The identification of relevant threats also considered the need for inclusion across all geographical regions of the state. The use of geography as a qualifier supports future regional and local interactions, allowing for a comprehensive, state-wide perspective and recognizing that all events have impacts and needs that are directly proportional to the local and regional ability to address them. A smaller event in a less resource-enabled locality might have a parallel overall impact level as a more resource-enabled community in the wake of a larger event.

The threats included in this Appendix correspond to the technological and human-caused hazards included in the 2014 and 2018 C-THIRA reports. These threats are:

- Hazardous Materials Incident (2018 C-THIRA)
- Complex Coordinated Attack (2014 C-THIRA, 2018 C-THIRA)
- Cyber Attack (2018 C-THIRA)
- Improvised Nuclear Device (2014 C-THIRA, 2018 C-THIRA)

Electromagnetic pulse (EMP) is a human-caused hazard that is new for the 2023 update. These threats were also reviewed and discussed with stakeholders during the Advisory Committee workshop in April 2022.

D.1 Hazardous Materials Incident

D.1.1 Description

Hazardous material (HAZMAT) incidents involve the accidental or intentional release of solid, liquid, and/or gaseous material that poses significant threats to public health, infrastructure, or the environment. HAZMAT incidents may last hours or days and the harmful effects from contamination may extend over longer periods of time. This hazard profile includes various types of HAZMAT incidents – fixed site, waterway, highway, pipeline, and railway.

HAZMAT incidents sometimes co-occur with other hazards and threats. For example, explosions and fires may follow the initial release of contaminants. HAZMAT incidents may also occur due to other hazard events – in the wake of Hurricane Katrina in 2005 over 200 reports were filed noting the release of petroleum, natural gas, and other hazardous materials. HAZMAT incidents can include any discharge of hazardous materials but notably excludes the release of poisons solely within a workplace, emissions from engine exhaust, material from nuclear activities or incidents, and the application of fertilizers.

The impacts of HAZMAT incidents span the economic, environmental, and public health/safety domains. Economic impacts may include the closure of critical facilities, roads, or a reduction in commerce due to the incident. Large incidents may incur a cost for fire response, controlling the spread of contaminants, and cleanup. Other economic impacts include the costs of litigation and repair costs. For example, a chlorine gas cloud in Bedford, Virginia in 2022 caused the evacuation of nearby homes and businesses as well as a road closure.

Environmental impacts may include impacts to local water supplies, wildlife, and wetlands near shorelines. HAZMAT incidents that include fires may harm local plant and animal life. A spill may seep into groundwater, afflicting well water and impacting the health and safety of nearby residents. Gas clouds are known to impact migratory bird corridors. Illegal dumping and unreported HAZMAT incidents are difficult to respond to and clean up.

Residents and first responders may be harmed due to exposure to a HAZMAT incident. Response personnel are trained to protect themselves from HAZMAT, but exposure is possible. Gas clouds and groundwater contamination may lead to the evacuation of residents. Toxic floodwater events are also a danger to communities in Virginia. For example, the storm surge due to Hurricane Matthew in 2016 caused large portions of a public landfill to wash into inhabited areas.[1] In 2011, the Clinch River flooded into an industrial area, causing petroleum materials to be released into inhabited areas.[2]

The most common and complete listing of hazardous materials is found in 49 CFR, §172.101, *List of Hazardous Materials Descriptions,* and contains thousands of defined hazardous materials.[3]

The US Department of Transportation, via the Federal Motor Carrier Safety Administration, categorizes hazardous materials in nine classes, with some classes having further delineation within the class:

- Class 1 – Explosive
    - Class 1.1 – Explosive with a mass explosion hazard
    - Class 1.2 – Explosive with a projection hazard, but not a mass explosion hazard
    - Class 1.3 – Explosive with a fire hazard, a minor blast hazard, and/or a minor

    projection hazard, but not a mass explosion hazard
    - Class 1.4 – Explosive presented no significant hazard (explosion limited to package)
    - Class 1.5 – Insensitive explosive with a mass explosion hazard
    - Class 1.6 – Extremely insensitive explosive without a mass explosion hazard
- Class 2 – Gas
    - Class 2.1 – Flammable gas
    - Class 2.2 – Non-flammable, non-toxic gas
    - Class 2.3 – Toxic Gas
- Class 3 – Flammable liquid
    - Class 3.1 – Flammable liquid
    - Class 3.2 – Combustible liquid
- Class 4 – Other Flammable Substance
    - Class 4.1 – Flammable solid
    - Class 4.2 – Spontaneously combustible solid
    - Class 4.3 – Dangerous when wet
- Class 5 – Oxidizing Agent and Organic Peroxide
    - Class 5.1 – Oxidizing agent
    - Class 5.2 – Organic peroxide oxidizing agent
- Class 6 – Toxic and Infectious Substance
    - Class 6.1 – Poison
    - Class 6.2 – Biohazard
- Class 7 – Radioactive Substance
- Class 8 – Corrosive substance
- Class 9 – Miscellaneous [4]

The severity of a hazardous materials release depends upon the type of material released, the amount of the release, and the proximity to populations or environmentally sensitive areas such as wetlands or waterways. The release of materials can lead to injuries or evacuation of nearby residents. Wind direction at the time of the release can also have a bearing on the severity (as well as the location and extent) of a hazardous materials release.

D.1.2 Historic Occurrence

There are nearly 7000 reported HAZMAT incidents per year, the vast majority of which occur on highways. Of these, spills or releases of flammable liquids are the most common. Fixed facilities, like industrial plants, highways, and waterways are where most of the incidents occur. Hampton Roads historically has the greatest number of petroleum and other hazardous materials releases due to the large number of ports and shipping operations in the area.
Recent and notable hazardous materials incidents include:

- Tazewell, VA 2011 – the Clinch River flooded a populated area, where numerous hazardous materials were located. Five hazmat teams walked or floated over 70 miles to clean up the incident. All of the hazardous materials cataloged were petroleum based.[5]

- Norfolk, VA 2015 – a small fire was reported that occurred in a box that contained six 2.5-liter bottles of nitric acid. One worker was injured and evaluated by the Virginia Beach EMS. He was then later transported to an area hospital due to exposure to chemicals and complaints of difficulty breathing.[6]
- Mt. Crawford, VA 2021 – a forklift incident led to the release of potassium permanganate from a plastic drum. The materials burst into flames and were unable to be contained by use of fire extinguishers. The local fire department was called to contain the fire and a HAZMAT team cleaned the spilled chemicals. The event led to the evacuation of local businesses. No injuries or fatalities were reported.[7]
- Bedford, VA 2022 - A chlorine gas cloud was formed near the Bedford Regional Water Authority's (BRWA) Central Wastewater Treatment Plant due to the accidental mixing of 50 gallons of sodium bisulfite and sodium hypochlorite. 16 people were treated for injuries. 46 homes and seven businesses were evacuated as a precaution and the cloud dissipated.[8]

D.1.3 Risk Assessment

Probability

Hazardous materials incidents occur with regularity in Virginia. All jurisdictions in Virginia have a Local Emergency Planning Committee that identifies local industrial hazardous materials and keeps the community informed of the potential risks. All companies that have hazardous chemicals must adhere to federal reporting requirements monitored by the local government and/or planning committee and must inform local emergency management of their response plan.

Impact and Vulnerability

Virginia has large population centers and extensive transportation systems throughout the state that are vulnerable to hazardous materials incidents. Virginia's ports and waterways are also vulnerable to hazardous materials incidents. Minor incidents would likely cause no damage and little disruption, assuming they could be contained quickly and do not involve particularly volatile or damaging chemicals. Major incidents could have fatal and disastrous consequences. The severity of a hazardous material release relates primarily to its impact on human safety and welfare and on the threat to the environment.

Threats to human safety and welfare include:

- Poisoning of water or food sources and/or supply;
- Presence of toxic fumes or explosive conditions;
- Damage to personal property;
- Need for the evacuation of people; and
- Interference with public or commercial transportation.

Threats to the environment include:

- Injury or loss of animals or plants or habitats that are of economic or ecological importance such as: commercial, recreation, or subsistence fisheries (marine plants, crustaceans, shellfish, aquaculture facilities) or livestock; marine bird rookeries; and
- Impact to ecological reserves, forests, parks, archaeological, and cultural sites.

Figures D-1 through D-21 show critical asset vulnerability to hazardous materials incidents, including one mile buffer zones for highways, pipelines, and railroads, the most likely conveyances for hazardous materials. The following figures are organized by VDEM Region. In addition to Figure D-1 through D-21, section three of the plan includes discussion and mapping of hazardous materials facilities located in the floodplains of the Commonwealth.

Figure D-1: VDEM Region 1 Hazardous Materials Incident Highway Buffer Zones with Critical Assets

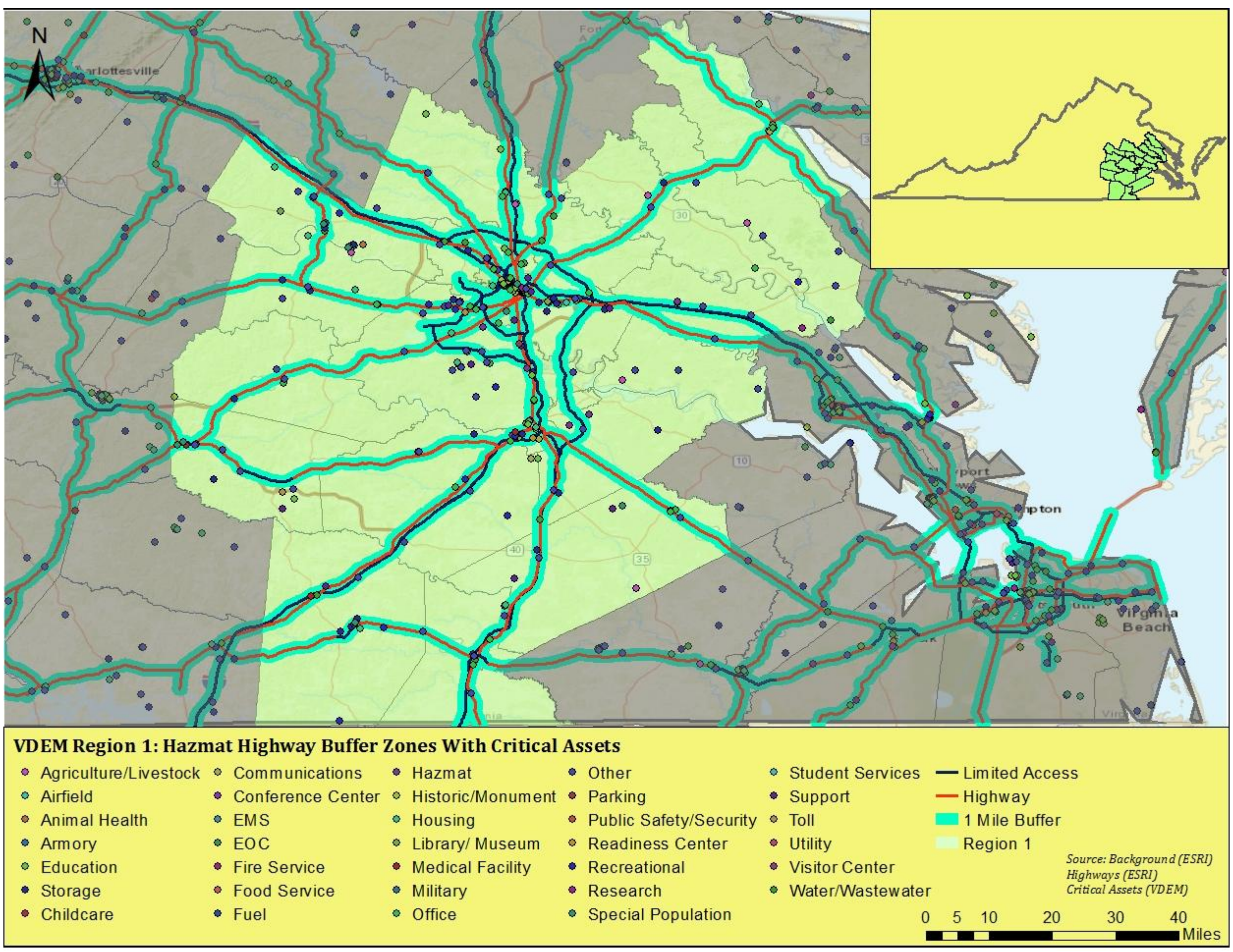


Figure D-2: VDEM Region 1 Hazardous Materials Incident Pipeline Buffer Zones with Critical Assets

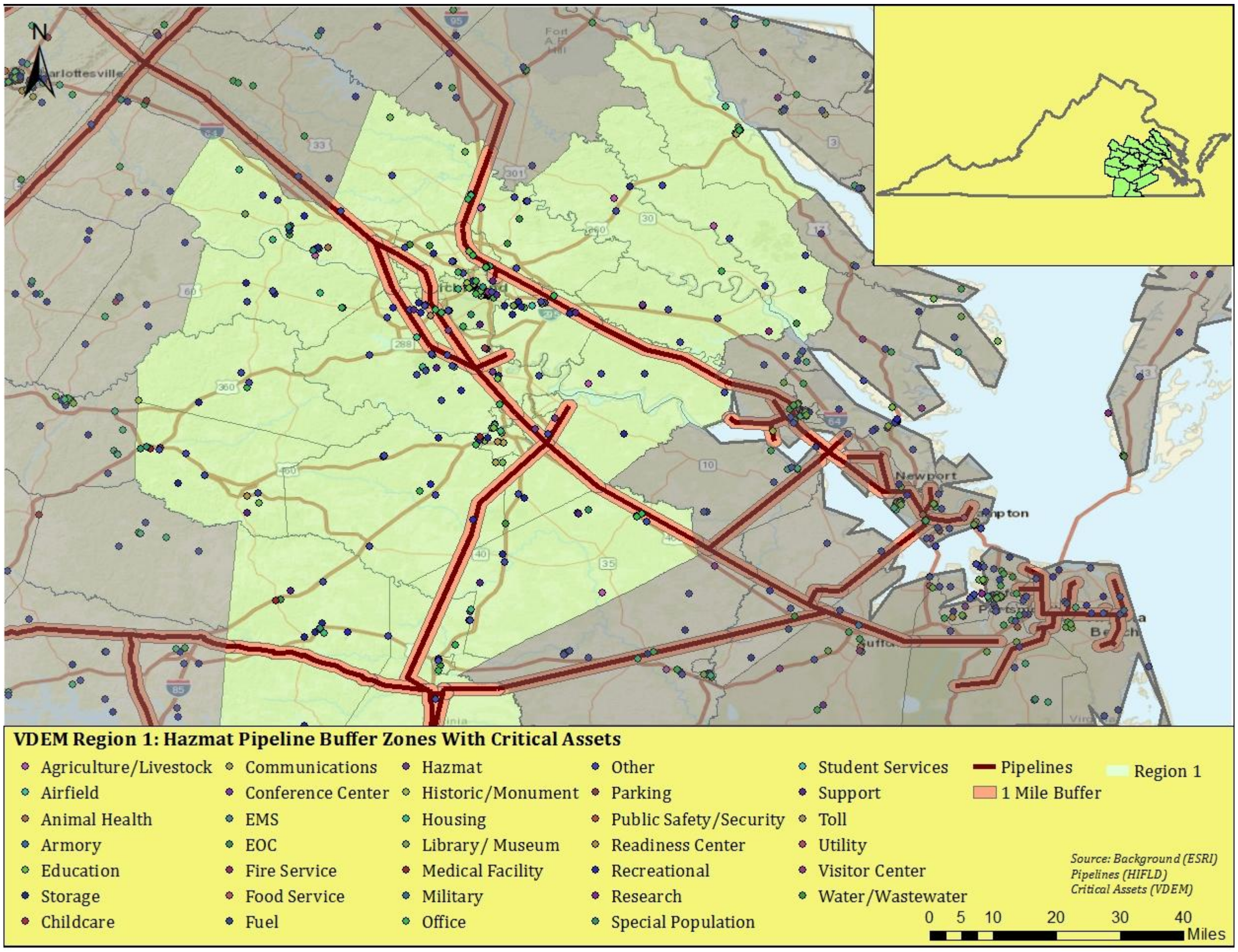


Figure D-3: VDEM Region 1 Hazardous Materials Incident Railroad Buffer Zones with Critical Assets

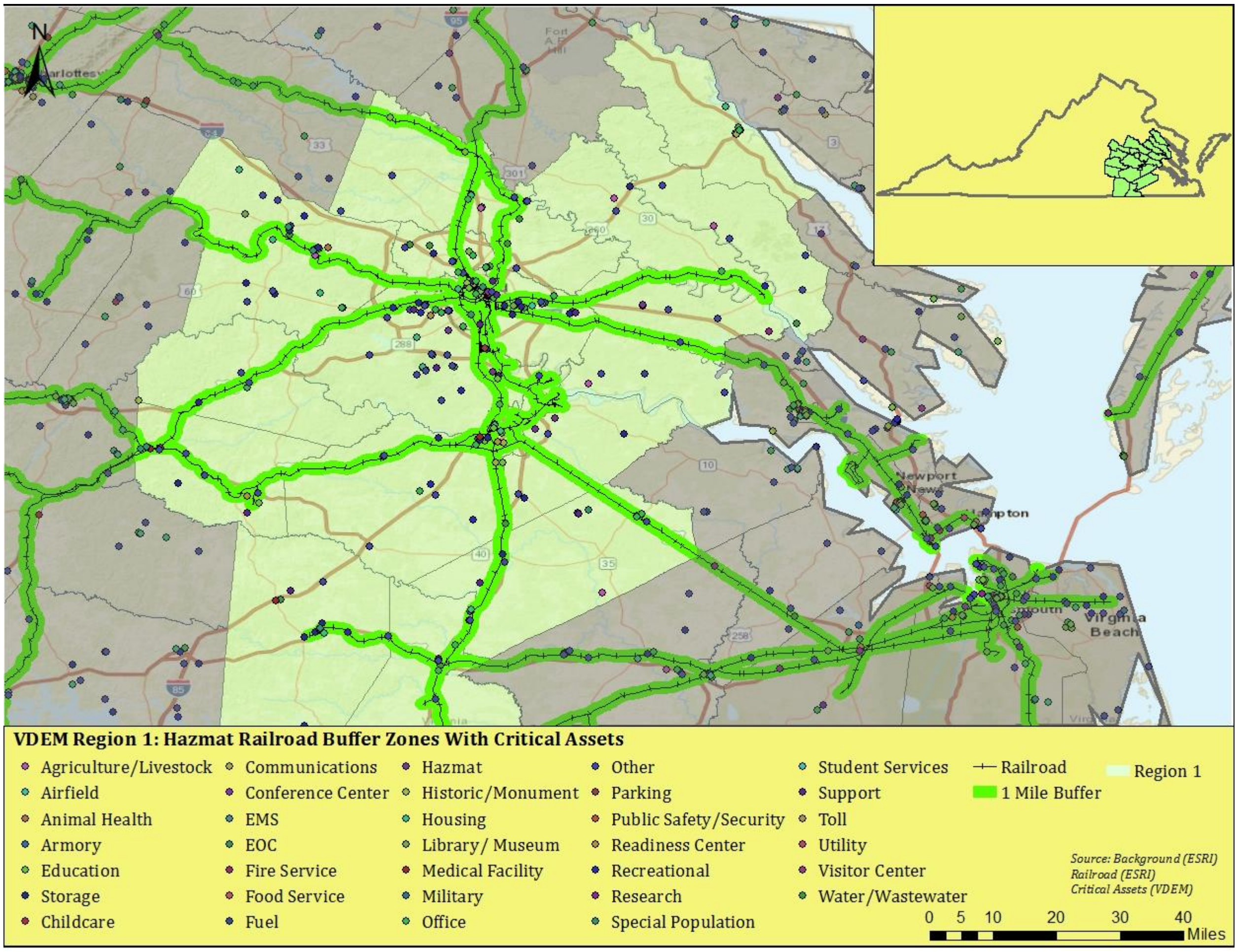


Figure D-4: VDEM Region 2 Hazardous Materials Incident Highway Buffer Zones with Critical Assets

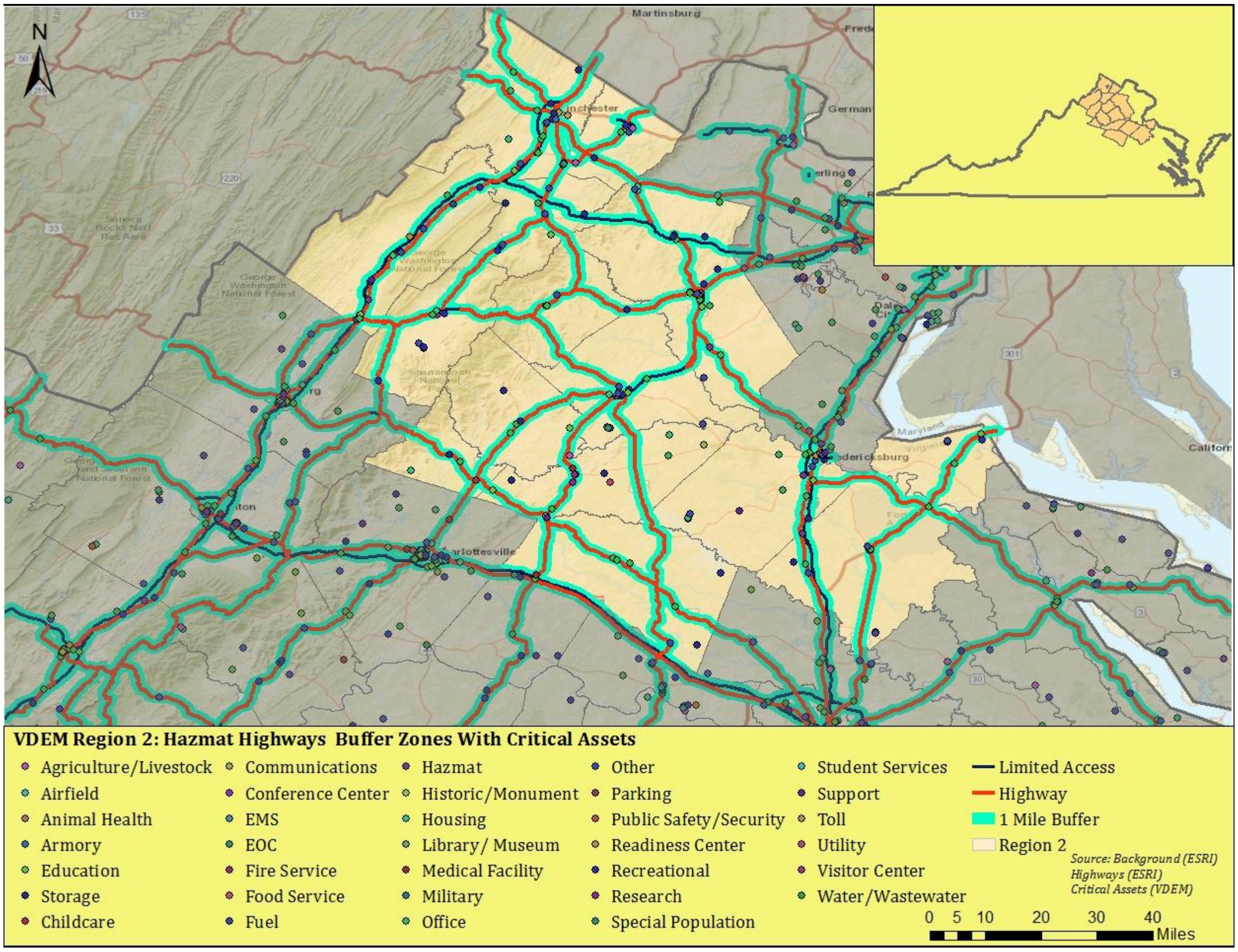


Figure D-5: VDEM Region 2 Hazardous Materials Incident Pipeline Buffer Zones with Critical Assets

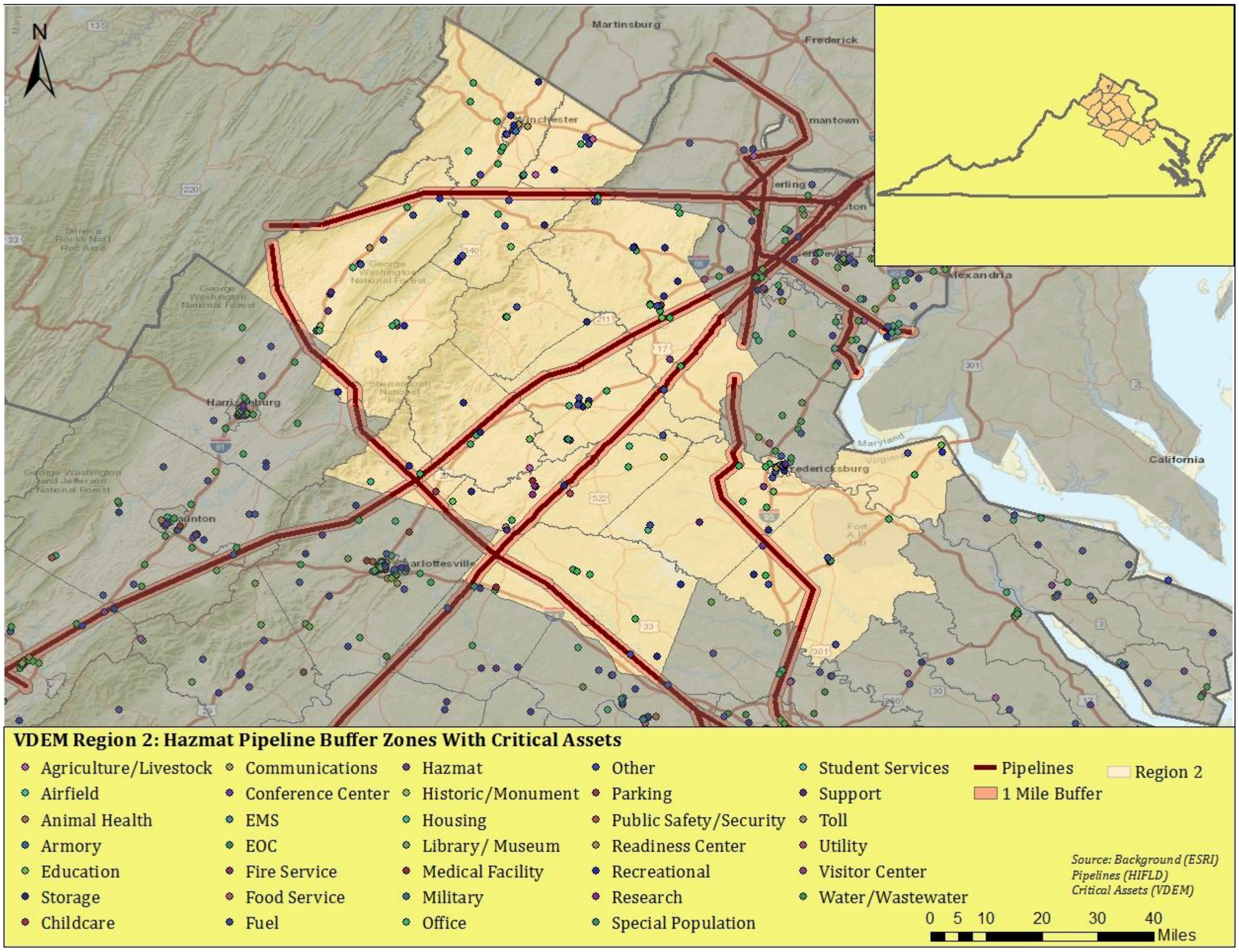


Figure D-6: VDEM Region 2 Hazardous Materials Incident Railroad Buffer Zones with Critical Assets

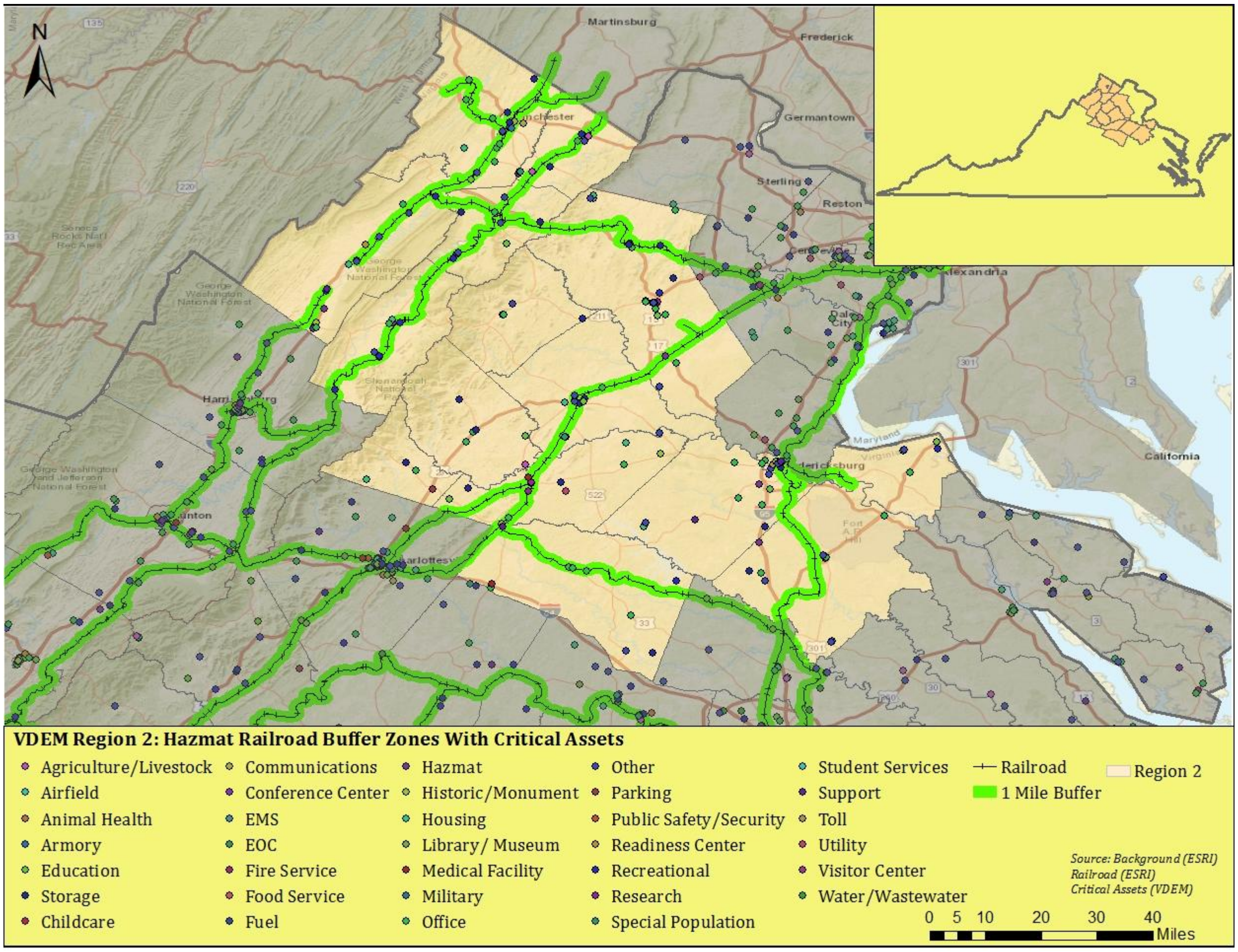


Figure D-7: VDEM Region 3 Hazardous Materials Incident Highway Buffer Zones with Critical Assets

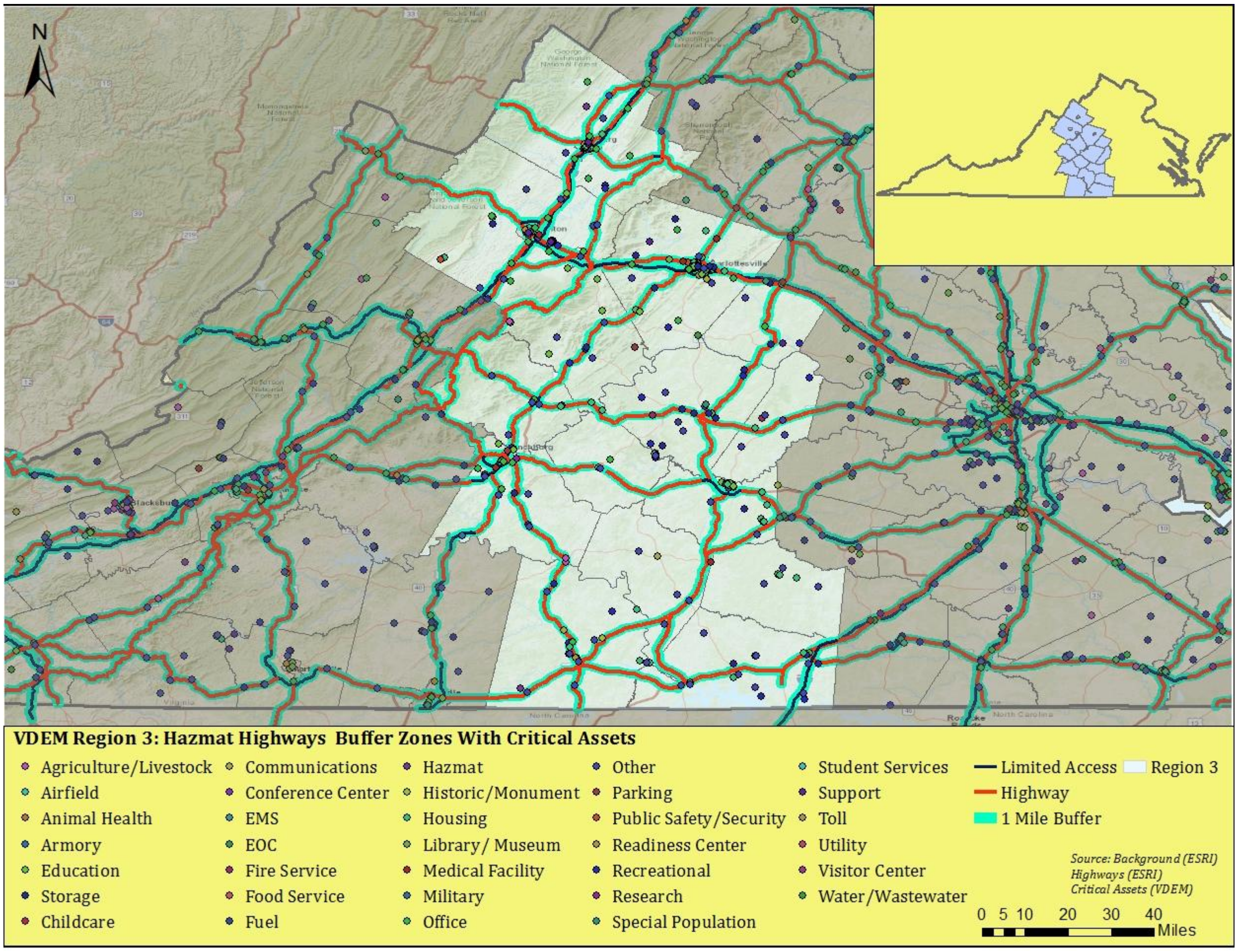


Figure D-8: VDEM Region 3 Hazardous Materials Incident Pipeline Buffer Zones with Critical Assets

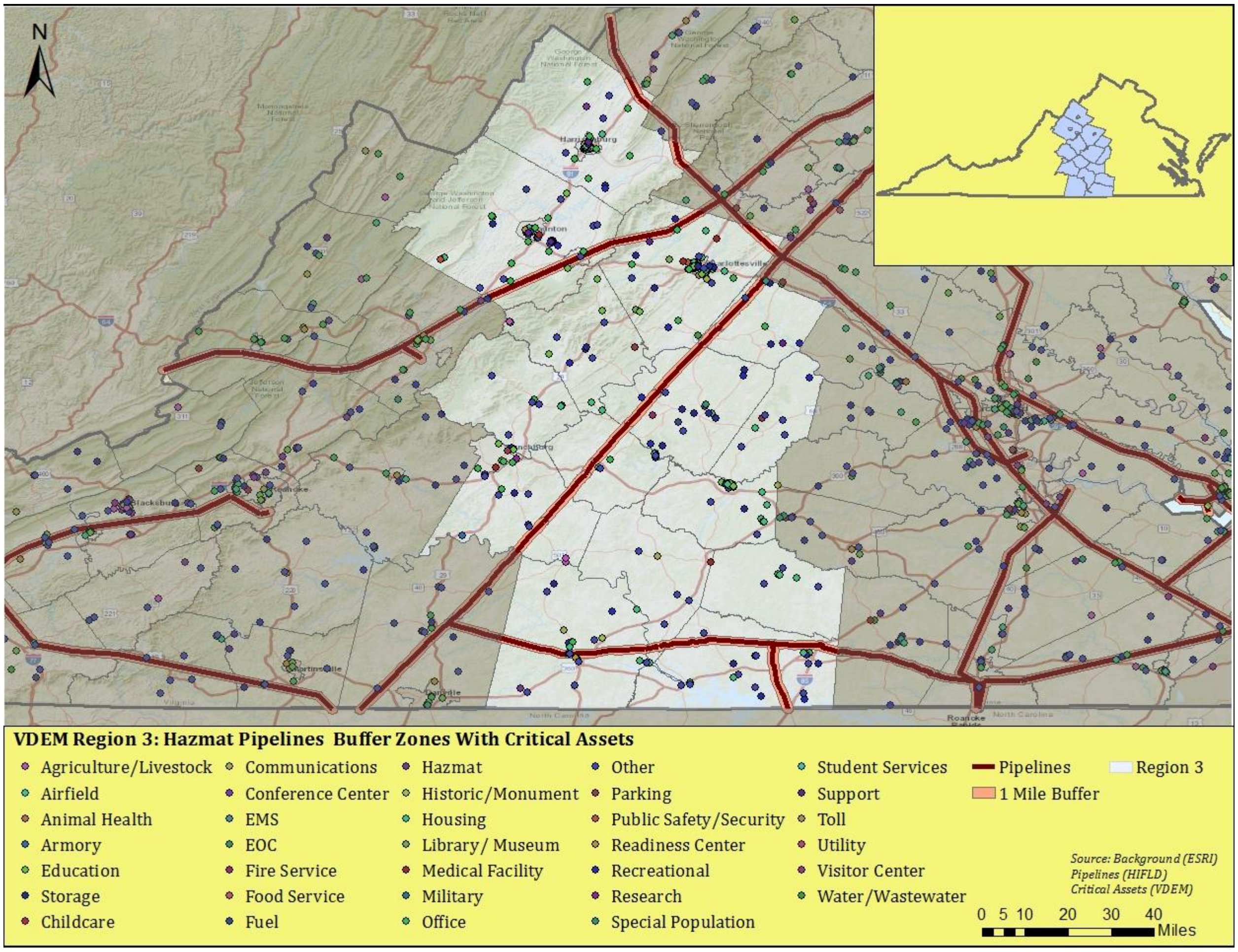


Figure D-9: VDEM Region 3 Hazardous Materials Incident Railroad Buffer Zones with Critical Assets

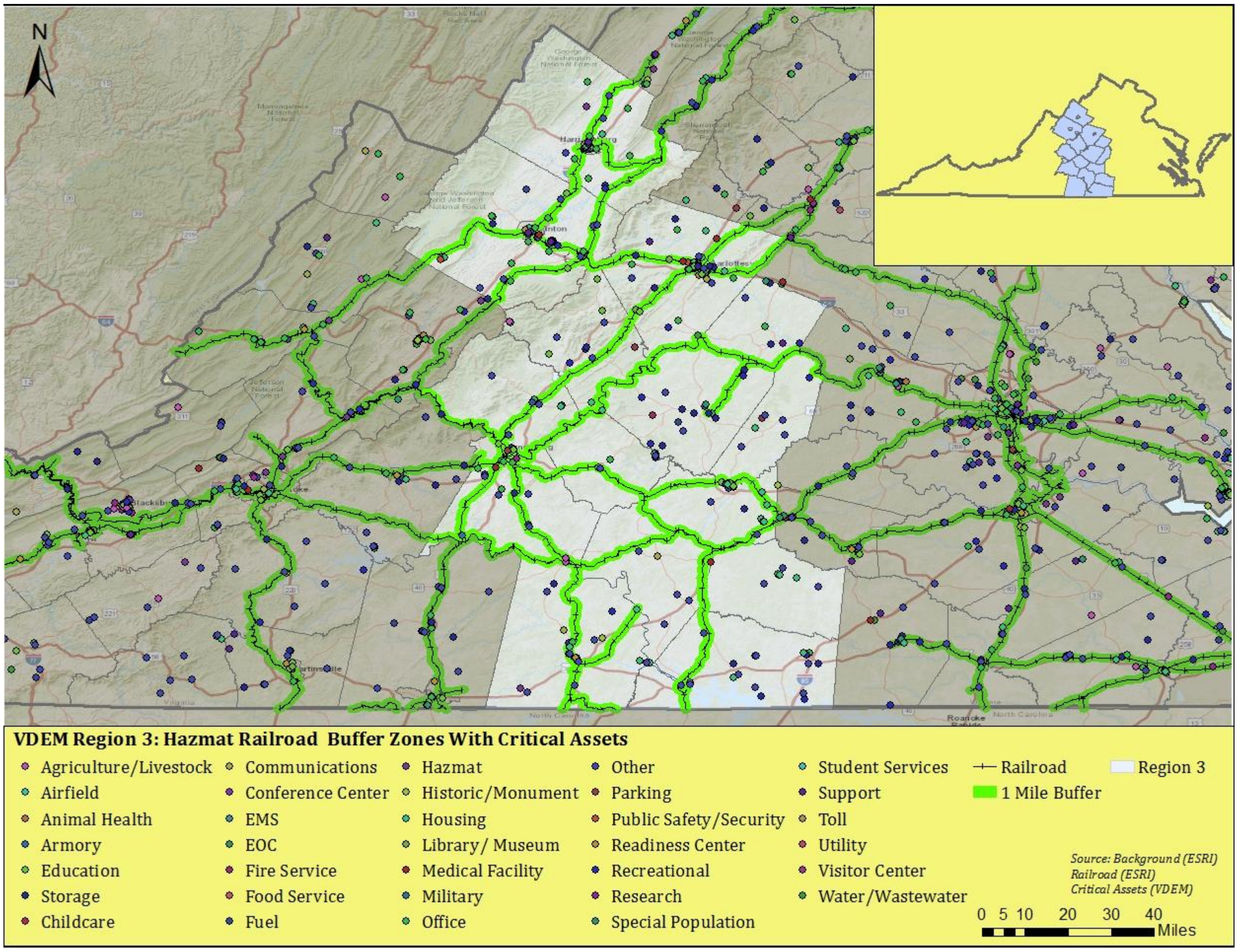


Figure D-10: VDEM Region 4 Hazardous Materials Incident Highway Buffer Zones with Critical Assets

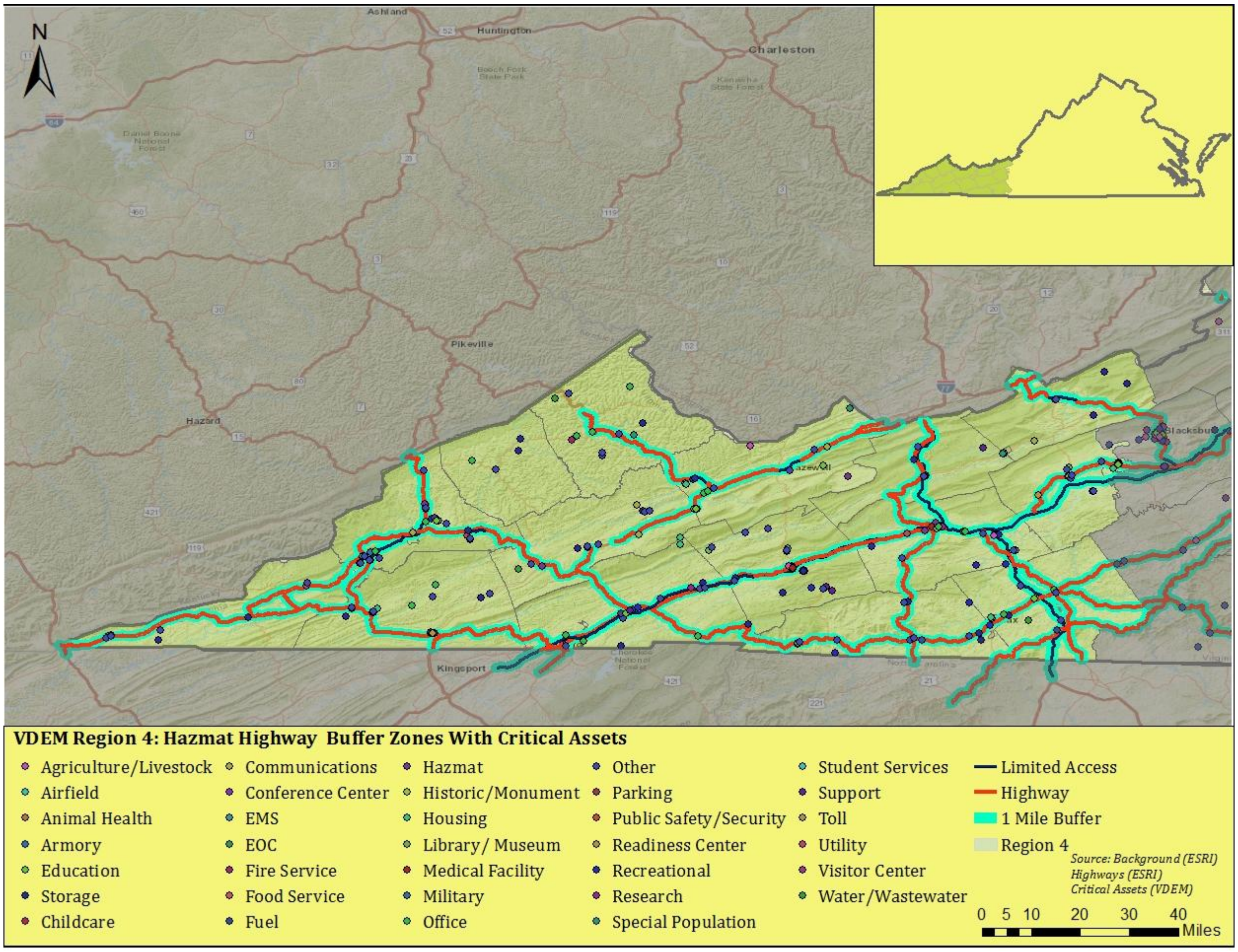


Figure D-11: VDEM Region 4 Hazardous Materials Incident Pipeline Buffer Zones with Critical Assets

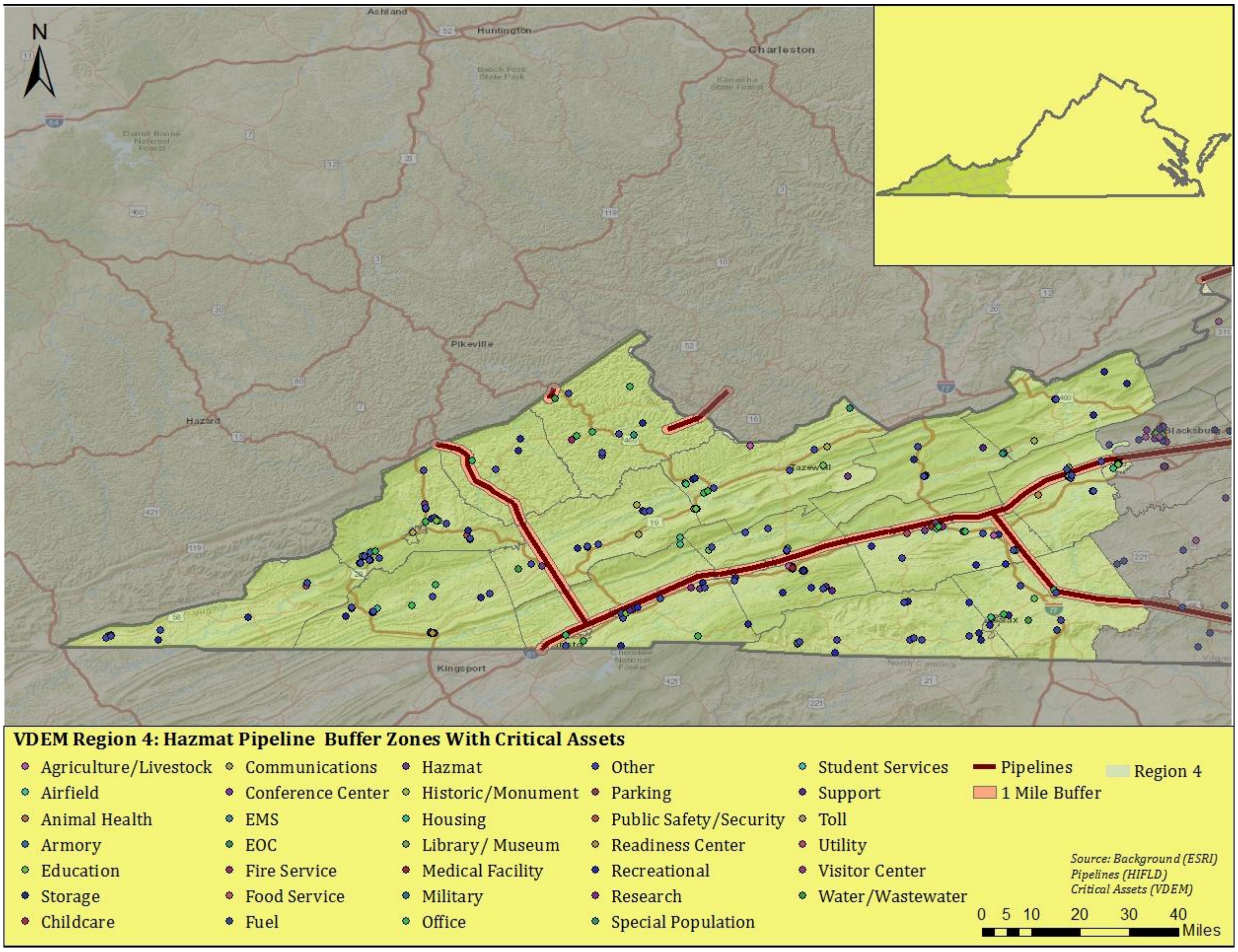


Figure D-12: VDEM Region 4 Hazardous Materials Incident Railroad Buffer Zones with Critical Assets

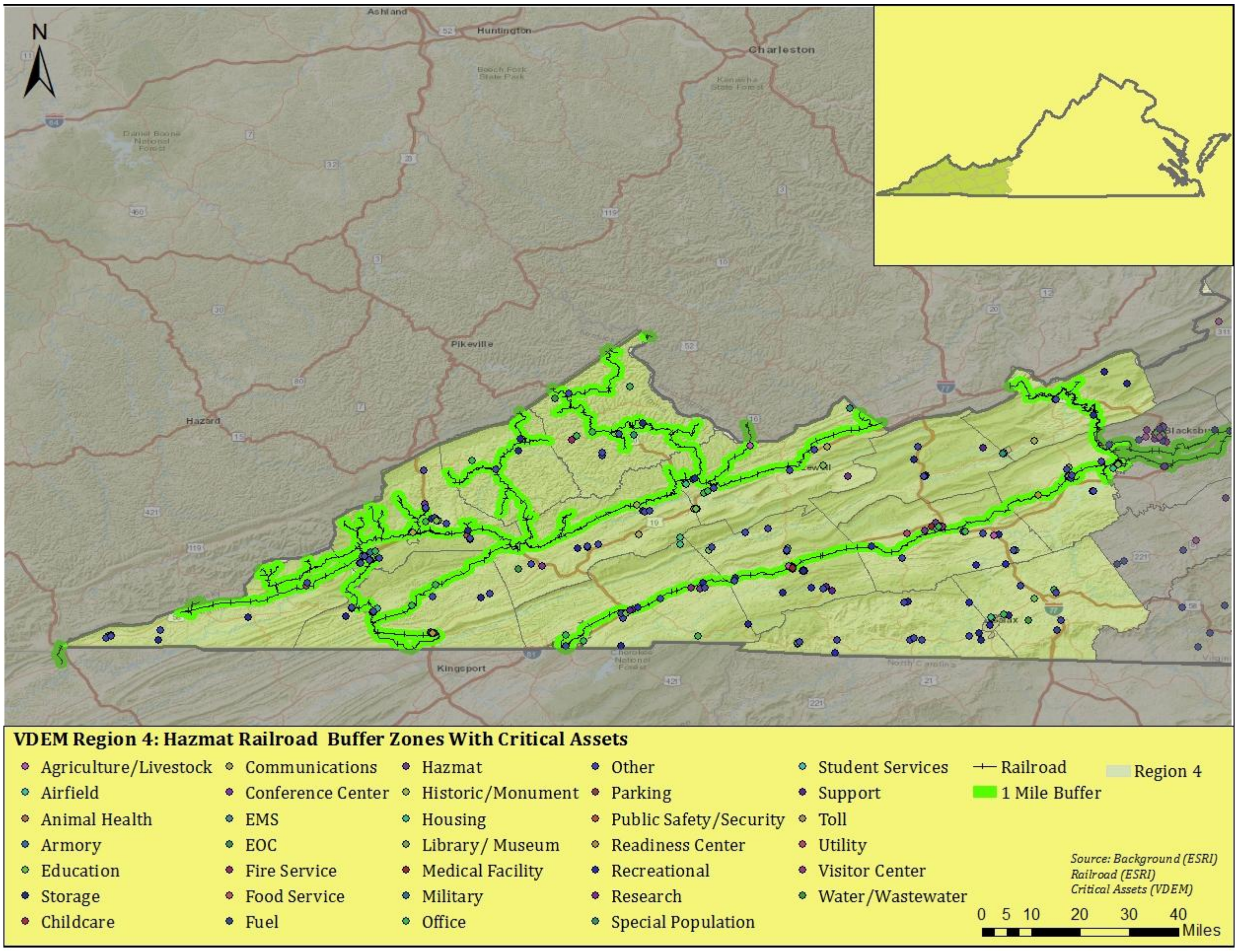


Figure D-13: VDEM Region 5 Hazardous Materials Incident Highway Buffer Zones with Critical Assets

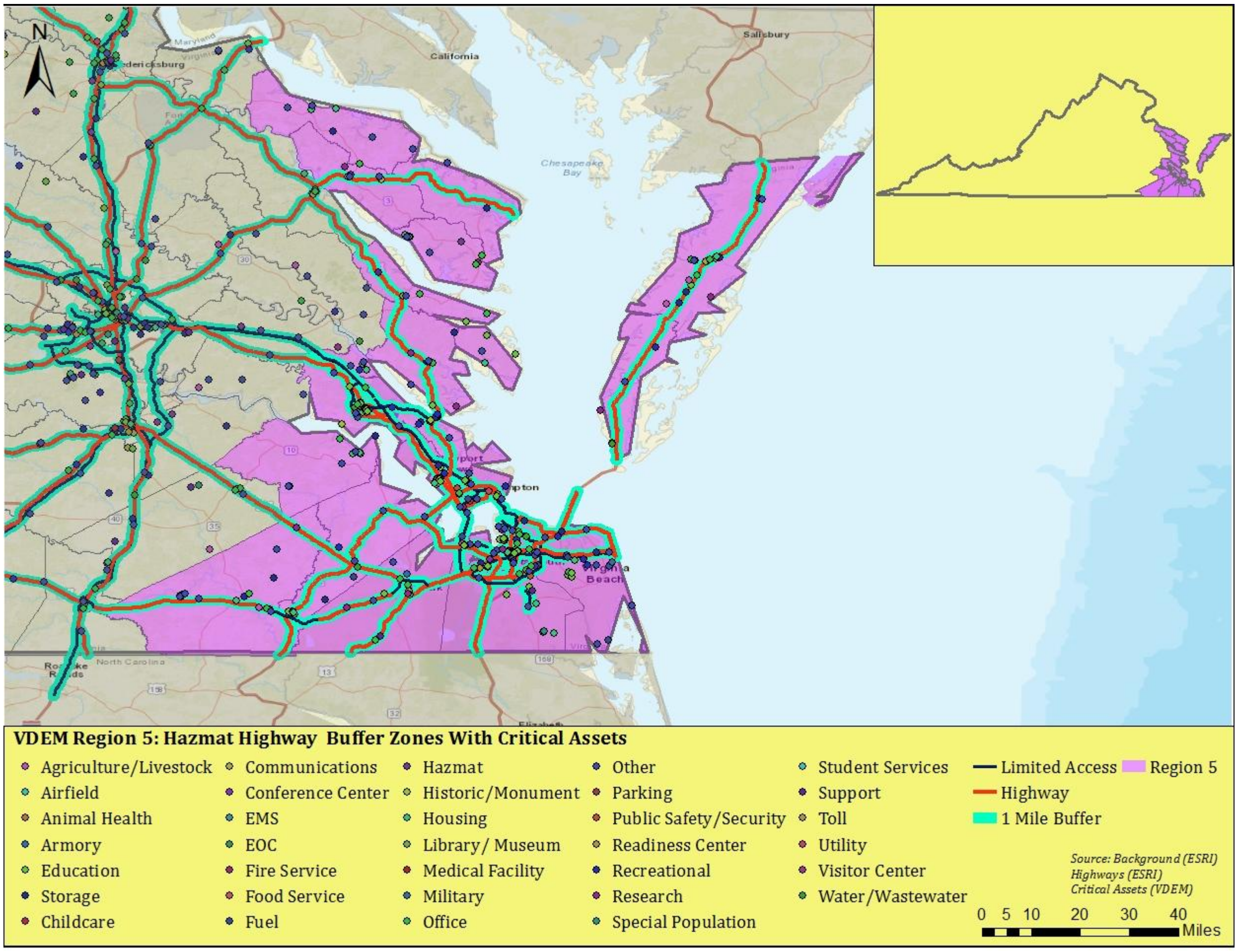


Figure D-14: VDEM Region 5 Hazardous Materials Incident Pipeline Buffer Zones with Critical Assets

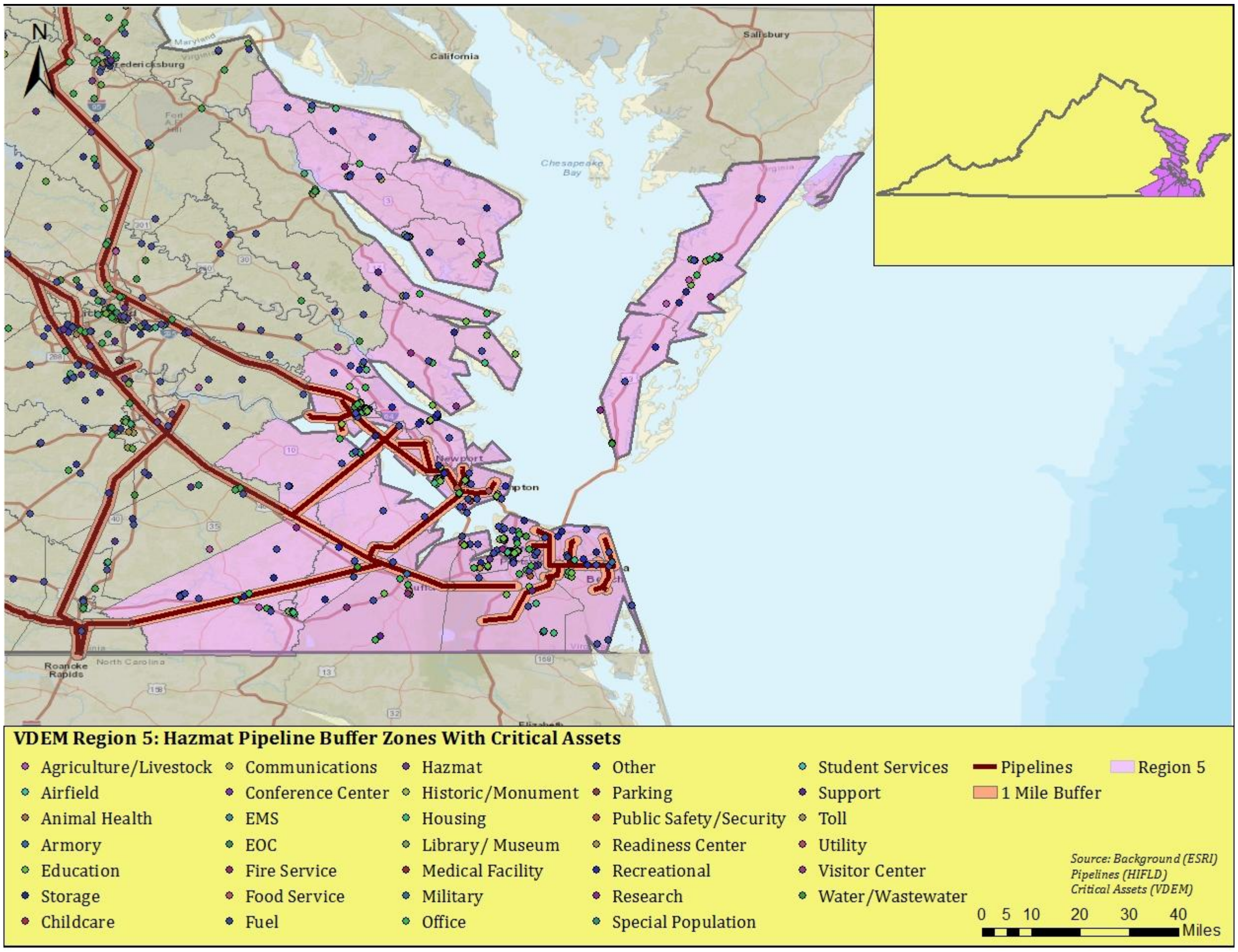


Figure D-15: VDEM Region 5 Hazardous Materials Incident Railroad Buffer Zones with Critical Assets

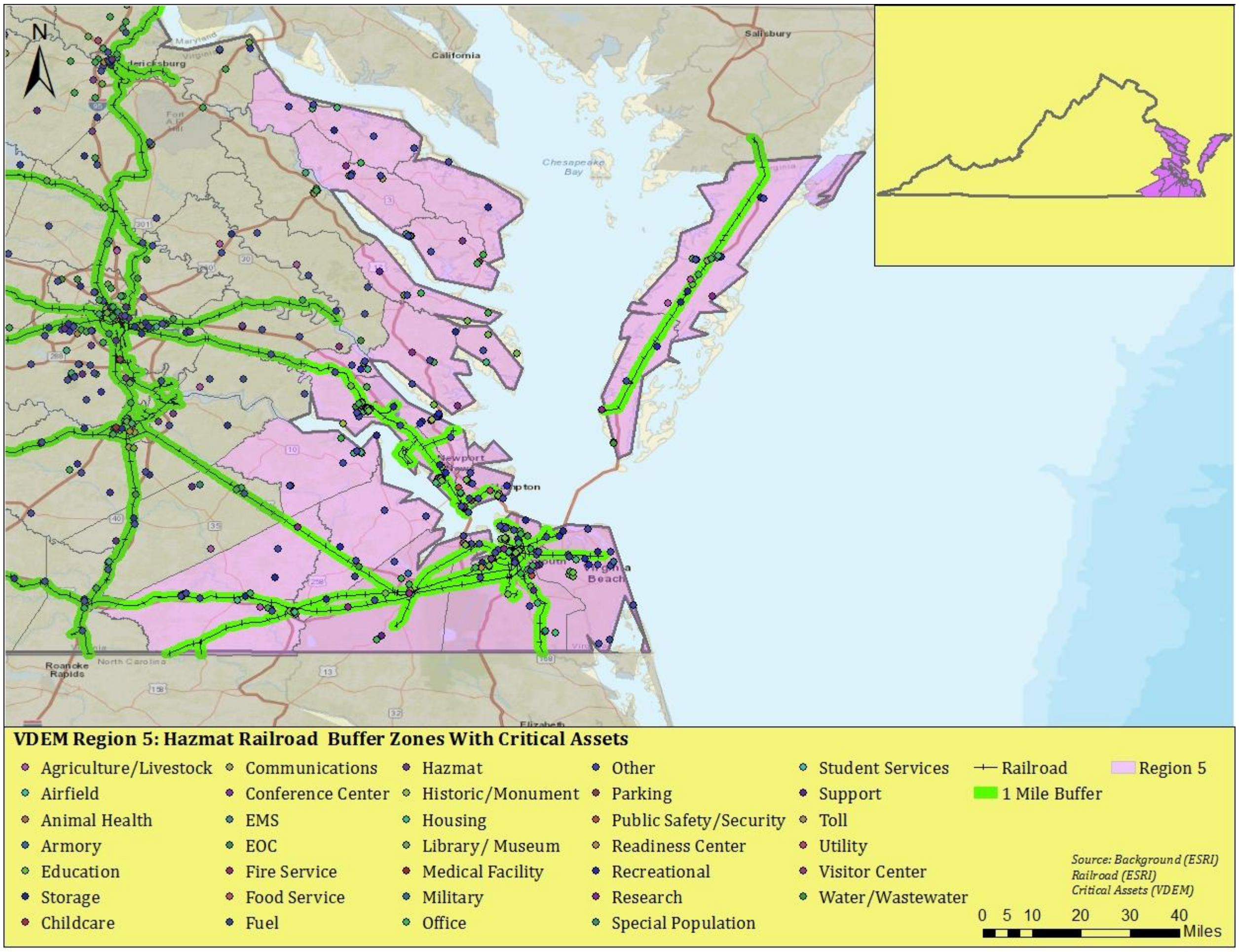


Figure D-16: VDEM Region 6 Hazardous Materials Incident Highway Buffer Zones with Critical Assets

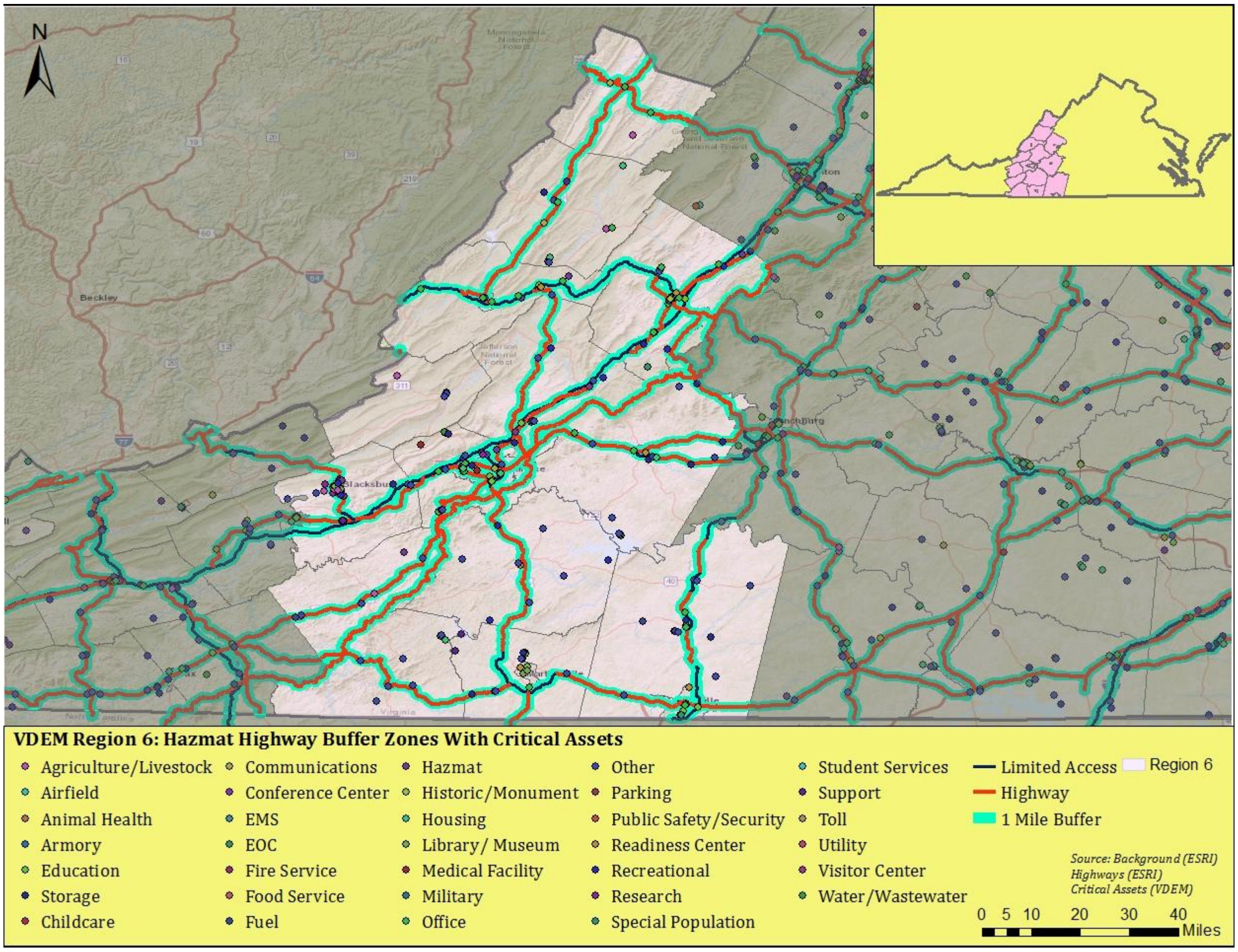


Figure D-17: VDEM Region 6 Hazardous Materials Incident Pipeline Buffer Zones with Critical Assets

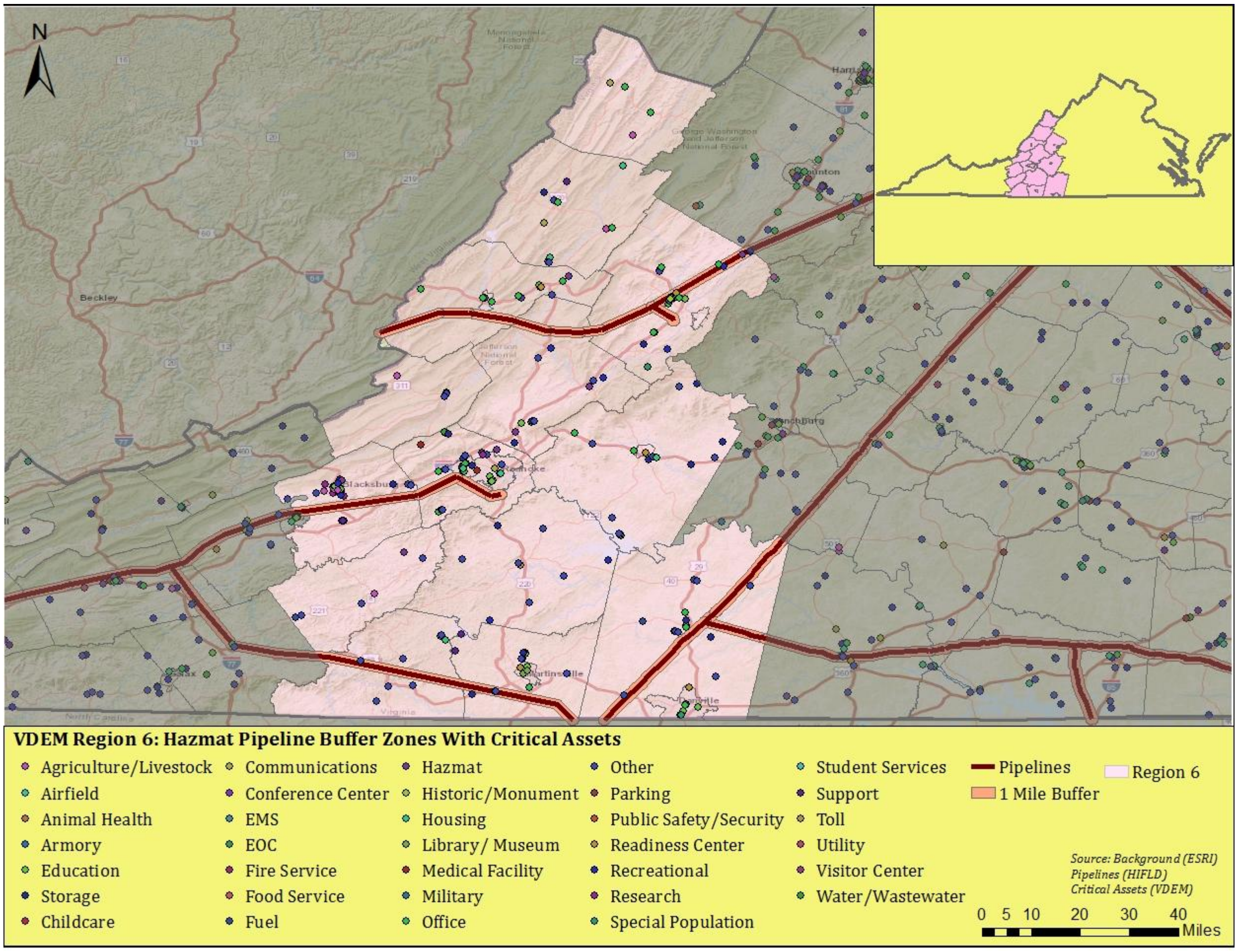


Figure D-18: VDEM Region 6 Hazardous Materials Incident Railroad Buffer Zones with Critical Assets

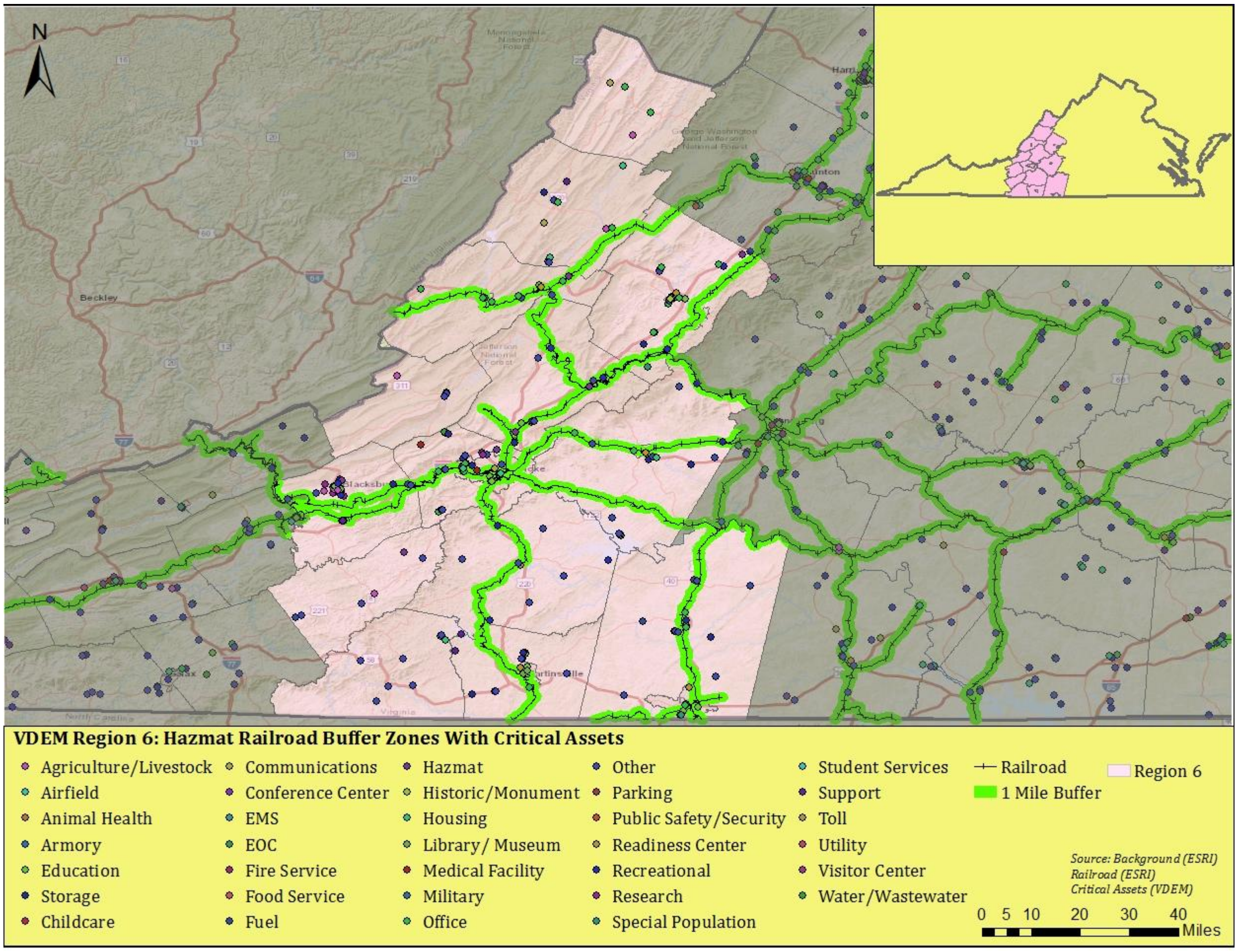


Figure D-19: VDEM Region 7 Hazardous Materials Incident Highway Buffer Zones with Critical Assets

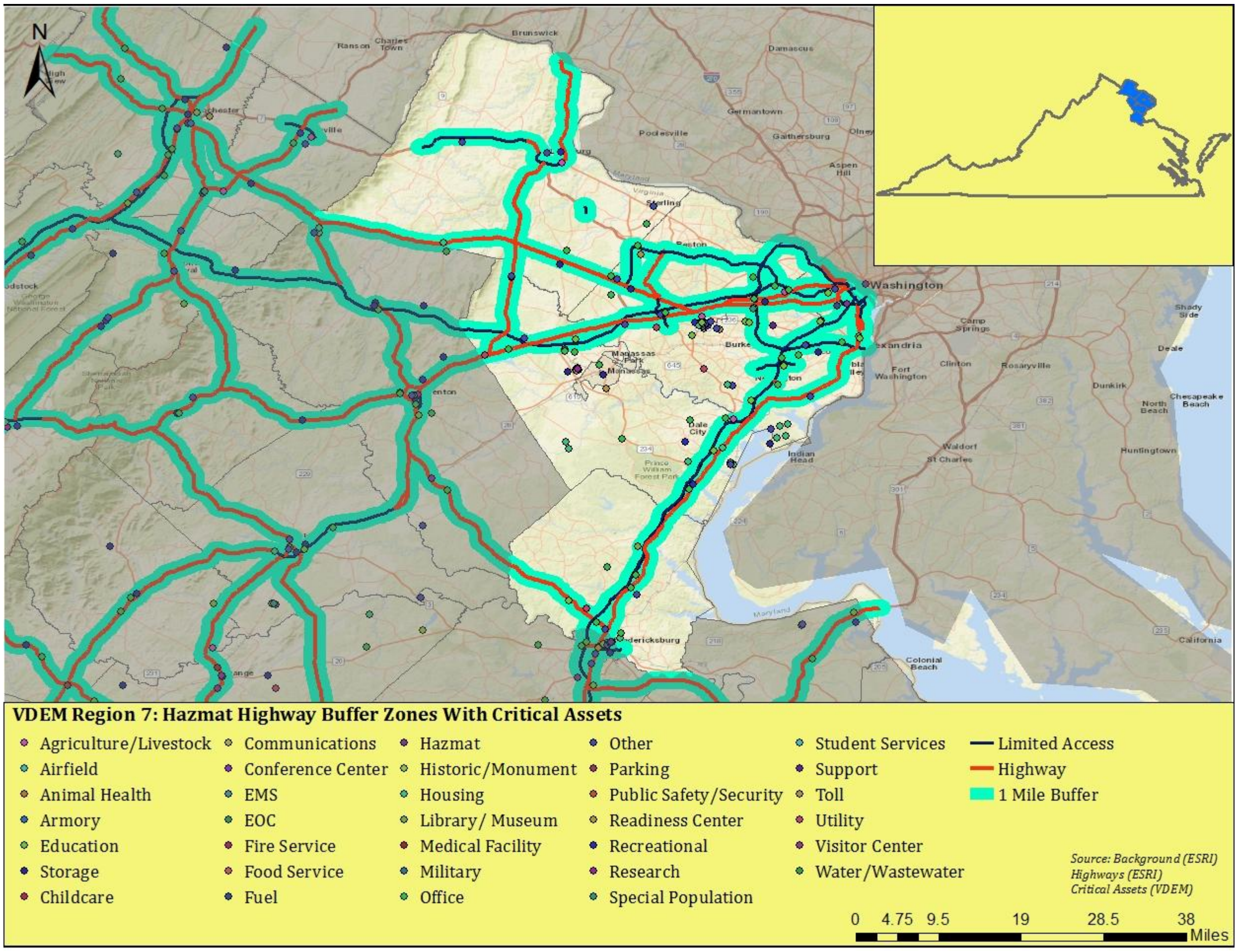


Figure D-20: VDEM Region 7 Hazardous Materials Incident Pipeline Buffer Zones with Critical Assets

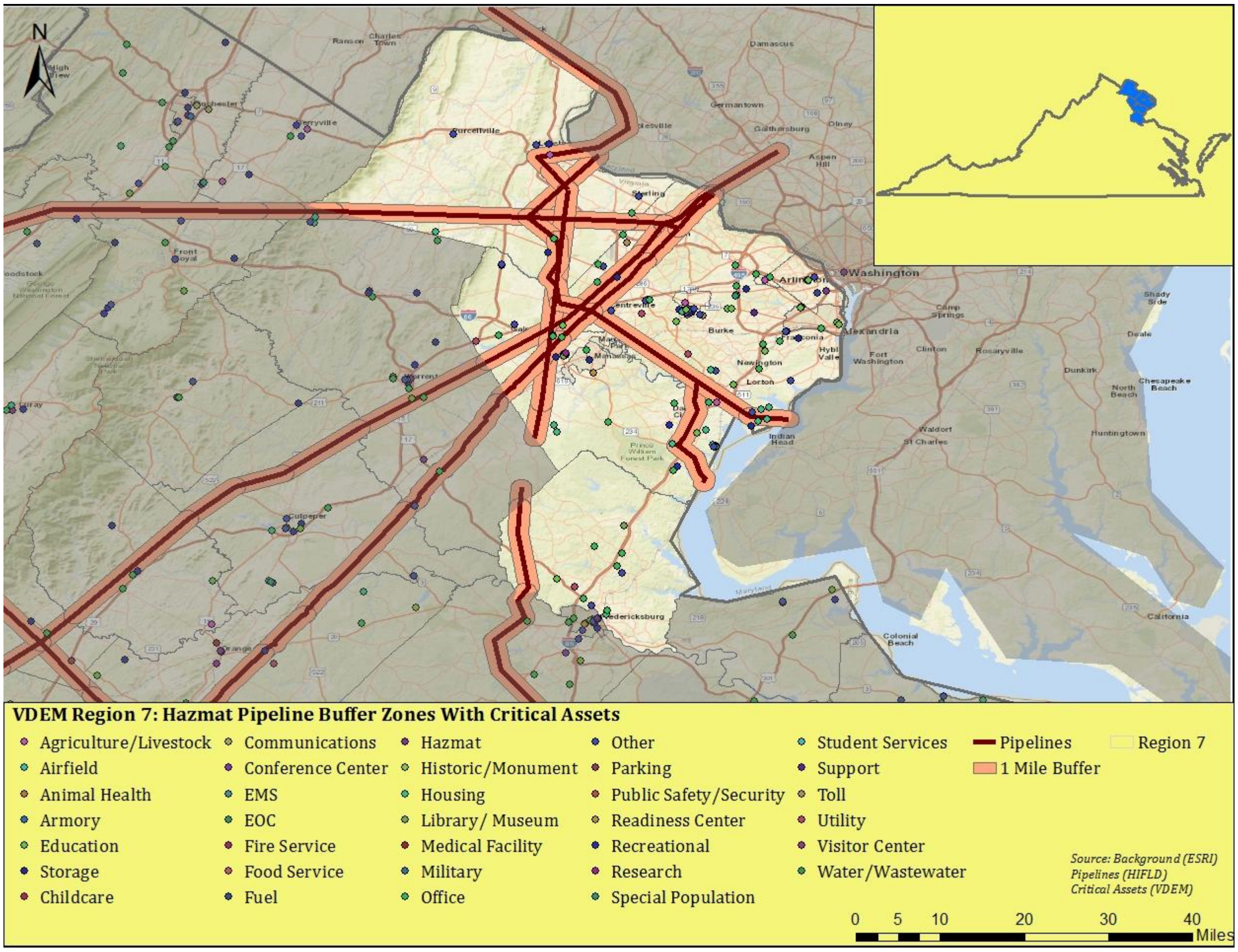
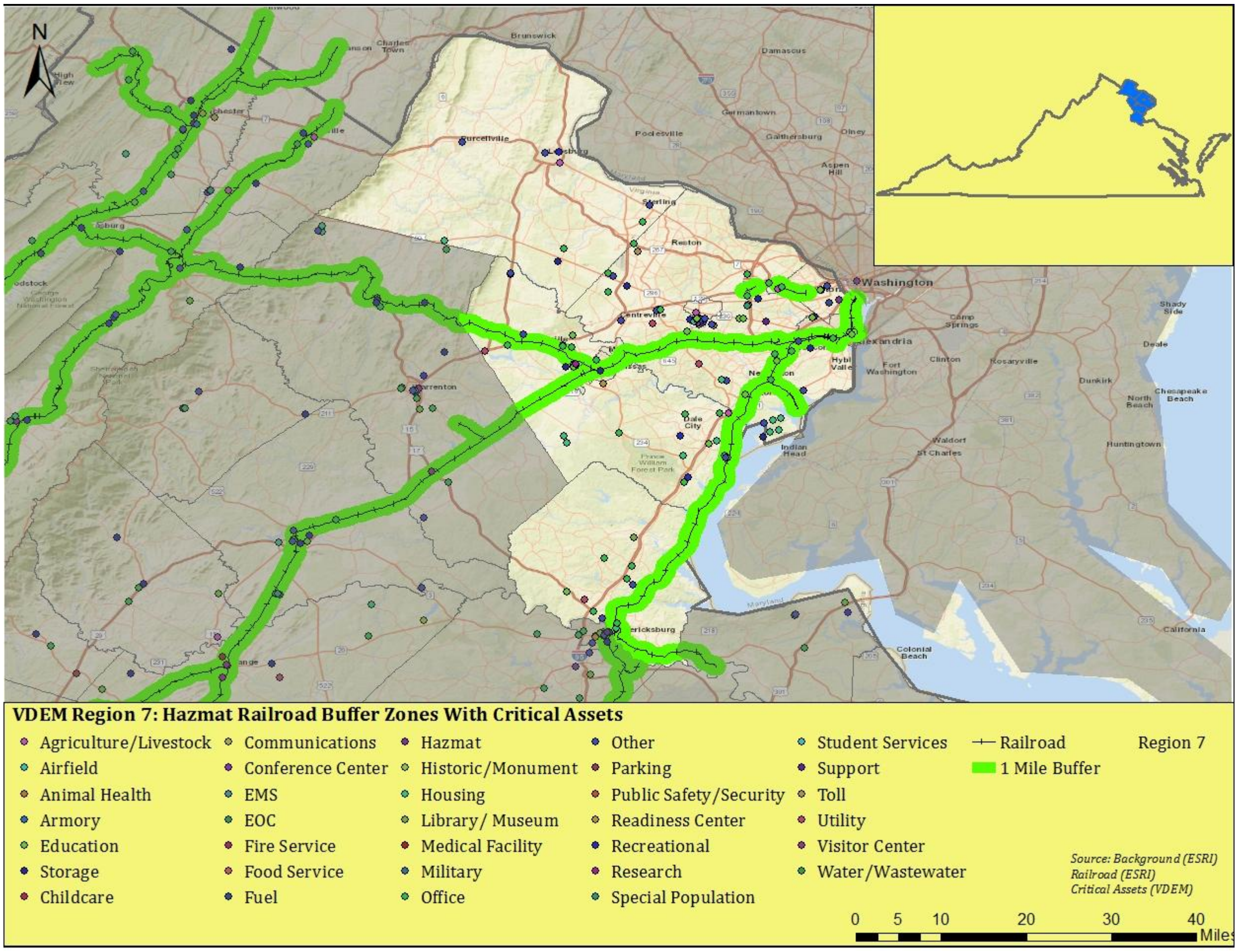


Figure D-21: VDEM Region 7 Hazardous Materials Incident Railroad Buffer Zones with Critical Assets



D.2 Complex Coordinated Attack

D.2.1 Description

According the Department of Homeland Security, complex coordinated terrorist attacks (CCTAs) are "acts of terrorism that involve synchronized and independent team(s) at multiple locations, sequentially or in close succession, initiated with little or no warning, and employing one or more weapon systems: firearms, explosives, fire as a weapon, and other nontraditional attack methodologies that are intended to result in large numbers of casualties".[9]

This threat profile addresses CCTAs, but includes active shooter situations as well.

Active Shooter

Active shooter is a term used by law enforcement to describe a situation where there is a shooting in progress and an aspect of the crime may affect the protocols used to respond. The "active" aspect implies that both law enforcement personnel and citizens have the potential to affect the outcome of the event based on their responses.

The definition of active shooter used by US government agencies is, "an individual actively engaged in killing or attempting to kill people in a confined and populated area." The use of firearms is implied.[10]

Terrorism

Though a commonly used term, terrorism has a very specific definition in the US, found at 18 USC §2331. [11]

International terrorism means those activities that have the following characteristics:

- Involve violent acts or acts dangerous to human life that violate state or federal law;
- Appear to be intended: 1) to intimidate or coerce a civilian population, 2) to influence the policy of a government by intimidation or coercion, or 3) to affect the conduct of a government by mass destruction, assassination, or kidnapping; and
- Occur primarily outside the territorial jurisdiction of the US, or transcend national boundaries in terms of the means by which they are accomplished, the persons they appear intended to intimidate or coerce, or the local in which their perpetrators operate or seek asylum.

Domestic terrorism has a slightly different definition, and means those activities with the following characteristics:

- Involve acts dangerous to human life that violate federal or state law;
- Appear to be intended 1) to intimidate or coerce a civilian population, 2) to influence the policy of a government by intimidation or coercion, or 3) to affect the conduct of a government by mass destruction, assassination, or kidnapping; and
- Occur primarily within the territorial jurisdiction of the US.

In addition, 18 USC §2332b defines the term "federal crime of terrorism" as an offense that:

- Is calculated to influence or affect the conduct of government by intimidation or coercion, or to retaliate against government conduct; and
- Is a violation of one of several listed statues, including §930 (c) (relating to killing or attempted killing during an attack on a federal facility with a dangerous weapon); and §1114 (relating to killing or attempted killing of officers and employees of the US).[12]

Chemical, Biological, Radiological, Nuclear, and Explosive Attacks

These attacks use chemical, biological, radiological, nuclear and explosive (CBRNE) materials that are intentionally released with the intent to cause harm to humans, property, business, or the environment. These materials can be weaponized or non-weaponized.

D.2.2 Historic Occurrence

Active Shooter

The FBI identified 61 active shooter incidents that occurred in the United States in 2021 alone. As a result of these incidents, 243 people were wounded or killed. From 2017 through 2021, the FBI reports 1,624 killed or wounded in mass shootings.[13]

Virginia has had several active shooter incidents, with several from 2007-2022 listed below:

- Blacksburg, VA 2007 – a student, armed with two handguns, started shooting in a dormitory at the Virginia Polytechnic Institute and State University. Two and a half hours later, the shooter chained doors shut to an education building on campus and began shooting at students and faculty. There were 32 people killed and 17 wounded.[14]
- Christiansburg, VA 2013 – a man armed with a shotgun began shooting in the New River Community College satellite campus in the New River Valley Mall. No one was killed; two were wounded. The shooter was apprehended by police after being detained by an off-duty mall security officer as he attempted to flee.[15]
- Alexandria, VA 2017 – a man shot several individuals including U.S. House Majority Whip Steve Scalise, U.S. Capitol police officer Crystal Griner, congressional aide Zack Barth, and lobbyist Matt Mika during a practice for the annual Congressional Baseball game. The man engaged in a ten-minute shootout with law enforcement during which he was shot and later died from his wounds.[16]
- Virginia Beach, VA 2019 – a man armed with two handguns, began shooting at the Virginia Beach Municipal Center. The shooter shot and killed one victim in the parking lot before entering the building and firing indiscriminately. 12 people were killed and four were wounded. The assailant was shot during an exchange of gunfire with law enforcement and later died of his wounds.[17]
- Bridgewater, VA 2022 – two officers were killed by an active shooter after a brief interaction at Bridgewater College. The shooter was arrested after the incident and several firearms belonging to the assailant were seized.[18]

Terrorism

The most notable terrorist attack in the United States occurred on September 11, 2001. The Pentagon, located in Arlington, Virginia, was heavily damaged after a commercial airliner, hijacked by al-Qaeda, an Islamic extremist group, crashed into the southwest corner of the building. Jet fuel from the Boeing 757 caused a devastating blaze that led to the structural collapse of a portion of the concrete structure. There were 189 casualties from this terrorist event.[19]

Other terrorist events in Virginia include:

- Suffolk, VA 2016 – a man was charged with attempting to provide material support to the Islamic State of Iraq and Syria (ISIS), a designated foreign terrorist organization.

Per the affidavit in support of the criminal complaint, the man sent money to a person who was collecting money for ISIS to purchase weapons and ammunition.[20]

- Roanoke, VA 2019 – A man was indicted for Attempting to Provide Material Support to ISIS. Beginning in February 2019, the man began communicating with an undercover employee (UCE) with the Federal Bureau of Investigation (FBI) who was posing as someone working on behalf of ISIS. The man revealed his plan to create training videos for creating deadly explosives that he intended to disseminate to members of ISIS.[21]
- Sterling VA, 2019 – a Virginia man was sentenced to 20 years in prison for obstructing a counterterrorism investigation. The man altered, destroyed, mutilated, concealed, and covered up a thumb drive and memory chip with the intent to impede and obstruct an FBI terrorism investigation. It was revealed during the investigation that the man intended on fleeing the United States and joining ISIS.[22]

D.2.3 Risk Assessment

Probability Active Shooter

While active shooter events are thought of as rare, frequency has increased over recent years. There are several indicators that may assist in pre-identifying a potential active shooter:

- Concerning behavior noted by friends, family, associates, and others, such as, disciplinary problems, depressed mood, changes in personality or performance, delusional statements, non-specific threats of violence, interest in or acquisition of weapons, odd or bizarre behavior;
- Verbal or written threats about causing harm to the target;
- Stalking or harassing behavior; or
- Physically aggressive acts toward the target.[23]

The FBI identified 11 locations where the public was most at risk during for an active shooter event: grade schools, institutions of higher education, government properties, military properties, open spaces, residences, houses of worship, health care facilities, businesses open to pedestrian traffic, businesses closed to pedestrian traffic, and malls.[24]

Probability Terrorism

The Commonwealth of Virginia has a higher probability of a terrorism event due to its location and proximity to Washington, D.C., as well as its large population and concentration of critical and military infrastructure.

The Virginia Fusion Center monitors international, national, and regional trends relating to terrorism and criminal extremism for indicators of emerging activity in the Commonwealth. Terrorism trends previously of greatest concern to law enforcement include: terrorism tradecraft; recruitment; radicalization; terrorist use of technology; and terrorism financing.

Probability Chemical, Biological, Radiological, Nuclear, and Explosive Attacks
An act of biological or chemical terrorism might range from dissemination of aerosolized anthrax spores to food product contamination, for example. Predicting when and how such an attack might occur is not typically possible, although intelligence services are constantly monitoring to prevent attacks. However, the possibility of biological or chemical terrorism should not be ignored, especially in light of recent events years such as the sarin gas attack in the Tokyo subway and the discovery of military bioweapons programs in Iraq and the former Soviet Union. Preparing to address these threats is a formidable challenge, but the consequences of being unprepared could be devastating.

Chemical terrorism acts are likely to be overt because the effects of chemical agents absorbed through inhalation or by absorption through the skin or mucous membranes are usually immediate and obvious. Such attacks elicit immediate response from police, fire, and EMS personnel.

In contrast, attacks with biological agents are more likely to be covert. They present different challenges and require an additional dimension of emergency planning that involves the public health infrastructure. Covert dissemination of a biological agent in a public place will not have an immediate impact because of the delay between exposure and onset of illness (i.e., the incubation period). Consequently, the first casualties of a covert attack probably will be identified by physicians or other primary health-care providers. Early detection of and response to biological or chemical terrorism are crucial. Without special preparation at the local and state levels, a large-scale attack with variola virus, aerosolized anthrax spores, a nerve gas, or a foodborne biological or chemical agent could overwhelm the local and perhaps national public health infrastructure. Large numbers of patients, including both infected persons and the "worried well," would seek medical attention, with a corresponding need for medical supplies, diagnostic tests, and hospital beds. Emergency responders, health-care workers, and public health officials could be at special risk, and everyday life would be disrupted as a result of widespread fear of contagion.

Impact and Vulnerability Active Shooter
Recent experience shows that the impacts of active shooter incidents affect the whole community no matter how isolated or contained the incident may be. Post-incident concerns for safety and security are common. There is a wide array of common responses to the shock of the situation, both for those involved and those in the surrounding community. The psychological scars left on the community can take years to heal.

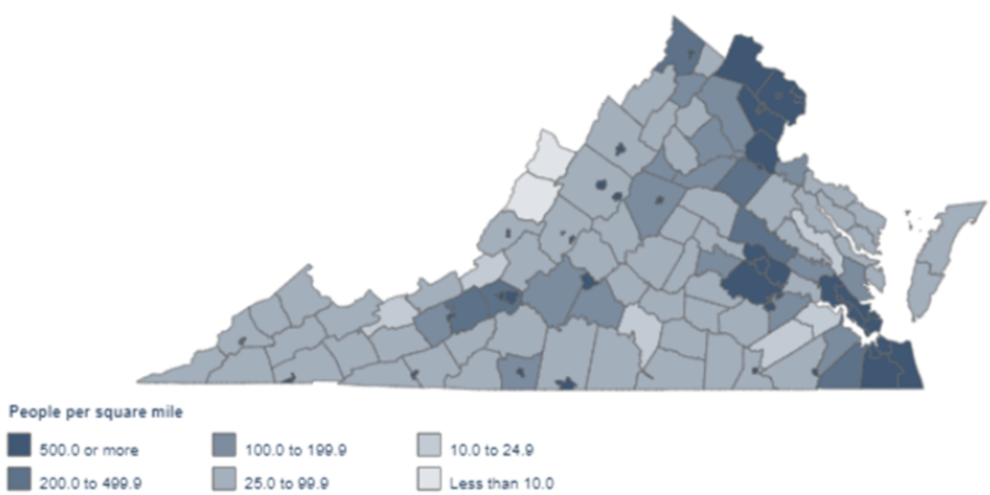
Training and exercises are the best way to effectively prepare responders and potential targets for an active shooter situation. All federal buildings have procedures in place on how to respond to an active shooter. Many healthcare institutions and businesses are also putting procedures in place for such an event. Schoolchildren, teachers and administrators are increasingly training and practicing recommended procedures for an active shooter in the school.

Impact and Vulnerability Terrorism

The Commonwealth of Virginia has several concentrations of critical infrastructure, including military installations such as the Pentagon, that are vulnerable to terrorism. Virginia also has numerous interstate highways with high-traffic bridges and tunnels; railways and subways; and aviation and port facilities that are vulnerable to a terrorism event because of the highly disruptive nature of failure of these assets and the concentration of population using the assets at once.

Threats to human safety are of concern. As of the 2020 Census, Virginia had a population of over 8.5 million, with high concentrations in the northern part of the state near the nation's capital, as well as along the coastline; all of which are vulnerable to a terrorism event (see Figure D-22).

Figure D-22: Population Density in Virginia Counties, 2020 Census



Impact and Vulnerability Chemical, Biological, Radiological, Nuclear, and Explosive Attacks

Terrorist incidents in the US and elsewhere involving bacterial pathogens, nerve gas, and a lethal plant toxin, have demonstrated that the US is vulnerable to biological and chemical threats, as well as explosives. For example, the 2001 anthrax attacks were responsible for the deaths of five people and injured 17 others. Recipes for preparing "homemade" agents are readily available and raise the possibility that terrorists might have access to highly dangerous agents, which have been engineered for mass dissemination as small-particle aerosols. Such agents as the Variola virus, the causative agent of smallpox, are highly contagious and often fatal. Responding to large-scale outbreaks caused by these agents will require the rapid mobilization of public health workers, emergency responders, and private health-care providers. Large-scale outbreaks will also require rapid procurement and distribution of large quantities of drugs and vaccines, which must be available quickly.

D.3 Cyber Attack

D.3.1 Description

Technology has allowed for increased productivity of the nation and made daily operations and markets reliant on cyber systems. Critical infrastructure such as electricity grids, transportation networks, and water supply systems are all critical assets for maintaining the safety and economy of society. Each of these systems relies on computer controls, real-time monitoring, and other cyber assets to provide high levels of service to customers. The coupling of the cyber and physical aspects of these systems introduces new vulnerabilities to the system, as the cyber element is exposed to attack. As a result, the US has become, and will continue to be, increasingly vulnerable to non-traditional attacks, including information warfare and operations. American companies are targeted for business practices and other sensitive corporate data, and universities for research and development. Citizens are also frequently targeted by fraudsters and identity thieves.[25]

D.3.2 Historic Occurrence

Cyber-attacks are becoming increasingly common. As new procedures are implemented to counter cyber-attacks, hackers are adapting and finding different methods to commit fraudulent acts. There have been numerous occurrences of cyber-attacks in or affecting Virginia; [number] of the highest profile include:

- August 2014, Community Health Systems, located throughout Virginia, announced that hackers broke into their physician network and stole patient information. Hackers were able to access patient names, addresses, social security information, and date of birth information.[26]
- August 2015, the University of Virginia's computer network was compromised by a cyber-attack. The investigation into the attack noted that no personal information,

such as student names, contact information, social security numbers, etc. was accessed by the hackers. Also, no sensitive research material was accessed.[27]

- June 28, 2017, a hospital in Princeton, West Virginia, along the Virginia border, was targeted by a cyber-attack. Apparently, personal information was not transferred from the servers; however, all electronic medical files were encrypted and inaccessible.[28]
- September 2019, Smyth County Public Schools were hit by a ransomware attack that temporarily paralyzed its network across the school system. Though there was no evidence that sensitive data was taken, the school system was forced to restore significant amounts of data from backups and accelerate its plans to migrate infrastructure to the cloud.[29]
- November 2020, a ransomware attack on the Hampton Roads Sanitation District successfully disabled phone and computer networks, including customer billing systems.[30]
- December 2020, a major cyber-attack alleged to have been committed by the Russian government successfully compromised data belonging to thousands of governments and private sector organizations. The malicious actors successfully hacked a widely used service provider known as SolarWinds, conducting a software supply chain attack believed to be one of the biggest cyber-espionage incidents in history.[31]
- May 2021, the Colonial Pipeline Company halted all pipeline operations in response to a ransomware attack impacting its information technology systems. The shutdown affected numerous supply chains for refined oil, leading to Commonwealth and federal disaster declarations.[32]
- December 2021, the Virginia Department of Legislative Automated Systems, which provides technology services to the legislative branch and General Assembly of Virginia, was targeted by a cyber-attack impacting several critical systems. The attack, which prohibited legislators and staff from accessing the systems that handle bills, also took down the Virginia Law Portal and several services of the Virginia Capitol Police.[33]

The Federal Trade Commission has noted an increase in the number of identity thefts and complaints over the past several years. In 2022, Virginia ranked 25th in the nation for reported identity theft complaints, with 225 complaints per 100,000 residents.[34]

D.3.3 Risk Assessment

Probability

The probability of a significant and damaging cyber-attack increases daily. Phishing scams have become more frequent in attempts to lure unsuspecting victims by sending unsolicited email or posing as legitimate websites, which attempt to collect personal and financial information.

Ransomware is also becoming more sophisticated and used more frequently. Ransomware is a type of malware that is designed to lock digital files; subsequently, attackers demand a ransom to unlock the files remotely. Ransomware is easily sent via spam email; however, spam email is increasingly filtered out by email servers. Hackers constantly adapt by targeting specific individuals with emails and in some cases with websites embedded with malicious code. Email and downloading from the internet are the primary sources of corporate malware infections.

Most local governments, businesses, and institutions of higher education as well as the Commonwealth of Virginia state government agencies have policies and procedures in place to reduce vulnerability to a cyber-attack. Continued research, training and outreach regarding awareness of cyber-attack techniques reduces the probability of occurrence.

Impact and Vulnerability
Cyber-attack threats are continuously evolving. Information security controls continuously threaten critical information and operations of government agencies and functions. For example, in 2020 and 2021 there have been 168 ransomware attacks on 1,763 clinics.[35] Cyber-attacks using social engineering temporarily disabled the Colonial Pipeline, risking access to oil products across the East Coast.[36]

Businesses continue to use evolving technologies to improve operations, and increasingly, personal and financial information is stored and transferred online. Phishing scams have reached an all-time high in 2022, up 60 percent from 2020 with over 1 million attacks in the first quarter of 2022 alone.[37]

Consumers continue usage of online services, such as banking and shopping, which increase vulnerability to personal and financial information theft or manipulation. Between 2016 and 2021, Americans lost more than $9 billion to lost or stolen financial information.[38]

D.4 Improvised Nuclear Device

D.4.1 Description

An improvised nuclear device (IND) is a type of nuclear weapon that when detonated gives off four types of energy: a blast wave, intense light, heat, and radiation.

When an IND explodes, a fireball is created. Everything in the fireball evaporates and is carried upward forming a mushroom shaped cloud. As the material in the mushroom cloud cools, it forms dust particles that fall back to earth as fallout. Fallout is radioactive and contaminates everything on which it lands.[39]

D.4.2 Historic Occurrence

The Commonwealth of Virginia has not experienced an IND event. The most memorable IND events occurred in 1945 when the U.S. dropped an atomic bomb onto Hiroshima on August 6th and Nagasaki on August 9th.

D.4.3 Risk Assessment

Probability

The probability of occurrence of an IND threat is low; however, due to Virginia's proximity to the nation's capital as well as the population centers around the Northern Virginia part of the Commonwealth, the impacts would be catastrophic.

Impact and Vulnerability

Virginia's proximity to Washington D.C. as well as the infrastructure, military presence and large population concentrations make the Commonwealth more vulnerable to an IND threat than many other locations throughout the county. An IND attack would result in thousands of casualties and injuries and billions in damages from the initial blast and then the fallout.
The impacts and vulnerability to an improvised nuclear device are extensive, including blast injuries, thermal/burn injuries, radiation injuries, and other fallout injuries.

- Blast injuries:
  - Direct effects from barotrauma, commonly affecting air filled organs and air-filled interfaces
  - Debris penetrating and fragmentation
  - Blunt trauma, amputations, and brain injuries
- Thermal/burn injuries
  - Direct absorption of thermal energy through exposed skin or heating or igniting clothing
  - Flash blindness caused by flash of light produced by explosion
  - Retinal scarring
- Radiation injuries
  - Gamma or neutron exposure
  - Delayed radiation exposure
- Other fallout injuries
  - Contaminated food and water sources
  - Radiation sickness
  - Fallout on the outside of body or clothing[40]

D.5 Electromagnetic Pulse (EMP)

D.5.1 Description

Electromagnetic pulses (EMPs) are a brief burst of electromagnetic energy. This threat profile specifically addresses the deliberate release of energy with the intent to disrupt critical societal functions such as the electric grid or transportation networks. Deliberate EMP attacks are likely to utilize non-nuclear directed energy weapons, high-altitude nuclear detonations, or other specialized explosive devices. Depending on the size and scope of the attack, effects may be localized or span an entire region.

High-altitude nuclear detonations are the greatest threat as they may cause significant and irreparable damage to portions of the national electric grids, leading to cascading failures in other systems. For example, loss of power in one region may prevent other regions from rendering aid. Failures of telecommunication services may reduce the effectiveness of vital assistance. Other critical functions, such as the delivery of clean food and water, is likely to be severely impacted.

The federal government is primarily responsible for any comprehensive regulatory or legislative strategy for reducing or preventing damage from an EMP occurrence. In March 2019, the White House ordered multiple agencies to start research and reviews aimed at enhancing resistance to the impacts of EMPs.[41]

D.5.2 Historic Occurrence

There are no instances of EMP attacks in Virginia or the United States.

Some naturally occurring EMP events have been recorded. The 1859 Carrington Event is one of the most extreme geomagnetic events in recorded history. Scientists theorize that a major coronal mass ejection initiated the Carrington Event. Effects of the event included auroras seen as far south as the Caribbean Islands.

Though society at the time was not as reliant on electricity, significant electrical and telecommunication failures were recorded. For example, telegraph machines were reported to have sparked and shocked users. Many telegraph devices failed due to the intense electromagnetic activity, greatly reducing interstate and international communication.

D.5.3 Risk Assessment

Probability

EMP events are considered low probability/high-risk scenarios. According to the US Commission to Assess the Threat to the United States from EMP Attack, though several United States adversaries have the capability to acquire and use EMPS, the likelihood of their use is minimal. However, the report also notes that the cascading impacts of such attacks may be catastrophic.[42]

Impact and Vulnerability
With Virginia's proximity to the nation's capital and the critical infrastructure contained within the state it makes it a target for an EMP attack and associated cascading disruptions. Further, Virginia contains several military assets such as the Defense Supply Center Richmond and several bases in the Hampton Roads region. These are considered high-risk targets of a military-based strike on the United States. An EMP strike may destroy the electronics and digital circuitry in these regions, severely impacting the local populations.[28] According to Dr. William Graham, chairman of the EMP Commission, "the loss of our electricity grid for an extended period would have catastrophic and fatal effects on our inhabitants and economy." Though the primary threat of an EMP attack is on the electric grid, other sectors are also at risk.

Telecommunication failures are likely and will increase the difficulty of delivering food and water to the population of the affected region. Medical systems will be severely inhibited as hospitals and clinics lose access to stable power. Finally, vehicles in the region may be rendered unusable due to circuitry failures, decreasing the rate at which affected individuals can evacuate safely, leaving the population vulnerable to other threats.[43]

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Appendix E:

Virginia Regulated Dams

Dam Name	Hazard Class	County
Benjamin Thomas Dam	Unknown	Accomack County
Bundick Creek Dam	Unknown	Accomack County
Cullen Winter Dam	Unknown	Accomack County
Custis Dam	Unknown	Accomack County
Drummonds Millpond Dam	Unknown	Accomack County
Duer Dam	Unknown	Accomack County
Otwell Green Acres Dam	Unknown	Accomack County
Snyder Dam	Unknown	Accomack County
Tankard Dam	Unknown	Accomack County
VA Truck Experimental Station Dam	Unknown	Accomack County
Wallops Pond Dam	Unknown	Accomack County
Walston Creek Dam	Unknown	Accomack County
Albemarle Dam	High	Albemarle County
Albemarle House Dam	Unknown	Albemarle County
Albie Road Dam	Unknown	Albemarle County
Allmans Dam	Unknown	Albemarle County
Apsara Farm North Dam	Unknown	Albemarle County
Atkinson Dam	Unknown	Albemarle County
Bailey Realty LLC	Unknown	Albemarle County
Baileys Dam	Unknown	Albemarle County
Beaver Creek Dam #1	High	Albemarle County
Bellair Farm Dam	Unknown	Albemarle County
Birdwood GC #13 Dam	Low	Albemarle County
Birdwood GC Hole #2 Dam	High	Albemarle County
Bishops Dam	Unknown	Albemarle County
Blandemar Dam	Unknown	Albemarle County
Blue Ridge Forest Dam	Significant	Albemarle County
Boaz Dam	Unknown	Albemarle County
Broadmoor Lake Dam	Significant	Albemarle County
Brocks Mill Dam	Unknown	Albemarle County
Burnt Mountain Dam	Unknown	Albemarle County
Camp Faith Lake Dam	Low	Albemarle County
Campbell Road Dam	Unknown	Albemarle County
Carroll Dam	Unknown	Albemarle County
Carrsbrook Western Pond	Unknown	Albemarle County
Chapel Springs Farm	Unknown	Albemarle County
Cherry Hill Dam	Unknown	Albemarle County
Chimney Rock Dam	Low	Albemarle County
Chisholm Dam Upper Farm	Low	Albemarle County
Chopin Dam	Unknown	Albemarle County
Chopping Branch Dam	Unknown	Albemarle County
Chris Greene Dam	High	Albemarle County
Clover Dam	Significant	Albemarle County
Club Dam	Unknown	Albemarle County
Coleman Dam	Unknown	Albemarle County
Colt Bower Dam	Unknown	Albemarle County
Cool Stream Farm West Dam	Unknown	Albemarle County
Cove Creek Dam	Unknown	Albemarle County
Crown Orchard North Dam	Unknown	Albemarle County
Crown Orchard South Dam	Unknown	Albemarle County
Crown Orchard Upper Dam	Unknown	Albemarle County
Crozet Sportsman Club Dam	Low	Albemarle County

Dam Name	Hazard Class	County
Doudera Pond Dam	Unknown	Albemarle County
Dover Dam	Unknown	Albemarle County
Edgehill Dam # 4	Unknown	Albemarle County
Edgehill Dam #7	Unknown	Albemarle County
Edgehill Farm Dam #2	Unknown	Albemarle County
Edgehill Farm NE Dam	Unknown	Albemarle County
Edgehill Farm NW Dam	Unknown	Albemarle County
Edgehill Farm SW Dam	Unknown	Albemarle County
Edgehill SE Pond Dam	Unknown	Albemarle County
Edgeworth Farm North Dam	Unknown	Albemarle County
Edgeworth Farm South Dam	Low, Special	Albemarle County
Ednam Drive Dam	Unknown	Albemarle County
Ellerslie Dam	Unknown	Albemarle County
Farmington Dam	Unknown	Albemarle County
Flordon Dam	Unknown	Albemarle County
Fontaine Dam	Unknown	Albemarle County
Forest Lakes Dam #2	Unknown	Albemarle County
Forest Lakes Subdiv A	Unknown	Albemarle County
Fox Hunt Dam	Unknown	Albemarle County
FR Farm Dam	Unknown	Albemarle County
Glen Lochan Dam	Significant	Albemarle County
Glenmore # 2 Dam	Unknown	Albemarle County
Glenmore # 8 Dam	Unknown	Albemarle County
Glenmore #1 Dam	Unknown	Albemarle County
Greens Dam	Low, Special	Albemarle County
Gretchen Watkins Dam	Unknown	Albemarle County
Hallock Dam	Unknown	Albemarle County
Hammon Dam	Unknown	Albemarle County
Happy Creek Dam	Unknown	Albemarle County
Henleys Dam	Significant	Albemarle County
Hillcrest Dam	Low	Albemarle County
Hollymead Dam	High	Albemarle County
Huckles Dam	Unknown	Albemarle County
Hunt Country Dam	Low	Albemarle County
Hurts Dam	Low	Albemarle County
Ida102 Dam	Unknown	Albemarle County
Ida103 Dam	Unknown	Albemarle County
Ida104 Dam	Unknown	Albemarle County
Indian Springs Dam	Low	Albemarle County
Irish Langhorne Dam	Unknown	Albemarle County
Ivy Creek Dam # 1	Unknown	Albemarle County
Ivy Farm Dam	Unknown	Albemarle County
Ivy MUC Irrigation Pond	Low	Albemarle County
James A. Strong Dam	Low	Albemarle County
James Rose Dam	Unknown	Albemarle County
Jenson Dam	Unknown	Albemarle County
Kimco Dam	Unknown	Albemarle County
Kinloch Farm Pond	Unknown	Albemarle County
Lake Reynovia Dam	Unknown	Albemarle County
Leake Lane Dam	Unknown	Albemarle County
Leveque Dam	Unknown	Albemarle County
Liberty Corner Farm Dam (3)	Low	Albemarle County

Dam Name	Hazard Class	County
Lickinghole Creek Dam	Low	Albemarle County
Lloyd Pond Dam	Unknown	Albemarle County
Loftlands Dam	Low	Albemarle County
Lower Adventure Dam	Unknown	Albemarle County
Mackey Dam	Unknown	Albemarle County
Martha Jefferson Retention Basin Dam	Significant	Albemarle County
Mayo Dam	Unknown	Albemarle County
McDaniel Dan	Unknown	Albemarle County
McLean Dam	Unknown	Albemarle County
MGMT SRS Dam	Unknown	Albemarle County
Middle Mint Spings Dam	High	Albemarle County
Mike Johnson Dam	Unknown	Albemarle County
Miller Lake Dam	Unknown	Albemarle County
Miller School Dam	Significant	Albemarle County
Mink Creek Dam	High	Albemarle County
Mont Air South Dam	Unknown	Albemarle County
Montfair West Dam	High	Albemarle County
Morris Dam	Unknown	Albemarle County
Mosby Mountain Dam #2	Unknown	Albemarle County
Mountain Valley Dam 1	High	Albemarle County
Mountain Valley Dam 4	High	Albemarle County
Mt. Amos Dam	Unknown	Albemarle County
Murcielago Boomerang Dam	Unknown	Albemarle County
Murcielago Exempt Dams (11)	Unknown	Albemarle County
Murcielago Lake Dam	Unknown	Albemarle County
Murcielago Southwest Dam	Unknown	Albemarle County
Murray Lake Dam	Unknown	Albemarle County
Murrays Dam	Unknown	Albemarle County
North Fork Park Pond Dam	High	Albemarle County
Oakey Dam	Unknown	Albemarle County
Old Trail Dam #1	Unknown	Albemarle County
Old Trail Dam #2	Unknown	Albemarle County
Paines Dam	Unknown	Albemarle County
Pantops Dam	Unknown	Albemarle County
Pavlosky Dam	Unknown	Albemarle County
Peacock Hill Dam	High	Albemarle County
Peter Jefferson Place- Lake I Dam	Low	Albemarle County
Plain Dealing Dam	Unknown	Albemarle County
Pounding Brook Dam	Unknown	Albemarle County
Pounding Dick Woods Dam	Unknown	Albemarle County
Preddy Creek Road	Unknown	Albemarle County
PVCC Dam	Low	Albemarle County
Ragged Mountain Dam	High	Albemarle County
Red Hill Orchard Dam	Unknown	Albemarle County
Rivanna W&S Dam	Unknown	Albemarle County
Rockfield Dam	Unknown	Albemarle County
Rogers Road Dam	Unknown	Albemarle County
Rose Dam	Unknown	Albemarle County
Rosemont Dam	Unknown	Albemarle County
Samuel Walker Dam	Unknown	Albemarle County
Scogo Dam	Unknown	Albemarle County
Seabright Dam	Unknown	Albemarle County

Dam Name	Hazard Class	County
Shelford Farm Dam	Unknown	Albemarle County
Smiths Dam	Significant	Albemarle County
Southern Regional Park Dam	Low	Albemarle County
Spencer Young Dam	Unknown	Albemarle County
Spring Valley Dam	Unknown	Albemarle County
Steven White Dam	Unknown	Albemarle County
Stillfrieds Dam	Unknown	Albemarle County
Sugar Hollow Dam	High	Albemarle County
Totier Creek Dam	Low	Albemarle County
Upper Blandemar Dam	Unknown	Albemarle County
Upper Mint Springs Dam	High	Albemarle County
Upper Rose Dam	Unknown	Albemarle County
Van Clief Dam	Unknown	Albemarle County
Village Dam	Unknown	Albemarle County
Virginia Farms Dam	Unknown	Albemarle County
Watermarks Dam	Unknown	Albemarle County
Whistle Dam #1	Unknown	Albemarle County
Whites / Roseland Farm Dam	Unknown	Albemarle County
Wieboldts Dam	Unknown	Albemarle County
Wildon Grove Dam	Unknown	Albemarle County
Windsor Hill Dam	Unknown	Albemarle County
Wissel Roy Dam	Unknown	Albemarle County
Clifton Forge Dam	High	Alleghany County
Hanna Dam	Unknown	Alleghany County
Landfill No. 2 Dam	High	Alleghany County
Pond Lick Branch Dam	Low, Special	Alleghany County
West Virginia Pulp Dam B	Unknown	Alleghany County
WestRock #1 Embankment Dam	Unknown	Alleghany County
Amelia County Dam # 1	Unknown	Amelia County
Amelia County Dam # 10	Unknown	Amelia County
Amelia County Dam # 11	Unknown	Amelia County
Amelia County Dam # 12	Unknown	Amelia County
Amelia County Dam # 13	Unknown	Amelia County
Amelia County Dam # 14	Unknown	Amelia County
Amelia County Dam # 15	Unknown	Amelia County
Amelia County Dam # 16	Unknown	Amelia County
Amelia County Dam # 17	Unknown	Amelia County
Amelia County Dam # 18	Unknown	Amelia County
Amelia County Dam # 19	Unknown	Amelia County
Amelia County Dam # 2	Unknown	Amelia County
Amelia County Dam # 20	Unknown	Amelia County
Amelia County Dam # 21	Unknown	Amelia County
Amelia County Dam # 22	Unknown	Amelia County
Amelia County Dam # 3	Unknown	Amelia County
Amelia County Dam # 4	Unknown	Amelia County
Amelia County Dam # 5	Unknown	Amelia County
Amelia County Dam # 6	Unknown	Amelia County
Amelia County Dam # 7	Unknown	Amelia County
Amelia County Dam # 8	Unknown	Amelia County
Amelia County Dam # 9	Unknown	Amelia County
Amelia Dam	Low	Amelia County
Anderson Dam	Low	Amelia County

Dam Name	Hazard Class	County
Bardens Dam	Unknown	Amelia County
Barnard Dam	Unknown	Amelia County
Bridgeforth Mill Dam	High	Amelia County
Bultje Dam	Unknown	Amelia County
Chesapeake Dam	Unknown	Amelia County
Crawford Dam	Unknown	Amelia County
Davenports Pond Dam	Unknown	Amelia County
Jones Dam	Unknown	Amelia County
Manns Dam	Unknown	Amelia County
Sanderson Dam	Unknown	Amelia County
Saunders Dam	Low	Amelia County
Stark Dam	Unknown	Amelia County
Swiss Dixie Dam	Low	Amelia County
Vaughans Dam	Unknown	Amelia County
Whitakers Dam	Unknown	Amelia County
Whittington Dam	Unknown	Amelia County
Amherst County Dam # 1	Unknown	Amherst County
Amherst County Dam # 10	Unknown	Amherst County
Amherst County Dam # 11	Unknown	Amherst County
Amherst County Dam # 13	Unknown	Amherst County
Amherst County Dam # 2	Unknown	Amherst County
Amherst County Dam # 3	Unknown	Amherst County
Amherst County Dam # 4	Unknown	Amherst County
Amherst County Dam # 5	Unknown	Amherst County
Amherst County Dam # 6	Unknown	Amherst County
Amherst County Dam # 7	Unknown	Amherst County
Amherst County Dam # 9	Unknown	Amherst County
Buffalo River Dam # 2	High	Amherst County
Buffalo River Dam # 3	High	Amherst County
Buffalo River Dam # 4A	High	Amherst County
Burruss Dam	Unknown	Amherst County
Dan E. French Reservoir Dam	High	Amherst County
Dan E. French Reservoir Dam	High	Amherst County
Dan E. French Reservoir Dam	High	Amherst County
Dan E. French Reservoir Dam	High	Amherst County
Earley Dam	High	Amherst County
General Albert's Dam	Unknown	Amherst County
General Albert's Other Dam	Unknown	Amherst County
Greif Aeration Pond Dam	High	Amherst County
Greif Holding Pond Dam	High	Amherst County
Greif Sludge Pond # 2 Dam	High	Amherst County
Greif Sludge Pond # 3 Dam	Low	Amherst County
Homewood Lake Dam	Low	Amherst County
Lower Izaak Walton Dam	Significant	Amherst County
Mays Dam	Unknown	Amherst County
Pedlar River Dam	High	Amherst County
Pleasantview Hunt Club Dam	Unknown	Amherst County
Sweet Briar College - Lower Dam	High	Amherst County
Sweet Briar College - Upper Dam	Low	Amherst County
Triple Z Dam	Low	Amherst County
Tusculum Dam	Significant	Amherst County
Upper Izaak Walton Dam	Significant	Amherst County

Dam Name	Hazard Class	County
Wennings Dam	Unknown	Amherst County
Winton Country Club Dam	Significant	Amherst County
Drinkard Dam	Unknown	Appomattox County
East Fork Falling River Dam # 15	Significant	Appomattox County
East Fork Falling River Dam # 21	Significant	Appomattox County
East Fork Falling River Dam # 7	Significant	Appomattox County
Fairview Youth Camp Dam	Unknown	Appomattox County
George Taylor Dam	Low	Appomattox County
Henry Pack Dam	Unknown	Appomattox County
Holliday Lake Dam	Significant	Appomattox County
Lucas Trust Dam	Unknown	Appomattox County
Muddiman Dam	Unknown	Appomattox County
Paradise Lake Dam	Low	Appomattox County
Ralph Reynolds Dam	Unknown	Appomattox County
Ronnie Bryant Dam	Unknown	Appomattox County
Schenkel Inc. Dam	Unknown	Appomattox County
Thomas Raber Dam	Unknown	Appomattox County
William Curd Dam	Unknown	Appomattox County
Wrights Dam	Low, Special	Appomattox County
Zack Hudson Dam	Unknown	Appomattox County
Camp Shenandoah Dam	Low	Augusta County
Coles Run Dam	High	Augusta County
Elizabeth Hearn Dam	Unknown	Augusta County
Fauber Dam	Unknown	Augusta County
Lower Wallace Dam	Low	Augusta County
Morris Glen Dam	Unknown	Augusta County
Scottland Land Dam	Unknown	Augusta County
Smith Dam	Unknown	Augusta County
Smithleigh Dam	Unknown	Augusta County
South River Dam #10A	High	Augusta County
South River Dam #11	High	Augusta County
South River Dam #19	High	Augusta County
South River Dam #23	High	Augusta County
South River Dam #23	High	Augusta County
South River Dam #24	Low	Augusta County
South River Dam #25	High	Augusta County
South River Dam #26	High	Augusta County
South River Dam #3	Significant	Augusta County
South River Dam #4	High	Augusta County
South River Dam #6	High	Augusta County
South River Dam #6	High	Augusta County
South River Dam #7	High	Augusta County
Staunton Dam	High	Augusta County
Sugarloaf Farm Dam	Unknown	Augusta County
Upper North River #76	High	Augusta County
Upper North River #77	High	Augusta County
Upper North River Dam #10	High	Augusta County
Upper North River Dam #10	High	Augusta County
Upper Wallace Dam	High	Augusta County
Wood Dam	Unknown	Augusta County
Bath Alum Farm Dam	Significant	Bath County
Bear Loop Hunt Club Dam	Unknown	Bath County

Dam Name	Hazard Class	County
Douthat Lake Dam	High	Bath County
John Lawrence Dam	Significant	Bath County
Lake Bacova Dam	Unknown	Bath County
3E's LLC Dam	Unknown	Bedford County
Abert Water Plant - Sludge Lagoon Dam	High	Bedford County
Anderson dam	Unknown	Bedford County
Andrews Dam	Unknown	Bedford County
Beard Dam	Unknown	Bedford County
Beaverdam Creek Dam	High	Bedford County
Bedford Lake Dam	High	Bedford County
Big Island Pond Dam	Low, Special	Bedford County
Boonsboro Country Club #1	Low	Bedford County
Brent L.West Dam	Unknown	Bedford County
Bryan Dam	Unknown	Bedford County
Burnely Pond Dam	Unknown	Bedford County
Carrington Dam	Unknown	Bedford County
Chambers Dam	Unknown	Bedford County
Chattin Dam	Unknown	Bedford County
Chilarna Lake Dam	Unknown	Bedford County
Cifax Lake Dam	Low	Bedford County
Clyde D. Bays Dam	Unknown	Bedford County
Costran Art #2	Unknown	Bedford County
Craghead Dam	Unknown	Bedford County
Crowder Dam	Unknown	Bedford County
Davis Dam	Unknown	Bedford County
Davis Lake Dam	Unknown	Bedford County
Delaware Properties Dam	Unknown	Bedford County
Demasters Dam	Unknown	Bedford County
Duis Dam	Unknown	Bedford County
Eagle Eyrie Lake Dam	High	Bedford County
Elk Garden Lake Dam	High	Bedford County
Evergreen Lake Dam	Low	Bedford County
Falling Creek Reservoir Dam	High	Bedford County
Farris Dam	Unknown	Bedford County
Ferguson Farms Dam	Unknown	Bedford County
Fessler dam	Unknown	Bedford County
Garrard Lake Dam	Unknown	Bedford County
Georgia-Pacific Aeration Pond Dam	Low, Special	Bedford County
Gilliam Dam	Unknown	Bedford County
Gladys Meador Hoover Dam	Unknown	Bedford County
Goode Dam	Unknown	Bedford County
Greg Lester Dam	Unknown	Bedford County
Grizzard #2 Dam	Unknown	Bedford County
Grove Dam	Unknown	Bedford County
Hackman Dam	Unknown	Bedford County
Hardwick Dam	Unknown	Bedford County
Harrington Dam	Unknown	Bedford County
Hawk's View farm Dam	Unknown	Bedford County
Hickory Lake Club Dam	Unknown	Bedford County
Holden Dam	Unknown	Bedford County
Holdrens Dam	Unknown	Bedford County
Horner's Dam	Unknown	Bedford County

Dam Name	Hazard Class	County
Ivy Hill Dam	High	Bedford County
Ivy Hills Golf Club Dam	Unknown	Bedford County
Ivy Wolf Farm Dam	Unknown	Bedford County
James M. Stephens Dam	Significant	Bedford County
Jetters Chapel Mountain Dam	Unknown	Bedford County
John Edward Dam	Unknown	Bedford County
Lake Ridge Drive Dam	Unknown	Bedford County
Lake Vista Dam #1	Significant	Bedford County
Lollis Dam	Unknown	Bedford County
London Downs Dam	Unknown	Bedford County
Lorton Dam	Unknown	Bedford County
Markham Dam	Unknown	Bedford County
Meador Dam	Unknown	Bedford County
Mountain Run Farms #1	Unknown	Bedford County
Mountain Run Farms #2	Unknown	Bedford County
Nelson Dam	Unknown	Bedford County
New London Dam #1	Unknown	Bedford County
New London Dam #2	Unknown	Bedford County
Old Elkton Lake Dam	Unknown	Bedford County
Perry Morgan Dam	Unknown	Bedford County
Poplar Forest Dam	Unknown	Bedford County
Powers Dam	Unknown	Bedford County
Ramsey Dam	Significant	Bedford County
Ring Dam	Unknown	Bedford County
Ronald L.Todd Dam	Unknown	Bedford County
Saunders Pond Dam	Unknown	Bedford County
Scott Dam	Unknown	Bedford County
Simpkins Dam	Low, Special	Bedford County
Spring Lake Dam	Unknown	Bedford County
Springhill Lake Dam	High	Bedford County
Stoney Creek Reservoir Dam (Bedford)	High	Bedford County
Strawberry Ridge Farms Dam	Unknown	Bedford County
Stroobants Dam	High	Bedford County
Swan Lake Dam	Significant	Bedford County
Swine Meyer Dam	Low	Bedford County
Thomas Dam	Unknown	Bedford County
Thomas L. and Patricia Smith Dam	Unknown	Bedford County
Tommy L. McCraw Dam	Unknown	Bedford County
TPD Enterprises	Unknown	Bedford County
Unidentified Dam	Unknown	Bedford County
Walmark Farms Dam	Unknown	Bedford County
Warren Dam	Unknown	Bedford County
Wilkes Dam	Unknown	Bedford County
Woods Landing Dam	High	Bedford County
Bland County Farm Dam	Unknown	Bland County
Crab Orchard Creek Dam	High	Bland County
Hunting Camp Dam	Unknown	Bland County
Blue Ridge Estates Dam	High	Botetourt County
Botetourt Country Club Dam	Unknown	Botetourt County
Carvin Cove Dam	High	Botetourt County
Goldberg Beaver Dam	Unknown	Botetourt County
Greenfield Lake Dam	Unknown	Botetourt County

Dam Name	Hazard Class	County
Hancock Dam	Unknown	Botetourt County
Orchard Lake Dam	Unknown	Botetourt County
Rainbow Forest Dam	High	Botetourt County
Stokes Dam	Unknown	Botetourt County
Wilburn Dam	Unknown	Botetourt County
Brunswick Lake Dam	High	Brunswick County
Epperson Dam	Unknown	Brunswick County
Flatrock Pond Dam	Unknown	Brunswick County
Great Creek Dam # 6A	High	Brunswick County
Harrisons Dam	Unknown	Brunswick County
L. M. Epperson Dam	Unknown	Brunswick County
Masons Mill Dam	Unknown	Brunswick County
Buchanan Dam #2	Unknown	Buchanan County
Allen Lake Dam	Unknown	Buckingham County
Buckingham County Dam #1	Unknown	Buckingham County
Buckingham County Dam #11	Unknown	Buckingham County
Buckingham County Dam #13	Unknown	Buckingham County
Buckingham County Dam #15	Unknown	Buckingham County
Buckingham County Dam #16	Unknown	Buckingham County
Buckingham County Dam #2	High	Buckingham County
Buckingham County Dam #20	Unknown	Buckingham County
Buckingham County Dam #24	Unknown	Buckingham County
Buckingham County Dam #27	Unknown	Buckingham County
Buckingham County Dam #35	Unknown	Buckingham County
Buckingham County Dam #39	Unknown	Buckingham County
Buckingham County Dam #5	Unknown	Buckingham County
Buckingham County Dam #6	Unknown	Buckingham County
Buckingham County Dam #8	Unknown	Buckingham County
Buckingham County Dam #9	Unknown	Buckingham County
Carter Dam	Unknown	Buckingham County
Central Va. Water Storage Corporation	Low	Buckingham County
Doug Branch Pond	Low	Buckingham County
Fender Dam	Unknown	Buckingham County
Fitzgerald Dam	Unknown	Buckingham County
Horsepen Creek Dam	High	Buckingham County
Lucas Dam	Unknown	Buckingham County
Martin Dam	Unknown	Buckingham County
Monroe, Melvin & Johns Dam	Unknown	Buckingham County
Muddy Creek Dam #1	High	Buckingham County
Muddy Creek Dam #2	High	Buckingham County
Orange Dam	Unknown	Buckingham County
Slate River Dam #13	Significant	Buckingham County
Slate River Dam #14	Significant	Buckingham County
Slate River Dam #2	High	Buckingham County
Slate River Dam #7	High	Buckingham County
Slate River Dam #8	High	Buckingham County
Solite Corp. Dam	Unknown	Buckingham County
Sutherland Dam	Unknown	Buckingham County
Turner Dam	Unknown	Buckingham County
Willis River Dam #1A	High	Buckingham County
Willis River Dam #1B	Significant	Buckingham County
Willis River Dam #2	High	Buckingham County

Dam Name	Hazard Class	County
Willis River Dam #3	High	Buckingham County
Willis River Dam #4	High	Buckingham County
Willis River Dam #5E	High	Buckingham County
Willis River Dam #5F	High	Buckingham County
Willis River Dam #6	High	Buckingham County
Willis River Dam #6A	High	Buckingham County
Willis River Dam #7	Significant	Buckingham County
Willis River Dam #9	High	Buckingham County
Bates Dam	Unknown	Campbell County
Brookneal Dam	Significant	Campbell County
Byrd Pond Dam	Unknown	Campbell County
Camp Hydaway Lake Dam	Unknown	Campbell County
Farmer Dam	Unknown	Campbell County
Framatome Storm Water and Fire Pond Dam	Low	Campbell County
Grandview Lake Dam	Unknown	Campbell County
Hall Dam	Unknown	Campbell County
Humble Creek Pond Dam	Unknown	Campbell County
Hutchinson Dam	Low, Special	Campbell County
Jones Dam	Unknown	Campbell County
Lake Shalom Dam	Low	Campbell County
Lakewood Dam	Significant	Campbell County
Little Falling River Dam # 1	Significant	Campbell County
Little Falling River Dam # 2	Significant	Campbell County
Little Falling River Dam # 3	Significant	Campbell County
Moody Dam	Unknown	Campbell County
New Camp Hydaway Lake Dam	High	Campbell County
Otter River Raw Water Terminal Reservoir Dam	High	Campbell County
Patrick Lower Dam	Unknown	Campbell County
Patrick Upper Dam	Unknown	Campbell County
Perrow Dam	Unknown	Campbell County
Pine Lake Dam	Unknown	Campbell County
Thomas Dam	Unknown	Campbell County
Timberlake Dam	High, Special	Campbell County
Wildwood Dam # 1	Low	Campbell County
Wildwood Dam # 2	Unknown	Campbell County
Wildwood Dam # 3	Unknown	Campbell County
Ames Dam	Unknown	Caroline County
Ball Dam	Unknown	Caroline County
Bear Island Dam	Unknown	Caroline County
Boulwares Millpond Dam	Unknown	Caroline County
Broaddus Dam	Unknown	Caroline County
Byrds Mill Dam	Unknown	Caroline County
Campbells Dam	Unknown	Caroline County
Cedar Fork Dam	Unknown	Caroline County
Chenault Dam	Unknown	Caroline County
Chesterfield Road Dam	Unknown	Caroline County
Coburn Dam	Unknown	Caroline County
Coleman Pond Dam	Unknown	Caroline County
Colemans Millpond Dam	Unknown	Caroline County
Collins Dam	Unknown	Caroline County
D. Pitts Dam	Unknown	Caroline County

Dam Name	Hazard Class	County
Daltons Dam	Unknown	Caroline County
Elliotts Dam	Unknown	Caroline County
Flintshire Farm Dam	Unknown	Caroline County
former Tivette Farm Dam	Unknown	Caroline County
Gouldmans Dam	Unknown	Caroline County
Hackett Dam	Unknown	Caroline County
James Dam	Unknown	Caroline County
Jiles Milll pond Dam	Unknown	Caroline County
Kalita Dam	Unknown	Caroline County
Ladysmith Lake Dam	Significant	Caroline County
Lake Caroline Dam	High	Caroline County
Lake DeJarnette Dam	Low, Special	Caroline County
Lake Devolia Dam	Unknown	Caroline County
Lake Dover Dam	Unknown	Caroline County
Lake Heritage Dam	Unknown	Caroline County
Lake Holiday Dam	Low, Special	Caroline County
Lake Holly Dam	Unknown	Caroline County
Lake Land'or Dam	Significant	Caroline County
Lake Pinewood Dam	Low, Special	Caroline County
Lake Shannon Dam	Low, Special	Caroline County
Lower Mt. Olympus Dam	Unknown	Caroline County
Lower Tanyard Swamp Dam	Unknown	Caroline County
Margaret Pitts Dam	Unknown	Caroline County
Moss Neck Manor Lake Dam	Unknown	Caroline County
Mt. Airy North Dam	Unknown	Caroline County
Old Grays Dam	Unknown	Caroline County
Orrock Lane Dam	Unknown	Caroline County
Paige Road Dam	Unknown	Caroline County
Pattersons Corner Dam	Unknown	Caroline County
Pendleton G.C. Irrigation Lake #1	Low	Caroline County
Penola East Five Dam	Unknown	Caroline County
Penola East Six Dam	Unknown	Caroline County
Penola West One Dam	Unknown	Caroline County
Penola West Two Dam	Unknown	Caroline County
Pitts Pond Dam	Unknown	Caroline County
Poplar Dam	Unknown	Caroline County
Reedy Mill Dam	Unknown	Caroline County
Schoolhouse Road Dam	Unknown	Caroline County
Seals Middle Dam	Unknown	Caroline County
Seals North Dam	Unknown	Caroline County
Seals South Dam	Unknown	Caroline County
Smith Dairy East Dam	Unknown	Caroline County
Smith Dairy Southwest Dam	Unknown	Caroline County
Smith Dam	Unknown	Caroline County
Spring Lake Dam	Unknown	Caroline County
Temples Mill Dam	Unknown	Caroline County
Terrell Brothers Dam	Unknown	Caroline County
Terrell Farm Dam	Unknown	Caroline County
Thelma Pitts Dam	Unknown	Caroline County
Timberlake Dam	Unknown	Caroline County
Trahos Dam	Unknown	Caroline County
Upper Mt. Olympus Dam	Unknown	Caroline County

Dam Name	Hazard Class	County
Upper Tanyard Run Dam	Unknown	Caroline County
Usry Dam	Unknown	Caroline County
Bruce Bryant Dam	Unknown	Carroll County
Caviness Dam	Unknown	Carroll County
Grassy Creek Farm LLC Dam	Unknown	Carroll County
Isom Dam	High	Carroll County
Olde Mill Golf Club Dam	Unknown	Carroll County
Patch Inc. Dam	Unknown	Carroll County
Russell Dam	Unknown	Carroll County
Stewarts Creek - Lovills Creek Dam #9	High	Carroll County
West Dam	Unknown	Carroll County
Allen Dam	Unknown	Charles City County
Epps Dam	Unknown	Charles City County
Howard Farm Dam	Unknown	Charles City County
White Dam	Unknown	Charles City County
Eastern Pines Dam	Unknown	Charlotte County
Four Locusts Dam	Unknown	Charlotte County
Roanoke Creek Dam # 31B	High	Charlotte County
Roanoke Creek Dam # 35A	Low	Charlotte County
Roanoke Creek Dam # 43A	High	Charlotte County
Roanoke Creek Dam # 49A	Significant	Charlotte County
Roanoke Creek Dam # 4A	High	Charlotte County
Roanoke Creek Dam # 54	High	Charlotte County
Roanoke Creek Dam # 5B	High	Charlotte County
Roanoke Creek Dam # 61A	High	Charlotte County
Roanoke Creek Dam # 62	High	Charlotte County
Roanoke Creek Dam # 67	High	Charlotte County
Roanoke Creek Dam # 68	High	Charlotte County
Roanoke Creek Dam # 6A	High	Charlotte County
Roanoke Creek Dam # 70A	Significant	Charlotte County
Roanoke Creek Dam # 72A	High, Special	Charlotte County
Allied Concrete Dam	Unknown	Chesterfield County
Andrews Dam	Unknown	Chesterfield County
ARWA Sludge Lagoon Dam	Low, Special	Chesterfield County
Ashbrook Dam	Unknown	Chesterfield County
Beaufont Spring Dam	Unknown	Chesterfield County
Beaver Lake Dam	Low	Chesterfield County
Birkdale Dam	Unknown	Chesterfield County
Carr Dam	Unknown	Chesterfield County
Center Pointe Dam	Unknown	Chesterfield County
Chelsea Farm Dam	Unknown	Chesterfield County
Chester Club Dam	Unknown	Chesterfield County
Chesterfield County Dam #1	Unknown	Chesterfield County
Chesterfield County Dam #2	Unknown	Chesterfield County
Chesterfield Discharge Basin Dam	Low	Chesterfield County
Chesterfield Equalization Basin Dam	Significant	Chesterfield County
Chesterfield Power Station Lower Ash Pond Dam	Significant	Chesterfield County
Chesterfield Power Station Metals Treatment Pond	Significant	Chesterfield County
Chesterfield Power Station UAP	Significant	Chesterfield County
Clayville Lane Dam	Unknown	Chesterfield County

Dam Name	Hazard Class	County
Club Dam	Unknown	Chesterfield County
Condrey Dam	Unknown	Chesterfield County
Cosby Dam	High	Chesterfield County
Crostick Dam	Unknown	Chesterfield County
Evergreen Lake Dam	Unknown	Chesterfield County
Falling Creek Reservoir Dam	High	Chesterfield County
First Branch Dam	Significant	Chesterfield County
Geara Woods Dam	Unknown	Chesterfield County
General Land Company Dam	Unknown	Chesterfield County
Glen Tara Dam	Unknown	Chesterfield County
Gordon Dam	Unknown	Chesterfield County
Gregory's Pond Dam	Unknown	Chesterfield County
Ironbridge Dam	Unknown	Chesterfield County
Izaak Walton Park Dam	Unknown	Chesterfield County
Jessup Road Dam	Unknown	Chesterfield County
Kcratchs Dam	Unknown	Chesterfield County
Labrador Lake Dam	Unknown	Chesterfield County
Lake Crystal Dam	High	Chesterfield County
Lake Patrick Henry Dam	High	Chesterfield County
Lake Salisbury Dam	High	Chesterfield County
Leroy Dam	Unknown	Chesterfield County
Lewis Road Dam	Unknown	Chesterfield County
Lone Goose Dam	Unknown	Chesterfield County
Lower Beaver Pond Dam	Unknown	Chesterfield County
Margaret Dam	High	Chesterfield County
Meadowbrook Country Club Dam	Unknown	Chesterfield County
Meadowville BMP	Unknown	Chesterfield County
Minor dams at Tate estate	Unknown	Chesterfield County
Napiers Savage Dam	Significant	Chesterfield County
Page Dam	Unknown	Chesterfield County
Pells Dam	Unknown	Chesterfield County
R J Reynolds Raw Water Pond Dam	Low, Special	Chesterfield County
Radcliffe Dam	Unknown	Chesterfield County
Reed Dam	Unknown	Chesterfield County
Reynolds Dam	Unknown	Chesterfield County
Richmond Zoo Dam	Unknown	Chesterfield County
Rieves Dam	Unknown	Chesterfield County
Rock Creek Park Dam	Unknown	Chesterfield County
Rowlett Road Dam	Low	Chesterfield County
Second Branch Road Dam	Unknown	Chesterfield County
Shoosmith Dam	Unknown	Chesterfield County
Spray Dam	Unknown	Chesterfield County
Spring Creek Upper Dam	Unknown	Chesterfield County
Spruance Polishing Dam	Low	Chesterfield County
Swift Creek Dam	High	Chesterfield County
Swift Creek Mill Dam	Unknown	Chesterfield County
Swift Creek Reservoir Dam	High	Chesterfield County
Tates Dam	Low, Special	Chesterfield County
Thomas Dam	Unknown	Chesterfield County
Timsbury South Dam	Unknown	Chesterfield County
Upper Beaver Pond Dam	Unknown	Chesterfield County
Vescova Road Dam	Unknown	Chesterfield County

Dam Name	Hazard Class	County
Village Lake Dam	Unknown	Chesterfield County
Wake Lake Dam	High	Chesterfield County
Waterford #1 Dam	Unknown	Chesterfield County
Westham GC Irrigation Lake Dam	Unknown	Chesterfield County
Woodland Pond	High	Chesterfield County
Chesapeake Energy Center Bottom Ash and Sediment Pond Dam	High	City of Chesapeake
Boatwright Dam	Low, Special	City of Danville
Boatwright Dam #1	Unknown	City of Danville
LPI Dam	Unknown	City of Danville
Riverside Dam	Unknown	City of Danville
Ray Development Dam	Unknown	City of Franklin
Central Park POA Dam	Unknown	City of Fredericksburg
Embry Dredge Material Spoil Dam	Unknown	City of Fredericksburg
Smith Run D - Dam	Unknown	City of Fredericksburg
Twin Lakes Inc. Dam	Unknown	City of Fredericksburg
Coliseum Lake Dam	Low	City of Hampton
Crystal Lake Dam	Unknown	City of Hampton
Sandy Bottom Lake Dam	Unknown	City of Hampton
JMU Amphitheatre Dam	Unknown	City of Harrisonburg
Newman Lake Dam	High	City of Harrisonburg
College Lake Dam	High	City of Lynchburg
Hollins Mill Dam	Unknown	City of Lynchburg
Lake Summit Dam	High	City of Lynchburg
Lakeland Dam	High	City of Lynchburg
Scotts Mill Dam	Low	City of Lynchburg
Manassas Dam #2	Unknown	City of Manassas
Manassas Dam #3	Unknown	City of Manassas
Manassas Dam #4	Unknown	City of Manassas
Manassas Dam #5	Unknown	City of Manassas
Winters Branch Dam	Significant	City of Manassas
Mount Bethel Church Dam	Unknown	City of Martinsville
Kerry Lake Dam	Low	City of Newport News
Lee Hall Reservoir Dam	High	City of Newport News
Lion's Bridge Dam	Unknown	City of Newport News
Skiffes Creek Dam	Low	City of Newport News
Sluice Dam	Unknown	City of Newport News
Lake Whitehurst Dam	High	City of Norfolk
Lower Norton Reservoir Dam	High	City of Norton
Upper Norton Reservoir Dam	High	City of Norton
Wilcox Dam	High	City of Petersburg
Cherokee Dam	Unknown	City of Richmond
Hobby Hill Dam	Unknown	City of Richmond
Hollywood Power Plant Dam	Low, Special	City of Richmond
University Commons Dam	Unknown	City of Richmond
Upper Shields Lake Dam	Unknown	City of Richmond
Westbury Lake Dam	Unknown	City of Richmond
Williams Island Dam	Unknown	City of Richmond
Winston Lake Dam	High	City of Richmond
Youngs Pond Dam	Unknown	City of Richmond
Spring Valley Lake Dam	High	City of Roanoke
Windsor Lake Dam	High	City of Roanoke

Dam Name	Hazard Class	County
Staunton City Dam #1	Unknown	City of Staunton
Brights Dam	Unknown	City of Suffolk
C - Pond Dam	High	City of Suffolk
D - Pond Dam	Unknown	City of Suffolk
Ferry Point Dam	Unknown	City of Suffolk
Godwin - Culpepper Dam	Unknown	City of Suffolk
Godwins Millpond Dam	High	City of Suffolk
Governor's Point Dam	Low, Special	City of Suffolk
Izaak Walton Dam	Low	City of Suffolk
Lake Burnt Mills Dam	High	City of Suffolk
Lake Cohoon Dam	High	City of Suffolk
Lake I Dam	Low, Special	City of Suffolk
Lake Kilby Dam	High	City of Suffolk
Lake Kilby Water Treatment Plant Sludge Lagoon Dam	Low	City of Suffolk
Lake Meade Dam	High	City of Suffolk
Lake Prince Dam	Low	City of Suffolk
Mathews Dam	Unknown	City of Suffolk
Norfleet Dam	Unknown	City of Suffolk
Rountree North Dam	Unknown	City of Suffolk
Rountree South Dam	Unknown	City of Suffolk
Sleepy Lake Dam	Low, Special	City of Suffolk
Speights Run Dam	High	City of Suffolk
Western Branch Dam	High	City of Suffolk
Great Neck Lake # 7 Dam	Unknown	City of Virginia Beach
Great Neck Lake Dam	Unknown	City of Virginia Beach
Indian Lakes Dam	Unknown	City of Virginia Beach
Kingston Lake Dam	Low, Special	City of Virginia Beach
Lake 6 Great Neck Area Dam	Unknown	City of Virginia Beach
Lake Joyce Dam	Unknown	City of Virginia Beach
Lake Smith Dam	High	City of Virginia Beach
Little Creek Reservoir Dam	High	City of Virginia Beach
Salem Court Condominium Spillway Dam	Unknown	City of Virginia Beach
Stumpy Lake Dam	Significant	City of Virginia Beach
Thoroughgood Dam	Unknown	City of Virginia Beach
Trant Lake Spillway Dam	Unknown	City of Virginia Beach
Wolfsnare Lake Dam	Unknown	City of Virginia Beach
South River Dam #8A	High	City of Waynesboro
Lake Matoaka Dam	High	City of Williamsburg
Tutters Neck Pond Dam	Unknown	City of Williamsburg
Clowser Dam	Unknown	Clarke County
Helco Dam	Unknown	Clarke County
Long Pond Farm Dam	Low	Clarke County
Soonthornchai Dam	Unknown	Clarke County
The Willows Dam	Unknown	Clarke County
Willow Lake Dam	Unknown	Clarke County
Craig County Dam #6	Unknown	Craig County
Johns Creek Dam #1	High	Craig County
Johns Creek Dam #2	High	Craig County
Johns Creek Dam #3	High	Craig County
Johns Creek Dam #4	High	Craig County
Attoek Dam	Unknown	Culpeper County

Dam Name	Hazard Class	County
Beauregard Dam No. 1	Unknown	Culpeper County
Beauregard Dam No. 2	Unknown	Culpeper County
Benzinger Dam	Unknown	Culpeper County
Birmingham Farm Dam	Unknown	Culpeper County
Brandy Rock Farm Dam	Unknown	Culpeper County
Charles Hudson Dam	Unknown	Culpeper County
Cole Dam #1	Low	Culpeper County
Compton Dam #1	Unknown	Culpeper County
Compton Dam #2	Unknown	Culpeper County
Gallo Dam	Unknown	Culpeper County
Hawkins Dam	Unknown	Culpeper County
Hazel Lake Dam	Unknown	Culpeper County
Holland Dam	Unknown	Culpeper County
Lake Ridge Ventures Dam	Unknown	Culpeper County
Lake Rillhurst Dam	Significant	Culpeper County
Lake Rillhurst Dam	Significant	Culpeper County
Mayo Dam	Unknown	Culpeper County
Miller Place Dam	Unknown	Culpeper County
Mountain Run Dam #11	High	Culpeper County
Mountain Run Dam #13	High	Culpeper County
Mountain Run Dam #18	High	Culpeper County
Mountain Run Dam #50	High	Culpeper County
Mountain Run Dam #8A	Significant	Culpeper County
Rapidan Mill Dam	Unknown	Culpeper County
Seven Islands Dam	Unknown	Culpeper County
Silver Dollar Lake Dam	Unknown	Culpeper County
Smiley - Henry	Unknown	Culpeper County
South Wales Country Club Dam	Low	Culpeper County
Swan Dam	Unknown	Culpeper County
Triple S Land Dam	Unknown	Culpeper County
Troiano Dam	Significant	Culpeper County
Willis Dam	Unknown	Culpeper County
Atkins Dam	Unknown	Cumberland County
Barrett Dam	Unknown	Cumberland County
Bear Creek Dam	Significant	Cumberland County
Benelli Dam	Unknown	Cumberland County
Bish Dam	Unknown	Cumberland County
Blanton Dam	Unknown	Cumberland County
Bonbrook Lake Dam	Unknown	Cumberland County
Bunivan Dam	Unknown	Cumberland County
Ca Ira Dam	Unknown	Cumberland County
Clayton Dam	Low	Cumberland County
Clements Dam	Significant	Cumberland County
Cobbs Creek Regional Water Supply Dam (Main Dam A)	High	Cumberland County
Cobbs Creek Regional Water Supply Reservoir Dam Perimeter Dam (Dam C)	High	Cumberland County
Cobbs Creek Regional Water Supply Reservoir Saddle Dam (Dam B)	High	Cumberland County
Collins Lower Dam	Unknown	Cumberland County
Collins Upper Dam	Unknown	Cumberland County
David Asal Dam	Unknown	Cumberland County

Dam Name	Hazard Class	County
Earl Collier Dam	Unknown	Cumberland County
Flippen Dam	Unknown	Cumberland County
Frost Dam	Unknown	Cumberland County
Gnegy Dam	Unknown	Cumberland County
Harvey Jo Martin Dam	Unknown	Cumberland County
Ingle Dam	Unknown	Cumberland County
JCM LLC Dam	Unknown	Cumberland County
Jones Dam	Unknown	Cumberland County
Knorr Dam	Unknown	Cumberland County
L. G. Atkins Dam	Unknown	Cumberland County
Lancaster Dam	Unknown	Cumberland County
Landis Dam	Unknown	Cumberland County
Leon Hanson Dam	Low, Special	Cumberland County
Lillie's Dam	Low	Cumberland County
Lower Ayers Dam	Unknown	Cumberland County
Ortel Dam	Unknown	Cumberland County
Patricia Gills Dam	Unknown	Cumberland County
Pepper Land Co Dam #1	Unknown	Cumberland County
Pepper Land Co Dam #2	Unknown	Cumberland County
Rogers Dam	Unknown	Cumberland County
Sanderson Dam	Unknown	Cumberland County
Simanske Dam	Unknown	Cumberland County
Sports Dam	Unknown	Cumberland County
Sports Lake Dam	Unknown	Cumberland County
Swans Dam	Unknown	Cumberland County
T&R Scott Dam	Unknown	Cumberland County
T. Edward Stimpson Dam	Unknown	Cumberland County
Trices Lake Dam	Significant	Cumberland County
Upper Ayers Dam	Unknown	Cumberland County
Wapelala Dam	Significant	Cumberland County
White Level Dam	Unknown	Cumberland County
Wilck Dam	Unknown	Cumberland County
Wilck Family Dam #1	Unknown	Cumberland County
Wilcks Dam	Unknown	Cumberland County
Wilsons Dam	Unknown	Cumberland County
Winston Lake Dam	Low	Cumberland County
WTL Prop Dam	Unknown	Cumberland County
Laurel Lake Dam	Unknown	Dickenson County
Mullins Dam	Low, Special	Dickenson County
Nicewonder Dam	Low, Special	Dickenson County
White Oak Creek Dam	High	Dickenson County
Burnt Quarter Dam	Unknown	Dinwiddie County
Cernys Dam	Unknown	Dinwiddie County
Clarkes Dam	Unknown	Dinwiddie County
Claytons Dam	Unknown	Dinwiddie County
Colemans Lake Dam	Low	Dinwiddie County
Commerce Park Dam	High	Dinwiddie County
Eades Dam	Unknown	Dinwiddie County
J. C. Stafford Dam	Unknown	Dinwiddie County
Jones Dam	Unknown	Dinwiddie County
Lake Jordan Dam	Low	Dinwiddie County
McKenney Hunt Club Dam	Unknown	Dinwiddie County

Dam Name	Hazard Class	County
Musgrove Dam	Unknown	Dinwiddie County
Pee Wee Dam	Low	Dinwiddie County
Perkins Dam	Unknown	Dinwiddie County
Picture Dam	Unknown	Dinwiddie County
Steers Mill Pond Dam	Unknown	Dinwiddie County
Stokes Dam	Unknown	Dinwiddie County
Baylors Dam	Unknown	Essex County
Cedar Creek Dam	Unknown	Essex County
Cedar Creek Lower Dam	Unknown	Essex County
Cortney Dam	Unknown	Essex County
Courtney Dam	Unknown	Essex County
Dillard Dam	Unknown	Essex County
Hundley Dam	Unknown	Essex County
Lewis Dam	Unknown	Essex County
Millers Dam	Unknown	Essex County
Penniston Dam	Unknown	Essex County
Purkins HOA Dam	Unknown	Essex County
Rose Hill Dam	Unknown	Essex County
Scotts Millpond Dam	Unknown	Essex County
Spindles Mill Dam	Unknown	Essex County
Taliaferro Dam	Unknown	Essex County
Taliaferro Mill Dam	Unknown	Essex County
Wrights Millpond Dam	Unknown	Essex County
ARRF P Holdings Dam	Unknown	Fairfax County
Barcroft Dam	High	Fairfax County
Brookfield Park Dam	Low, Special	Fairfax County
Burke Centre Section 11B Dam	High	Fairfax County
Burke Hill Dam	Unknown	Fairfax County
Burke Lake Dam	High	Fairfax County
Carrington Regional Dam	High	Fairfax County
Chantilly Country Club Dam	Low	Fairfax County
Crippen Dam	Unknown	Fairfax County
Crosspointe Lake Dam	High	Fairfax County
Daddy Long Lake Dam	Significant	Fairfax County
Dulles Corner Lake Dam	Significant	Fairfax County
Dulles Station Regional Pond Dam	Low	Fairfax County
East Market Pond Dam	Significant	Fairfax County
Emergency Sewage Retention Pond No.1 Structure	Significant	Fairfax County
Emergency Sewage Retention Pond No.2 Structure	Significant	Fairfax County
F.P. Griffith Water Plant Lorton Quarry	Significant	Fairfax County
F.P. Griffith Water Plant Stormwater Outflow #6	Unknown	Fairfax County
Fair Lakes Dam #1	High	Fairfax County
Fair Lakes Land Bay 2 SWM BMP Pond Dam	High	Fairfax County
Fairfax Center Regional SWM Pond #D77	Low	Fairfax County
Fairview Lake Dam	High	Fairfax County
Fox Lair Regional Pond Embankment	Unknown	Fairfax County
Fox Lake Dam	Low	Fairfax County
Hampton Forest Section 4 SWM Dam	High	Fairfax County
Hidden Spring Dam	Unknown	Fairfax County

Dam Name	Hazard Class	County
Hunter Mill Estates Regional Pond D-52/25	Low	Fairfax County
Island Creek Dam	Significant	Fairfax County
Kings Park West Section 18 Dam	Significant	Fairfax County
Kingstowne Lake Dam	High	Fairfax County
Kingstowne SWM DP #4 Regional	High	Fairfax County
Kingstowne SWM/BMP Basin #1	Unknown	Fairfax County
Lake Accotink Dam	High	Fairfax County
Lake Anne Dam	High	Fairfax County
Lake Audubon Dam	High	Fairfax County
Lake Fairfax Dam	High	Fairfax County
Lake Newport Dam	High	Fairfax County
Lake Thoreau Dam	High	Fairfax County
Lakeside Dam No. 2	Unknown	Fairfax County
Laurel Hill Lake Dam	Unknown	Fairfax County
Lower Timber Lake Dike	Unknown	Fairfax County
Marmota Farm Pond Dam	Unknown	Fairfax County
Martins Lake Dam	Unknown	Fairfax County
Mule Pen Quarry Structure No. 1 (1 of 3 structures)	Unknown	Fairfax County
No. 2 Dam of 4 Kingstowne Park Impoundments	Significant	Fairfax County
North Twin Lake Dam	Significant	Fairfax County
NVCC Annandale Campus Dam	Significant	Fairfax County
Penderbrook North Pond Dam	Unknown	Fairfax County
Penderbrook South Pond Dam	Unknown	Fairfax County
Pohick Creek Dam #1	High	Fairfax County
Pohick Creek Dam #2	High	Fairfax County
Pohick Creek Dam #3	High	Fairfax County
Pohick Creek Dam #4	High	Fairfax County
Pohick Creek Dam #7	High	Fairfax County
Pohick Creek Dam #8	High	Fairfax County
Pulte McLean SWM Pond Dam	High	Fairfax County
Reston Northern Sector Pond 1 Dam	High	Fairfax County
Reston Parkway Phase 2 SWM facility #2	Low	Fairfax County
Reston Parkway Phase 2 SWM Facility No. 3	Unknown	Fairfax County
Reston Section 43 SWM Facility	Unknown	Fairfax County
Reston Town Center Western BMP Dam	High	Fairfax County
Sewage Holding Pond No.2 Lower Potomac Pollution Control Plant	Low	Fairfax County
South Twin Lake Dam	Significant	Fairfax County
Springfield Golf & Country Club Lower Dam	Unknown	Fairfax County
Springfield Golf & Country Club Upper Dam	Unknown	Fairfax County
Trinity Centre Dam	Unknown	Fairfax County
Upper Occoquan Sewage Authority Dam	High	Fairfax County
Walnut Branch Road Detention Pond Dam	Unknown	Fairfax County
West Ox Road BMP Dam	High	Fairfax County
Westfields SWM Retention Pond No. 13 Dam	Unknown	Fairfax County
Airlie Dam	Significant	Fauquier County
Antoinette Hudson Dam	Unknown	Fauquier County
Ardarra Farm Dam	Unknown	Fauquier County
Barr Dam	Significant	Fauquier County
Belle Vue Farms Dam	Unknown	Fauquier County

Dam Name	Hazard Class	County
Belvoir Farm Dam	Unknown	Fauquier County
Belvoir Farm Dam	Unknown	Fauquier County
Benhard Dam	Unknown	Fauquier County
Big Lake Dam	Unknown	Fauquier County
Bobby Payne Dam	Unknown	Fauquier County
Bowmans Dam	Unknown	Fauquier County
Brian Montgomery Dam	Unknown	Fauquier County
Brick House Dam	Unknown	Fauquier County
Brockett Dam	Unknown	Fauquier County
Cedar Run Dam #3	High	Fauquier County
CJ Koehr Dam	Unknown	Fauquier County
Clifton Farm Lower Dam	Significant	Fauquier County
Colten Inc Dam	Unknown	Fauquier County
Coventry Dam	Significant	Fauquier County
CRL Dam	Unknown	Fauquier County
Curtis Haight Dam	Unknown	Fauquier County
Daniel Wight Dam	Unknown	Fauquier County
Diane Brown Dam	Unknown	Fauquier County
DiGuilian Dam	Unknown	Fauquier County
DP Mason Dam	Unknown	Fauquier County
Fleetwood Farm Dam #1	Unknown	Fauquier County
Fleetwood Farm Dam #2	Unknown	Fauquier County
Florian Hauter Dam	Unknown	Fauquier County
Gap Run Dam	Unknown	Fauquier County
Glascock Run Dam	Unknown	Fauquier County
Graham Stephen Dam	Unknown	Fauquier County
Granville Farm Dam #2	Unknown	Fauquier County
Grass roots Dam	Unknown	Fauquier County
Harrell Parker Dam	Unknown	Fauquier County
Hauter Dam	Unknown	Fauquier County
Herbert Dam	Unknown	Fauquier County
Hickory Tree Farm Dam	Unknown	Fauquier County
Hideaway Hills Dam	Unknown	Fauquier County
High Clover Dam	Unknown	Fauquier County
High Mountain Farm Dam	Low	Fauquier County
Hill Crest Dam	Unknown	Fauquier County
HSBC Bank Dam	Unknown	Fauquier County
Johnson Dam	Unknown	Fauquier County
Johnson Dam	Unknown	Fauquier County
Joker Lake Dam	Unknown	Fauquier County
JR Ritchie Dam	Unknown	Fauquier County
Katherine Owens Dam	Unknown	Fauquier County
Keltonic Lake Dam	Unknown	Fauquier County
Kinloch Farm Dam	Significant	Fauquier County
Lake Anne Dam	High	Fauquier County
Lake Ashby Dam	High	Fauquier County
Lake Brittle Dam	High	Fauquier County
Leeton Assoc Dam	Unknown	Fauquier County
Licking Run Dam	High	Fauquier County
Little River LLC Dam	Unknown	Fauquier County
Lower Warrenton Lakes Dam	Low	Fauquier County
Mathews Dam	Unknown	Fauquier County

Dam Name	Hazard Class	County
Mellott Dam	Significant	Fauquier County
Menmuir Dam	Unknown	Fauquier County
Merry Oak Dam	Unknown	Fauquier County
Midwood Farm Dam	Unknown	Fauquier County
Montgomery Pond	Unknown	Fauquier County
Oak Spring Farms Dam #2	Unknown	Fauquier County
Perch Dam #1	Unknown	Fauquier County
Perch Dam #2	Unknown	Fauquier County
Pickett Dam	Unknown	Fauquier County
Sawyer Dam	Significant	Fauquier County
Sherwood Dam	Unknown	Fauquier County
Silbersiepe Dam	Unknown	Fauquier County
Springhill Farm Dam	Unknown	Fauquier County
Terwilliger Dam	Unknown	Fauquier County
Thompson Dam	High	Fauquier County
Thorn Dam	Unknown	Fauquier County
Valley Green Dam	Unknown	Fauquier County
Viveca Morris Dam	Unknown	Fauquier County
Volgenau Dam	Significant	Fauquier County
Warrenton Dam	High	Fauquier County
Warrenton Lake Dam	High	Fauquier County
Waterford Farm	Unknown	Fauquier County
Waterfowl Impoundment Dam	Low, Special	Fauquier County
Willow Dam	Unknown	Fauquier County
Winslow Dam	Significant	Fauquier County
Beagle Dam_test	Unknown	Floyd County
Donnelly Dam	Unknown	Floyd County
Park Ridge Dam	Significant	Floyd County
Spinella Dam	Unknown	Floyd County
Andersons Dam	Unknown	Fluvanna County
Bowles Dam	Unknown	Fluvanna County
Bremo Power Station Dam	High	Fluvanna County
Bremo Power Station East Ash Pond Dam	High	Fluvanna County
Cosner Dam	Unknown	Fluvanna County
David Easter Dam	Unknown	Fluvanna County
East Settlement Pond Dam	Unknown	Fluvanna County
Fluvanna Correction Ctr for Women Dam	Unknown	Fluvanna County
Fluvanna County Dam #1	Unknown	Fluvanna County
Fluvanna County Dam #10	Unknown	Fluvanna County
Fluvanna County Dam #11	Unknown	Fluvanna County
Fluvanna County Dam #12	Unknown	Fluvanna County
Fluvanna County Dam #2	Unknown	Fluvanna County
Fluvanna County Dam #3	Unknown	Fluvanna County
Fluvanna County Dam #4	Unknown	Fluvanna County
Fluvanna County Dam #5	Unknown	Fluvanna County
Fluvanna County Dam #6	Unknown	Fluvanna County
Fluvanna County Dam #7	Unknown	Fluvanna County
Fluvanna County Dam #8	Unknown	Fluvanna County
Fluvanna County Dam #9	Unknown	Fluvanna County
Fluvanna Ruritan Dam	High	Fluvanna County
Fluvanna Ruritan Dam	High	Fluvanna County
Lake Monticello Dam	High	Fluvanna County

Dam Name	Hazard Class	County
Lake Monticello Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Lake Monticello Settlement Pond Dam	High	Fluvanna County
Linton Dam	Unknown	Fluvanna County
Lower Dam at Fluvanna CCW	Unknown	Fluvanna County
Michie Dam	Unknown	Fluvanna County
Rivanna Woods Dam	Low	Fluvanna County
Rivanna Woods Golf Dam	Unknown	Fluvanna County
State Prison Camp #12 Dam	Unknown	Fluvanna County
Strickler & Benzinger's Dam	Unknown	Fluvanna County
T. Potts Dam #1	Unknown	Fluvanna County
T. Potts Dam #2	Unknown	Fluvanna County
Tenaska Virginia Partners	Low	Fluvanna County
Thomas Dam	Unknown	Fluvanna County
West Ash Pond Dam	Low	Fluvanna County
West Ash Pond Dam	Low	Fluvanna County
Wyllies Dam	Unknown	Fluvanna County
Adkins Dam	Unknown	Franklin County
Aud Dam	Unknown	Franklin County
Barnhart Dam	Unknown	Franklin County
Belcher Dam	Unknown	Franklin County
Bernard Dam	Unknown	Franklin County
Bowmans Dam	Unknown	Franklin County
Brooks dam	Unknown	Franklin County
Brumback Dam	Unknown	Franklin County
Burdettes Dam	Unknown	Franklin County
Carmon Bennett Dam	Unknown	Franklin County
Carter Family Dam	Unknown	Franklin County
Cobbs Dam	Unknown	Franklin County
Custer Dam	Unknown	Franklin County
Dillon Dam	Unknown	Franklin County
Fitts Dam	Unknown	Franklin County
Flora Dam	Unknown	Franklin County
Franklin County Parks and Recreation Dam	Unknown	Franklin County
Hetrick Dam	Unknown	Franklin County
Hodges Dam	Unknown	Franklin County
Jones Dam	Low	Franklin County
Kennett Dam	Unknown	Franklin County
Lakewatch Resolution Company Dam	Unknown	Franklin County
Lawless Dam	Unknown	Franklin County
Martin Dam	Unknown	Franklin County
Meeks Dam	Unknown	Franklin County
Melody Lake Dam	Unknown	Franklin County
Moore Dam	Unknown	Franklin County
Nakhle Dam	Unknown	Franklin County
Prillaman Dam	Unknown	Franklin County

Dam Name	Hazard Class	County
Richardson Dam	Unknown	Franklin County
Snyder Dam	Unknown	Franklin County
Southwest Builders Dam	Unknown	Franklin County
Sunset Lake Dam	Unknown	Franklin County
Upper Blackwater River Dam #4	High	Franklin County
Upper Blackwater River Dam #6	High	Franklin County
Walker Dam	Unknown	Franklin County
Woody Dam	Unknown	Franklin County
Worley Dam #1	Unknown	Franklin County
Worley Dam #2	Unknown	Franklin County
Bartonville Dam	Unknown	Frederick County
Cherokee Dam	Significant	Frederick County
Cove Dam #2	High	Frederick County
Cove Lake Dam #1	High	Frederick County
Daniel Mcdowell Dam	Unknown	Frederick County
Daniel Sullivan Dam	Unknown	Frederick County
DP Gum Dam	Unknown	Frederick County
Forest Lakes Dam	Unknown	Frederick County
Franklin Racey Dam	Unknown	Frederick County
High View Manor Dam	Unknown	Frederick County
Izaak Walton Park Pond	Unknown	Frederick County
Lake Frederick Dam	High	Frederick County
Lake Holiday Dam	High	Frederick County
Lake Isaac Dam	High	Frederick County
Lake Serene Dam	High	Frederick County
Lake St. Clair Dam	Significant	Frederick County
Lakeside Lake	Unknown	Frederick County
Lehmans Dam	Unknown	Frederick County
MA Smith Dam	Unknown	Frederick County
Meadow Lake Dam	Unknown	Frederick County
MHC Regency Lakes Dam	Unknown	Frederick County
Pleasant Valley Lake Dam	Significant	Frederick County
QST LLC Dam	Unknown	Frederick County
Richard Williams Dam	Unknown	Frederick County
Ruella Dam	Unknown	Frederick County
Seven Vistas Dam	Unknown	Frederick County
Silver Lake Dam	High	Frederick County
Summit Golf Course Dam	Unknown	Frederick County
Summit Golf Dam	Unknown	Frederick County
Tri Mountain Winery Dam	Unknown	Frederick County
Twin Lakes Dam	Low	Frederick County
Vansickler Dam	Unknown	Frederick County
Celanese Acetate Pond A	High	Giles County
Glen Lyn Bottom Ash Dam	Unknown	Giles County
Glen Lyn Fly Ash Dam	High	Giles County
West Pond Dam	High	Giles County
Beaverdam Lake Dam	High	Gloucester County
Burke Dam	Unknown	Gloucester County
Cow Creek Dam	High	Gloucester County
Haynes Dam	Unknown	Gloucester County
Laneview Dam	Unknown	Gloucester County
Leigh Pond Dam	Unknown	Gloucester County

Dam Name	Hazard Class	County
Robins Dam	Unknown	Gloucester County
Thousand Trails Dam	Unknown	Gloucester County
Weaver Dam	Unknown	Gloucester County
Wood Duck Pond Dam	Low	Gloucester County
Woodberry Farm Dam	Unknown	Gloucester County
Adams Dam	Unknown	Goochland County
Alvis Dam	Unknown	Goochland County
Bauham Dam	Unknown	Goochland County
Beardog Too Dam	Unknown	Goochland County
Blausten Dam	Unknown	Goochland County
Boles Dam	Unknown	Goochland County
Bolling Hall Dam	Unknown	Goochland County
Bolling Hall Farm Dam	Unknown	Goochland County
Bonneys Dam	Unknown	Goochland County
Bowles Dam	Low	Goochland County
Broad Branch Dam	High	Goochland County
Broad Run IV Dam	Unknown	Goochland County
Brookview Farm Dam	Unknown	Goochland County
Bullock Dam	Unknown	Goochland County
Byrd Creek Farm North Dam	Unknown	Goochland County
Carter & Harrell Dam	Unknown	Goochland County
CBR LLC Dam	Unknown	Goochland County
Cheneys Creek Dam	Unknown	Goochland County
Childress Dam	Unknown	Goochland County
Clover Forest Dam	Unknown	Goochland County
Dover Lake Dam	High	Goochland County
Dovershire Dam	Unknown	Goochland County
Fairfield Dam	Unknown	Goochland County
Fords Dam	Unknown	Goochland County
Fox Downs Dam	Unknown	Goochland County
Gaeser Dam	Unknown	Goochland County
Gathrights Dam	Unknown	Goochland County
Goose Pointe Dam	Unknown	Goochland County
Governors Pond	Unknown	Goochland County
Grattan Dam	Unknown	Goochland County
Haden-Fife-Pryor Dam	Unknown	Goochland County
Hard Times Dam	Unknown	Goochland County
Harris Pond Dam	Unknown	Goochland County
Hawk Town North Dam	Unknown	Goochland County
Hawk Town South Dam	Unknown	Goochland County
Haymaker West Dam	Unknown	Goochland County
Hicks Dam	Unknown	Goochland County
High Grove Dam	Unknown	Goochland County
Holland Hills Dam	Low	Goochland County
Hope Springs Dam	Unknown	Goochland County
Killarney Dam	Unknown	Goochland County
Koolwater Dam	Unknown	Goochland County
Lake Dillon Dam	Low	Goochland County
Lake Fullstream Dam	Unknown	Goochland County
Licking Hole Farm Dam	Unknown	Goochland County
Little Creek Dam	Unknown	Goochland County
Longwalk Dam	Unknown	Goochland County

Dam Name	Hazard Class	County
Lower Dover Farm Dam	Unknown	Goochland County
Lower East Leake Dam	Unknown	Goochland County
Lower Stonehorse Dam	Unknown	Goochland County
Manakin Ferry Dam	Low, Special	Goochland County
Mayo Dam	Unknown	Goochland County
Mt. Bernard Dam	Unknown	Goochland County
No. 4 Pond	Unknown	Goochland County
Orapax Dam	Unknown	Goochland County
Paint Dam	Unknown	Goochland County
Picketts Creek Dam	Significant	Goochland County
Pruitts Dam	Unknown	Goochland County
Queensmere Dam	Unknown	Goochland County
Ragland Dam	Unknown	Goochland County
Reservoir # 2	Significant	Goochland County
Reservoir #1	Low	Goochland County
Reynolds Dam	Unknown	Goochland County
Richmond Country Club Dams (4)	Unknown	Goochland County
Richmonds Dam	Unknown	Goochland County
Rivergate Lake Dam	Unknown	Goochland County
Royal Virginia Golf Club Dam	Unknown	Goochland County
Salmon Dam	Unknown	Goochland County
Shepher Dam	Unknown	Goochland County
Sheppard Town Dam	Unknown	Goochland County
South Tabscott Dam	Unknown	Goochland County
Stoney Pond Dam	Significant	Goochland County
Tabscott Dam	Unknown	Goochland County
Tag Pond	Unknown	Goochland County
The Forest Dam	Unknown	Goochland County
Towers Land Dam	Unknown	Goochland County
Tractor Dam	Unknown	Goochland County
Upper Dover Farm Dam	Unknown	Goochland County
Upper East Fork Genito Dam	Low, Special	Goochland County
Upper Logan Dam	Unknown	Goochland County
Upper Running Cedar Dam	Unknown	Goochland County
Upper Stonehorse Dam	Unknown	Goochland County
Vineyard Drive Dam	Unknown	Goochland County
West Creek Dam	Unknown	Goochland County
Westview Dam	Significant	Goochland County
Wincott Dam	Unknown	Goochland County
Wise Dam	Unknown	Goochland County
Woodlin Dam	Unknown	Goochland County
Bolt Dam	Unknown	Grayson County
Bottomley Evergreen & Farms Inc. Dam	Unknown	Grayson County
Chicago Heritage Farms LLC Dam	Unknown	Grayson County
Fields Dam	Low	Grayson County
Hidden Valley Estates Dam	High	Grayson County
Highlander Dam	Unknown	Grayson County
JoAnn Arey Dam	Unknown	Grayson County
John Hart Dam	Unknown	Grayson County
Laurel Creek Dam	Low	Grayson County
Parker Dam	Unknown	Grayson County
Roberts Dam	Unknown	Grayson County

Dam Name	Hazard Class	County
Shateley Dam	Unknown	Grayson County
Belle Monte Dam	Unknown	Greene County
Blue Ridge School Dam	Unknown	Greene County
Deer Lake Dam	High	Greene County
Greene Acres Dam	High	Greene County
Greene County Reservoir Dam	High	Greene County
Greene Hills Dam	Low, Special	Greene County
Greene Mountain Lake Dam	Significant	Greene County
Greene Mountain Lake Dam	Significant	Greene County
Greene Valley Section 7 Dam	Low	Greene County
Harlow Farm Dam	Unknown	Greene County
Poplar Lake Dam	Unknown	Greene County
Ruckers Lake Dam	High	Greene County
Saponi Dam	Low	Greene County
Teel Mt. Farm Dam	Unknown	Greene County
Twin Lakes Dam # 1	High	Greene County
Twin Lakes Dam # 2	High	Greene County
Twin Lakes Dam No. 3	High	Greene County
Wildwood Valley Lake Dam	Low	Greene County
Word Farm Dam	Unknown	Greene County
Bryants Dam	Unknown	Greensville County
Doyles Dam	Unknown	Greensville County
Garners Dam	Unknown	Greensville County
Jarratt Municipal Raw Water Storage Reservoir Dam	High	Greensville County
Mitchells Dam	Unknown	Greensville County
Rainey Dam	Unknown	Greensville County
Robinson Dam	Unknown	Greensville County
Slagles Dam	Unknown	Greensville County
Smiths Dam	Unknown	Greensville County
Spangler Dam	Unknown	Greensville County
Anderson Dam	Unknown	Halifax County
Bagwell Dam	Unknown	Halifax County
Bass Dam	Unknown	Halifax County
Burton Dam	Unknown	Halifax County
Burton Dam	Unknown	Halifax County
Cage Dam	Unknown	Halifax County
Claycomb Dam	Unknown	Halifax County
Cliborne Dam	Unknown	Halifax County
Cloverdale Lumber Co Dam	Unknown	Halifax County
Confroy Dam	Unknown	Halifax County
Conner Dam	Low	Halifax County
Duncan Dam	Unknown	Halifax County
East Temple Dam	Unknown	Halifax County
Edmunds Dam	Unknown	Halifax County
Edmunds Dam #1	Unknown	Halifax County
Edmunds Dam #2	Unknown	Halifax County
Edmunds Dam #3	Unknown	Halifax County
Edmunds Lake Dam	Low, Special	Halifax County
Founders Land Speculators Dam	Unknown	Halifax County
Fye Dam	Low	Halifax County
Gilliam Dam	Unknown	Halifax County

Dam Name	Hazard Class	County
Hall Dam	Unknown	Halifax County
Heart Pond Dam	Low, Special	Halifax County
Horse Shoe Lake Dam	Low, Special	Halifax County
Hughes Dam	Unknown	Halifax County
Hughes Dam	Unknown	Halifax County
J E Edmunds Dam	Unknown	Halifax County
J. T. Burton Dam	Unknown	Halifax County
Jaloway Dam	Unknown	Halifax County
James Solomon Dam	Unknown	Halifax County
Joyce Dam	Unknown	Halifax County
McDannald Dam	Unknown	Halifax County
McGhaulin & Mays Dam	Unknown	Halifax County
Motorplex Dam #1	Unknown	Halifax County
Motorplex Dam #2	Unknown	Halifax County
Motorplex Dam #3	Unknown	Halifax County
Oakes Dam	Unknown	Halifax County
Poore Dam	Unknown	Halifax County
Powell Farm Dam	Unknown	Halifax County
Prevette Dam	Unknown	Halifax County
R. R. Jones Dam	Unknown	Halifax County
Ragland Dam	Unknown	Halifax County
Raw Water Storage Pond	Low	Halifax County
Reaves Dam	Low, Special	Halifax County
Reese dam	Unknown	Halifax County
Rickman Dam	Unknown	Halifax County
Solomon Dam	Unknown	Halifax County
Staunton River Corp Dam	Unknown	Halifax County
Strong Dam	Unknown	Halifax County
Stump Pond Dam	Low, Special	Halifax County
Talbot Dam	Unknown	Halifax County
Temple Dam/Blue Ribbon Dairy Farm Dam	Unknown	Halifax County
Tribble Dam	Unknown	Halifax County
Twin Oak Farms Dam	Unknown	Halifax County
Wade Dam #1	Unknown	Halifax County
Wade Dam #2	Unknown	Halifax County
Wade Dam #2	Unknown	Halifax County
Wade Dam #3	Unknown	Halifax County
Wade Dam #4	Unknown	Halifax County
Ware Dam	Unknown	Halifax County
West Temple Dam	Unknown	Halifax County
Whitlow Dam	Unknown	Halifax County
Whitt Dam	Unknown	Halifax County
Williams Dam	Unknown	Halifax County
Wilson Dam	Unknown	Halifax County
Zastwony Dam	Unknown	Halifax County
Ashland Mill Dam	Unknown	Hanover County
Barkers Millpond Dam	Unknown	Hanover County
Beatties Mill Dam	Unknown	Hanover County
Brewster Dam	Unknown	Hanover County
Cady Lake Dam	Unknown	Hanover County
Camp Hanover Dam	Low	Hanover County
Campbell Dam	Unknown	Hanover County

Dam Name	Hazard Class	County
Carter-Hill Dam @ Hickory Hill Road	Unknown	Hanover County
Carter's Pond Dam	Significant	Hanover County
Cavalier Rifle & Pistol Club Dam	Low, Special	Hanover County
Charter Lake	Significant	Hanover County
Cherrydale Dam	High	Hanover County
Clifton Pond Dam	Low, Special	Hanover County
Cochrane Dam	Unknown	Hanover County
Covenant Woods Dam	Unknown	Hanover County
Cross Dam	Unknown	Hanover County
Crown Colony Dam	Unknown	Hanover County
Dabney Lake Dam	Significant	Hanover County
Drinkard Dam	Unknown	Hanover County
Dyer Dam	Unknown	Hanover County
Ellerson Mill Trace	Unknown	Hanover County
Farrington Dam	Unknown	Hanover County
Flanagans Mill Pond Dam	Unknown	Hanover County
Forest Lake Dam	Low	Hanover County
Francis Broaddus Dam	Unknown	Hanover County
Gaines Mill Dam	Unknown	Hanover County
Goldmine Creek Dam	Unknown	Hanover County
Grassy Dam	Unknown	Hanover County
Hanover Learning Center Dam	Unknown	Hanover County
Hartford Lake Dam	Low	Hanover County
Hidden Lake Dam	Unknown	Hanover County
Hidden Lakes Estates Dam	Unknown	Hanover County
Holstrum Dam	Unknown	Hanover County
Holtzgraph Dam	Unknown	Hanover County
Jones Dam #2	Unknown	Hanover County
Kanach Dam	Unknown	Hanover County
King Charter Dam	Unknown	Hanover County
Kings Pond Dam	Unknown	Hanover County
Lake Claybank Dam	Unknown	Hanover County
Lake Idylwild Dam	Significant	Hanover County
Lake Ivanhoe Dam	Low	Hanover County
Lower Lakes Dam	Significant	Hanover County
Lower SWM Pond @ Mountain Run	Unknown	Hanover County
Luck Pond Dam	Significant	Hanover County
Mannheim Dam	Unknown	Hanover County
Massey Dam	Unknown	Hanover County
Mattawan Dam	Unknown	Hanover County
Mission Court Lake Dam	Unknown	Hanover County
New Little River Dam	Unknown	Hanover County
Other Lucks Dam	Unknown	Hanover County
Overhill Dam	Unknown	Hanover County
Parsleys Mill Dam	Unknown	Hanover County
Pebble Creek Dam	Low	Hanover County
Pebblebrook Dam	Unknown	Hanover County
Pollards Dam	Unknown	Hanover County
Pugh Dam	Unknown	Hanover County
Regional Stormwater Facility T-40	Significant	Hanover County
Reisinger Dam	Unknown	Hanover County
Reynolds Dam	Unknown	Hanover County

Dam Name	Hazard Class	County
Rose Hill (estates) Dam	Significant	Hanover County
Sewage Disposal Pond Dam	Unknown	Hanover County
South Anna #52 B	Significant	Hanover County
Stanley Dam	Unknown	Hanover County
Stone Dam	Unknown	Hanover County
Stonehaven Dam	Low	Hanover County
Stumpy Road Dam	Unknown	Hanover County
Talley Millpond Dam	Unknown	Hanover County
The Fields Dam @ Cold Harbor	Unknown	Hanover County
Thetford Dam	Unknown	Hanover County
Tiller Lake Dam	High	Hanover County
Timberlake Dam #1	Unknown	Hanover County
Timberlake Dam #2	Unknown	Hanover County
Timberlake Dam #3	Unknown	Hanover County
Trainham Dam	Unknown	Hanover County
Tucket Dam	Unknown	Hanover County
Tyler Station Dam	Unknown	Hanover County
Upper SWM Pond @ Mountain Run	Low	Hanover County
Usry Lower Pond	Unknown	Hanover County
Velenovsky Dam	Unknown	Hanover County
Wachter Dam	Low	Hanover County
Walden's Pond Dam	Significant	Hanover County
Watkins Road Dam	Unknown	Hanover County
White Dam #1	Unknown	Hanover County
Woodland Hall Dam	Unknown	Hanover County
Wrights Dam	Unknown	Hanover County
Barrington Dam	High	Henrico County
Bosher Dam	Unknown	Henrico County
Canterbury Dam	High	Henrico County
Cox Road Dam	Significant	Henrico County
Dean Dam	Unknown	Henrico County
Duval Pond Dam	Unknown	Henrico County
Eberhard Dam	Unknown	Henrico County
Echo Dam	High	Henrico County
Gillie Creek Dam	Unknown	Henrico County
Gregorys Dam at Raintree Deep Run	Unknown	Henrico County
Griggs Dam	Unknown	Henrico County
Henrico Prop Dam	Unknown	Henrico County
Lake Innsbrook	Significant	Henrico County
Lake Overton Dam	High	Henrico County
Lake Rooty Dam	High	Henrico County
Red Bird Dam	Low, Special	Henrico County
Shirley Mill Dam	Unknown	Henrico County
Wellesley Dam	High	Henrico County
West Broad Village Dam	Unknown	Henrico County
West End Lake	Unknown	Henrico County
Westham Dam	Unknown	Henrico County
Wilde Lake Dam	Low	Henrico County
Wyndham Lake Dam	Significant	Henrico County
Beaver Creek Dam	High	Henry County
Bell Dam	Unknown	Henry County
Boxwood Hunt Club Dam #1	Unknown	Henry County

Dam Name	Hazard Class	County
Boxwood Hunt Club Dam #2	Unknown	Henry County
Burt Dam	Unknown	Henry County
Container Warehouse Corp Dam	Unknown	Henry County
Cox Dam	Unknown	Henry County
Dillon Dam	Unknown	Henry County
Dodson Dam	Unknown	Henry County
Eastland Dam	Unknown	Henry County
Fisher Dam	Low, Special	Henry County
Ford Dam	Unknown	Henry County
Frazier Dam	Unknown	Henry County
H&W LLC Dam	Unknown	Henry County
Hamelt Dam	Unknown	Henry County
Hereford Dam	Unknown	Henry County
Hodges Dam	Unknown	Henry County
Hopco LLC dam	Unknown	Henry County
Horse Pasture Creek Dam #1C	High	Henry County
Horse Pasture Creek Dam #2	High	Henry County
Hunt Country Farms Dam	High	Henry County
Kings Grant Dam No 2	Unknown	Henry County
Lanier Dam	Unknown	Henry County
Leatherwood Creek Dam #2A	High	Henry County
Leatherwood Creek Dam #3	High	Henry County
Leatherwood Creek Dam #4	High	Henry County
Leatherwood Creek Dam #5	High	Henry County
Leatherwood Creek Dam #6	High	Henry County
Marrowbone Creek Dam #1	High	Henry County
Morten Dam	Unknown	Henry County
Mountain Valley Lake Dam	Unknown	Henry County
Nease dam	Unknown	Henry County
Nelson Dam #1	Unknown	Henry County
Nelson Dam #2	Unknown	Henry County
Patrick Henry Farm Corp Dam 1	Unknown	Henry County
Patrick Henry Farm Corp Dam 2	Unknown	Henry County
Patriot Centre SW Pond #2	High	Henry County
Pintler Dam	Low, Special	Henry County
Pugh Dam	Unknown	Henry County
Ridgeway Sportsman Club Dam	Unknown	Henry County
Roach Dam	Unknown	Henry County
Robertson Dam	Low, Special	Henry County
Smith River Dam	High	Henry County
Tate Dam	Unknown	Henry County
White Dam	Unknown	Henry County
William Franck Dam	Unknown	Henry County
Zehr Pond Dam	Unknown	Henry County
Alemar Dam	Unknown	Isle of Wight County
Arberdeen Dam	Unknown	Isle of Wight County
ASB Pond Dam	High	Isle of Wight County
B - 1 Pond Dam	High	Isle of Wight County
B - 2 Pond Dam	High	Isle of Wight County
Butlers Dam	Unknown	Isle of Wight County
Carisbrooke Dam	Unknown	Isle of Wight County
Echo Dam	Unknown	Isle of Wight County

Dam Name	Hazard Class	County
Edwards Dam	Unknown	Isle of Wight County
Gail Dam	Unknown	Isle of Wight County
Jenkins Dam	Unknown	Isle of Wight County
Rhodes Dam	Unknown	Isle of Wight County
Smithfield Downs Golf Course Dam	Unknown	Isle of Wight County
Smithfield Lake Dam	Significant	Isle of Wight County
Tormentor Dam	Unknown	Isle of Wight County
Ajacan Lake BMP Dam	Unknown	James City County
Barlows Pond Dam	Significant	James City County
Brewery Road Dam	Low	James City County
Cowles Dam	Unknown	James City County
Cranston Mill Pond Dam	Significant	James City County
Deer Lake Dam	Low	James City County
Dozier Dam	Unknown	James City County
Eastern Pond Dam (PC 106)	Low	James City County
Ford Colony Dam #1	Unknown	James City County
Ford Colony Dam #2	Unknown	James City County
High Street SWM	Unknown	James City County
Horne's Lake Dam	Significant	James City County
Joachim Lake	Unknown	James City County
Jolly Pond Dam	Low	James City County
Kingsmill Dam	Unknown	James City County
Kingspoint Dam	Low	James City County
Kiskiack South Dam	Low	James City County
Lake Nice Dam	Significant	James City County
Lake Pasbehegh Dam	Unknown	James City County
Lake Powell Dam	Unknown	James City County
Little Creek Dam	High	James City County
Massie Farm Pond	Low	James City County
Mirror Lakes Dam No. 1 (west)	Significant	James City County
Mirror Lakes Dam No. 2	Unknown	James City County
Old Mill Pond Dam	Unknown	James City County
Perry Dam	Unknown	James City County
Rennicks Pond Dam	Unknown	James City County
Richardson Millpond Dam	Unknown	James City County
Scotts Pond	Unknown	James City County
Stieffen Pond Dam	Unknown	James City County
Taylor Pit Dam	Unknown	James City County
Warburton Pond Dam	Unknown	James City County
Warehams Pond	Low, Special	James City County
Warhill Complex Swamp	Unknown	James City County
Wenger Dam	Unknown	James City County
Western Pond	Low	James City County
Whittaker Lake Dam	Low	James City County
Williamsburg National Dam	Unknown	James City County
Wingfield Lake Dam	Low	James City County
Corbin Mill Dam	Unknown	King and Queen County
Dew Dam	Unknown	King and Queen County
Fleets Millpond Dam	Unknown	King and Queen County
Garnett Millpond Dam	Unknown	King and Queen County
Gressitt Dam	Unknown	King and Queen County
Gwathmeys Dam	Unknown	King and Queen County

Dam Name	Hazard Class	County
Ice House Dam	Significant	King and Queen County
Indian Mound Ponds Dam	Unknown	King and Queen County
King and Queen County Dam #1	Unknown	King and Queen County
King and Queen County Dam #2	Unknown	King and Queen County
King and Queen County Dam #5	Unknown	King and Queen County
King and Queen County Dam #6	Unknown	King and Queen County
Kochs Dam	Unknown	King and Queen County
Normans Dam	Unknown	King and Queen County
North Walker Refuge Dam	Unknown	King and Queen County
Powers Dam	Unknown	King and Queen County
South Walker Refuge Dam	Unknown	King and Queen County
Spring Branch Dam	Significant	King and Queen County
Stevensville Dam	Unknown	King and Queen County
Townsend Dam	Unknown	King and Queen County
Walker Coleman Dam	Significant	King and Queen County
Walkerton Mill Dam	Unknown	King and Queen County
Wyatts Dam	Unknown	King and Queen County
Burns Dam	Unknown	King George County
Commanche Ridge Dam	Unknown	King George County
Darr Dam	Low, Special	King George County
Debenard Dam #1	Unknown	King George County
Lake Jefferson Dam	Significant	King George County
Lake Madison Dam	Significant	King George County
Lake Monroe Dam	High	King George County
Madison Mill Dam	Unknown	King George County
Powhatan Plantation Dam	Low	King George County
Whitehall-Arabian Dam	Unknown	King George County
William Childress Dam	Unknown	King George County
Acquinton Dam	Unknown	King William County
Aylett Mill Dam	Unknown	King William County
Boshers Mill Pond	Unknown	King William County
Central Crossing Dam	Low	King William County
Chelsea Dam	Unknown	King William County
Cohoke Mill Dam	Unknown	King William County
Curling Dam	Unknown	King William County
Custis Dam	Unknown	King William County
Dabneys Millpond Dam	Unknown	King William County
Deckers Dam	Unknown	King William County
Dublin Millpond Dam	Unknown	King William County
Fogg Dam	Unknown	King William County
Fox Hill Dam	Unknown	King William County
Fox Run Dam	Unknown	King William County
Garretts Dam	Unknown	King William County
Gutherie Dam	Unknown	King William County
Hall Dam	Unknown	King William County
Hays Farm Dam	Unknown	King William County
Johnsons Dam	Unknown	King William County
Kellys Dam	Unknown	King William County
King William County Dam #1	Unknown	King William County
King William County Dam #10	Unknown	King William County
King William County Dam #11	Unknown	King William County
King William County Dam #12	Unknown	King William County

Dam Name	Hazard Class	County
King William County Dam #13	Unknown	King William County
King William County Dam #3	Unknown	King William County
King William County Dam #5	Unknown	King William County
King William County Dam #7	Unknown	King William County
King William County Dam #8	Unknown	King William County
King William County Dam #9	Unknown	King William County
Lafferty Dam No. 1	Unknown	King William County
Lancaster Road Dam	Unknown	King William County
McGeorge Pond Dam	Unknown	King William County
Mitchells Millpond Dam	Unknown	King William County
Old Town Farm Dam	Unknown	King William County
Olssons Dam	Unknown	King William County
Townsends Dam #1	Unknown	King William County
Ball's Millpond Dam	Unknown	Lancaster County
Golden Eagle Dam	Low	Lancaster County
Lancaster County Dam #1	Unknown	Lancaster County
Lancaster County Dam #2	Unknown	Lancaster County
Lancaster County Dam #3	Unknown	Lancaster County
Lancaster Roller Mill Dam	Unknown	Lancaster County
Marsh Dam	Unknown	Lancaster County
Twin Branch Milldam	Unknown	Lancaster County
Blanken Dam	Unknown	Lee County
Keokee Dam	High	Lee County
Middleton Dam	Unknown	Lee County
Parkey Dam	Unknown	Lee County
Ridgetop Dam	Unknown	Lee County
13415 White Marsh Lane Dam	Unknown	Loudoun County
15164 Berlin Pike Dam	Unknown	Loudoun County
20776 Dockside Terrace Dam	Unknown	Loudoun County
27132 Gum Springs Road Dam	Unknown	Loudoun County
Algonkian Regional Park Interconnected Impoundemnts	Unknown	Loudoun County
AOL Dam No. 1	Unknown	Loudoun County
AOL Dam No. 2	Unknown	Loudoun County
Archbold Dam	Unknown	Loudoun County
Arcola Center Dam	Significant	Loudoun County
Ashbrook Dam	Unknown	Loudoun County
Ashburn Village Lake #1	High	Loudoun County
Ashburn Village Lake #2	High	Loudoun County
Ashbury Church Road Dam	Unknown	Loudoun County
Beaverdam Creek Dam	High	Loudoun County
Bell Dam	Unknown	Loudoun County
Belmont Golf Club Dam	Unknown	Loudoun County
Birch Street Johnson Dam	Unknown	Loudoun County
Brambleton Golf Course Dam	Unknown	Loudoun County
Brambleton Land Bay 3 Pond 6 Dam	High	Loudoun County
Brambleton Land Bay 3 Pond 6 Dam	High	Loudoun County
Brambleton Land Bay 3 Pond 6 Dam	High	Loudoun County
Brambleton Land Bay 3 Pond 6 Dam	High	Loudoun County
Bronze Hill Farm Dam	Low	Loudoun County
Cherry Hill Dam	Unknown	Loudoun County
Cooperative Way Dam	Unknown	Loudoun County

Dam Name	Hazard Class	County
Creekspring Court Dam	Unknown	Loudoun County
Creighton Farms Dam	Unknown	Loudoun County
Creighton Hills Dam	Significant	Loudoun County
Daley Dam	Significant	Loudoun County
Dulles Airport Dam	Significant	Loudoun County
Dulles Greenway Wetlands Mitigation Project Dike	Unknown	Loudoun County
Evans Pond Dam	Unknown	Loudoun County
Farmwell Hunt Dam	Unknown	Loudoun County
Farmwell Road and Estate Place Dam	Unknown	Loudoun County
Godfrey Dam	Unknown	Loudoun County
Goose Creek Dam	High	Loudoun County
Gore Dam	High	Loudoun County
Haynes Dam	Significant	Loudoun County
Hillside Circle Dam	Low	Loudoun County
Hope Parkway Dam	High	Loudoun County
Horsepen Dam	High	Loudoun County
Huber-Mount Gilead Road Dam	Unknown	Loudoun County
HUI Dam	Unknown	Loudoun County
J.T. Hirst Dam	Significant	Loudoun County
JT Gable Dam	Unknown	Loudoun County
Kalnasy Dam	High	Loudoun County
Kingsley Dam	Unknown	Loudoun County
Koerner Lane Dam	Unknown	Loudoun County
Lake Pointe Dam	Unknown	Loudoun County
Lawrence Dam	Low	Loudoun County
Limestone Court Dam	Unknown	Loudoun County
Loudoun Golf & Country Club Dam	Unknown	Loudoun County
Lovettsville Game Protective Association Dam	Unknown	Loudoun County
Lower Spectacular Bid Drive Dam	Unknown	Loudoun County
Lower Theisman Dam	Unknown	Loudoun County
Lowry Dam	Unknown	Loudoun County
Luhrs Dam	Unknown	Loudoun County
McGhee Dam	Low	Loudoun County
Meadow Grove Farm #2 Dam	Unknown	Loudoun County
Moorefield Station East SWM Pond Dam	High	Loudoun County
Moorefield Station West SWM Pond Dam	High	Loudoun County
Morrisville Road Dam	Unknown	Loudoun County
Old Dominion Inc Dam	Unknown	Loudoun County
Old Waterford Road Dam	Unknown	Loudoun County
Oliver Dam	Significant	Loudoun County
Piney Swamp Road Dam	Unknown	Loudoun County
Potomac Lake Dam	Unknown	Loudoun County
Precision Dynamics Lake Dam	Significant	Loudoun County
Prentice Drive Dam (near Randolph Drive)	Unknown	Loudoun County
Proximity Dam	Unknown	Loudoun County
Quail Ridge Dam	Low	Loudoun County
Rayborn Dam	Unknown	Loudoun County
Reckmeyer Dam	Low	Loudoun County
Red Cedar Lake Two Dam	Significant	Loudoun County
Richmond Square Dam	High	Loudoun County
Shanondale Road Dam	Unknown	Loudoun County

Dam Name	Hazard Class	County
Skallerup Dam	Unknown	Loudoun County
Sleeter Lake Dam	High	Loudoun County
Speedwell Farm Dam	Unknown	Loudoun County
Springvalley Lane Dam	Unknown	Loudoun County
Sweetwater Lane Dam	Unknown	Loudoun County
Tarara Winery Dam	Unknown	Loudoun County
The Lakes at Red Rock Dam	High	Loudoun County
The Quarry Dam	Unknown	Loudoun County
The Ridings at Blue Spring Dam	Unknown	Loudoun County
Tippecanoe Lake Dam	Unknown	Loudoun County
Town Center Dam	Unknown	Loudoun County
Trappe Hill Farm Dam	Unknown	Loudoun County
Trump Nat'l Golf Club Interconnected Impoundments #4, 5, & X	Unknown	Loudoun County
Upper Godfrey Dam	Unknown	Loudoun County
Upperville Dam	Unknown	Loudoun County
UUNET Lower Pond Dam	Unknown	Loudoun County
Waltonian Dam	Low	Loudoun County
Watermill Road Dam	Unknown	Loudoun County
White Goose Lane Dam	Unknown	Loudoun County
Woodall Dam	Unknown	Loudoun County
Woodburn Road #2 Dam	Unknown	Loudoun County
Apple Grove Dam	Unknown	Louisa County
Bearden Dam	Unknown	Louisa County
Beaver Dam	Unknown	Louisa County
Bethany Dam	Unknown	Louisa County
Boswell Tavern Dam	Unknown	Louisa County
Byrd Mill Dam	Unknown	Louisa County
Chisholm Dam	Unknown	Louisa County
Cooper Dam	Unknown	Louisa County
Cox Dam	Unknown	Louisa County
Dongola Dam	Unknown	Louisa County
Ferron Dam	Unknown	Louisa County
Fox Pen Dam	Unknown	Louisa County
Glen Beau Dam	Unknown	Louisa County
Gordonsville Dam	High	Louisa County
Grassdale Dam	Unknown	Louisa County
Gum Spring Dam	Unknown	Louisa County
Harris Dam	Unknown	Louisa County
Holly Grove	Unknown	Louisa County
Izac Lake Dam	Low	Louisa County
Knapp Dam	Low	Louisa County
Lake Ellen Dam	Low	Louisa County
Lake Senaham Dam	Unknown	Louisa County
Lake Sherman	Unknown	Louisa County
Landover Road Dam	Low	Louisa County
Little Anna Dam	Unknown	Louisa County
Little River Dam #1	Significant	Louisa County
Little River Dam #4	Significant	Louisa County
Louisa Dam	Significant	Louisa County
Louisa H.S. Dam	Unknown	Louisa County
Melanie Morgan Dam	Unknown	Louisa County

Dam Name	Hazard Class	County
Meyerton Dam	Unknown	Louisa County
Mittleman Dam	Unknown	Louisa County
Moorefield Cedar Dam	Unknown	Louisa County
Nininger Dam	Unknown	Louisa County
Nolting Dam	Unknown	Louisa County
Old Mountain North Dam	Unknown	Louisa County
Old Mountain South Dam	Unknown	Louisa County
Orchid Lake Dam	Low	Louisa County
Pink House Dam	Unknown	Louisa County
Ponde Roachea Dam	Low	Louisa County
Ponde Roachea Dam	Low	Louisa County
Ponde Roachea Dam	Low	Louisa County
Ponde Roachea Dam	Low	Louisa County
Rapidan Dam	Unknown	Louisa County
Routes 522 & 605 Dam	Unknown	Louisa County
Shelton Dam	Unknown	Louisa County
Small Dam	Unknown	Louisa County
South Anna Dam #22	High	Louisa County
South Anna Dam #23	Significant	Louisa County
South Anna Dam #3	High	Louisa County
South Anna Dam #4	High	Louisa County
South Anna Dam #6B	High	Louisa County
South Anna Dam #7	Significant	Louisa County
South Anna Dam #7	Significant	Louisa County
South Anna Dam #7	Significant	Louisa County
South Anna Dam #7	Significant	Louisa County
South Anna No. 5	High	Louisa County
Spring Creek Golf Course Irrigation Lake	Significant	Louisa County
Spring Valley Dam	Unknown	Louisa County
Stonebridge Dam	Unknown	Louisa County
Swifts Dam	Unknown	Louisa County
Walmart SWM Pond Dam(s)	Unknown	Louisa County
Washington Farm Dam	Unknown	Louisa County
West Pond @ Shellhorn Dam	Unknown	Louisa County
Willow Ridge Dam	Significant	Louisa County
Woolfolk Brothers Dam #2	Unknown	Louisa County
Woolfolks Dam No. 1	Low	Louisa County
Bailey's Dam	Unknown	Lunenburg County
Bragg Dam	Unknown	Lunenburg County
Dixons Dam	Unknown	Lunenburg County
Kenbridge Dam	Unknown	Lunenburg County
Kirk Dam	Unknown	Lunenburg County
Lunenburg Beach Dam	Significant	Lunenburg County
Marshall Dam	Unknown	Lunenburg County
Mimosa Lake Park Dam	Unknown	Lunenburg County
Modest Creek Dam	Significant	Lunenburg County
Nottoway Falls Dam	Significant	Lunenburg County
Sneads Dam	Unknown	Lunenburg County
Thowhorn Dam	Unknown	Lunenburg County
Beautiful Run Dam #10	Low	Madison County
Beautiful Run Dam #11	Significant	Madison County
Beautiful Run Dam #1B	Low	Madison County

Dam Name	Hazard Class	County
Beautiful Run Dam #2A	High	Madison County
Beautiful Run Dam #4	Low	Madison County
Beautiful Run Dam #5	Low	Madison County
Beautiful Run Dam #6	Low	Madison County
Beautiful Run Dam #7	Low	Madison County
Deep Run Farm Dam	Low	Madison County
DT Wade Dam	Low	Madison County
Hablutzel Dam	Low	Madison County
Hartland Dam	Unknown	Madison County
Holly Brear Dam	Unknown	Madison County
Lovelace Dam	Unknown	Madison County
Malvern Dam	Low	Madison County
McMahon Dam	Unknown	Madison County
Oreil LLC Dam	Unknown	Madison County
Rohrbaugh Dam	Unknown	Madison County
Saxon Ford Dam	Unknown	Madison County
White Oak Dam #1	Significant	Madison County
Woodberry Forest Lake Dam	Low	Madison County
Blalock Dam	Unknown	Mecklenburg County
Buchanan Homeplace Farm Pond Dam	Unknown	Mecklenburg County
Butler's Dam	Unknown	Mecklenburg County
Clydes Pond Dam	Low, Special	Mecklenburg County
Copleys Dam	Unknown	Mecklenburg County
Gordons Dam	High	Mecklenburg County
Greenfield Farms Home Farm Pond # 1	Unknown	Mecklenburg County
Hundley Dam	Low, Special	Mecklenburg County
Johnsons Dam	Unknown	Mecklenburg County
Kidwell Dam	Unknown	Mecklenburg County
Moore Dam	Unknown	Mecklenburg County
Morgans Dam	Unknown	Mecklenburg County
Overbys Dam	Unknown	Mecklenburg County
Potts Landing Dam	Unknown	Mecklenburg County
Raineys Dam	Unknown	Mecklenburg County
River Ridge Assoc. Dam	Unknown	Mecklenburg County
Willis Dam	Unknown	Mecklenburg County
Winkle Dam	Unknown	Mecklenburg County
Barricks Dam	Unknown	Middlesex County
Beazley Dam	Unknown	Middlesex County
Buckingham Dam	Unknown	Middlesex County
Burch Mill Dam	Unknown	Middlesex County
Conrads Dam	Unknown	Middlesex County
Corbin Hall Farm Dam	Unknown	Middlesex County
Grays Dam	Unknown	Middlesex County
Healys Dam	Unknown	Middlesex County
Healys Mill Dam	Unknown	Middlesex County
Hilliards Mill Pond Dam	Low	Middlesex County
Lower Rosegill Lake Dam	Unknown	Middlesex County
Rosegill Upper Dam	Unknown	Middlesex County
Town Bridge Pond Dam	Unknown	Middlesex County
Bennetts Dam	Unknown	Montgomery County
Teel Dam	Unknown	Montgomery County
Black Creek Impoundment	Low	Nelson County

Dam Name	Hazard Class	County
Black Fox Hills Dam	Low	Nelson County
Lake Monocan Dam	High	Nelson County
Nelson County Dam #1	Unknown	Nelson County
Nelson County Dam #2	Unknown	Nelson County
Nelson County Dam #4	Unknown	Nelson County
Nelson County Dam #6	Unknown	Nelson County
Nelson County Dam #7	Unknown	Nelson County
Nelson County Dam #8	Unknown	Nelson County
Nelson Dam	Significant	Nelson County
Nelson Dam	Significant	Nelson County
Payne Pond	Unknown	Nelson County
Ramsay Knox Dam	Unknown	Nelson County
Rockfish Farms Dam	Low	Nelson County
Stevens Lake Dam	Unknown	Nelson County
Watts Dam	Unknown	Nelson County
Brickshire SWM Pond Dam	Unknown	New Kent County
Cattail Swamp Dam	Unknown	New Kent County
Cooks Mill Dam	Unknown	New Kent County
Coopers Mill Pond Dam	Low	New Kent County
Davis Pond North Dam	Unknown	New Kent County
Diascund Creek Dam	High	New Kent County
Fern Dam	Unknown	New Kent County
Green Arbor Lake Dam	Unknown	New Kent County
Lake Parker Dam	Significant	New Kent County
Lake Stafford Dam	Significant	New Kent County
Lake Washington Dam	Significant	New Kent County
Lilly Point Dam	Unknown	New Kent County
Lower Groves Dam	Unknown	New Kent County
New Kent County Dam #1	Unknown	New Kent County
New Kent County Dam #2	Unknown	New Kent County
New Kent County Dam #3	Unknown	New Kent County
New Kent County Dam #4	Unknown	New Kent County
Old Forge Pond Dam	Unknown	New Kent County
Putneys Mill Dam	Unknown	New Kent County
Ranch Acres Dam	Unknown	New Kent County
Taylors Dam	Unknown	New Kent County
Upper Groves Dam	Unknown	New Kent County
Walker's Dam	Low, Special	New Kent County
Woodhaven Dam	High	New Kent County
Dixon-Parson Dam	Unknown	Northampton County
Goffigon Dam	Unknown	Northampton County
Hungars Glebe Dam	Unknown	Northampton County
Jones Dam # 1	Unknown	Northampton County
Jones Dam # 2	Unknown	Northampton County
Kellam Dam	Unknown	Northampton County
Long Dam	Unknown	Northampton County
Mears Dam	Unknown	Northampton County
Miller Dam	Unknown	Northampton County
Northampton Dam # 1	Unknown	Northampton County
Northampton Dam # 2	Unknown	Northampton County
Northampton Dam # 3	Unknown	Northampton County
Northampton Dam # 5	Unknown	Northampton County

Dam Name	Hazard Class	County
Smith Dam	Unknown	Northampton County
Turner Family Dam	Unknown	Northampton County
Clarks Mill Dam	Unknown	Northumberland County
Courtney Millpond Dam	Unknown	Northumberland County
Eagle Lake Dam	Unknown	Northumberland County
Falling Mill Dam	Unknown	Northumberland County
Flyway Lake Dam	Unknown	Northumberland County
Hale Dam	Unknown	Northumberland County
Hurst Dam	Unknown	Northumberland County
Northumberland County Dam #1	Unknown	Northumberland County
Snowden Park Dam	Unknown	Northumberland County
Sydnors Millpond Dam	Unknown	Northumberland County
Arnolds Dam	Unknown	Nottoway County
Austin Dam	Unknown	Nottoway County
Crystal Dam	Unknown	Nottoway County
Daniels Dam	Unknown	Nottoway County
Davis Dam	Unknown	Nottoway County
Epes Dam	Low	Nottoway County
Gravatts Dam	Low, Special	Nottoway County
Hamilton Dam	Low	Nottoway County
Hobbs Dam	Unknown	Nottoway County
Holtes Dam	Unknown	Nottoway County
Horners Dam	Unknown	Nottoway County
Hurts Dam	Unknown	Nottoway County
Lush Dam	Low, Special	Nottoway County
Nottoway Lake Dam	High	Nottoway County
Sheltons Dam	Unknown	Nottoway County
SR607 Rocky Ford Road/Lazaretto Creek Dam	Unknown	Nottoway County
Terzs Dam	Unknown	Nottoway County
Walkers Dam	Unknown	Nottoway County
Williams Dam	Unknown	Nottoway County
Burrus Dam	Unknown	Orange County
Coleman Andrews Dam #1	Unknown	Orange County
Coleman Andrews Dam #2	Unknown	Orange County
David Kerr Dam	Unknown	Orange County
DeCoursey Dam	Low	Orange County
Grymes Mill Dam	Low	Orange County
James Strong Dam	Unknown	Orange County
Keaton's Run Dam	High	Orange County
Lake of the Woods Dam	High, Special	Orange County
Lake Orange Dam	High	Orange County
Neals Dam	Unknown	Orange County
Newman Dam	Unknown	Orange County
Northrup Dam	Low	Orange County
Orange Raw Water Reservoir Dam	Significant	Orange County
Orange Raw Water Reservoir Dam	Significant	Orange County
Orange Raw Water Reservoir Dam	Significant	Orange County
Orange Raw Water Reservoir Dam	Significant	Orange County
Ross Hopkins Dam	Unknown	Orange County
Spotswood Drive Dam	Low	Orange County
Spring Vale Dam	Significant	Orange County

Dam Name	Hazard Class	County
Trail of Faith Dam	Low	Orange County
Bryan Cooper Dam	Unknown	Page County
Dry Run Dam #101	High	Page County
Dry Run Dam #102	High	Page County
Adame Dam	Unknown	Patrick County
Ararat River Dam #17	Low	Patrick County
Ararat River Dam #2	Unknown	Patrick County
Ararat River Dam #28	Unknown	Patrick County
Ararat River Dam #32	Unknown	Patrick County
Ararat River Dam #63	Unknown	Patrick County
Ararat River Dam #64	Low	Patrick County
Ararat River Dam #69	Low	Patrick County
Boyce Dam	Unknown	Patrick County
Braswell's Dam	High	Patrick County
Brown Dam	Unknown	Patrick County
Burgess Dam	Unknown	Patrick County
Craddock Dam	Unknown	Patrick County
Drake Dam	Unknown	Patrick County
Duncan Dam	Unknown	Patrick County
Epperson dam	Unknown	Patrick County
Eutsler Dam	Unknown	Patrick County
Fain Dam	Unknown	Patrick County
Fairy Stone Dam	Low, Special	Patrick County
Franklin Dam	Unknown	Patrick County
Game and Inland Fisheries Dam	Unknown	Patrick County
George Dam	Unknown	Patrick County
Hancock Dam	Unknown	Patrick County
Haskins Dam	Unknown	Patrick County
Hazelwood Dam	Unknown	Patrick County
Holdaway Dam	Unknown	Patrick County
Horshshoe Hollow Dam	Unknown	Patrick County
Hoskins Dam	Unknown	Patrick County
Illum Dam	Unknown	Patrick County
Jim Boaz Dam	Unknown	Patrick County
King Dam	Unknown	Patrick County
Lawrence Dam	Unknown	Patrick County
Littell Dam	Unknown	Patrick County
Merritt Dam	Unknown	Patrick County
Mitchells Dam	Unknown	Patrick County
Moore Dam	Unknown	Patrick County
Moore Dam	Unknown	Patrick County
Osborne Dam	Unknown	Patrick County
Outdoor Recreation's Dam	Low, Special	Patrick County
Overby Dam	Unknown	Patrick County
R Beasley Dam 1	Unknown	Patrick County
R Beasley Dam 2	Unknown	Patrick County
Radford Dam	Unknown	Patrick County
Smart Dam	Unknown	Patrick County
Smith Dam	Unknown	Patrick County
Squall Creek Dam	Unknown	Patrick County
T Beasley Dam 1	Unknown	Patrick County
T Beasley Dam 2	Unknown	Patrick County

Dam Name	Hazard Class	County
Williams Dam	Unknown	Patrick County
Witcher Dam	Unknown	Patrick County
Wood dam	Unknown	Patrick County
Younger Dam	Unknown	Patrick County
Aaron Dam	Unknown	Pittsylvania County
Abbott Road Pond Dam	Unknown	Pittsylvania County
Anderson Dam	Unknown	Pittsylvania County
Atkinson Dam	Unknown	Pittsylvania County
Barringer Pond Dam	Unknown	Pittsylvania County
Blair Dam	Unknown	Pittsylvania County
Blair Dam	Unknown	Pittsylvania County
Bradley Pond Dam	Unknown	Pittsylvania County
Browning Dam	Low	Pittsylvania County
Brushy Mountain Dam	Low	Pittsylvania County
Bryant Dam	Unknown	Pittsylvania County
Bryant Dam	Unknown	Pittsylvania County
Burkhardt Dam	Low, Special	Pittsylvania County
Burnett Pond Dam	Unknown	Pittsylvania County
Burnette Lower Pond Dam	Unknown	Pittsylvania County
Burton Dam	High	Pittsylvania County
Camp Shawnee Lake Dam	Low	Pittsylvania County
Cedar Forest Mill Dam	Unknown	Pittsylvania County
Cherrystone Creek Dam # 1	High	Pittsylvania County
Cherrystone Creek Dam # 2A	High	Pittsylvania County
Collie Dam	Unknown	Pittsylvania County
Crews Dam	Unknown	Pittsylvania County
Deer Wood Springs Dam	Unknown	Pittsylvania County
Dews Dam	Unknown	Pittsylvania County
East - Cabin Pond Dam	Unknown	Pittsylvania County
Elkhorn Dam	Significant	Pittsylvania County
Epperson Dam	Unknown	Pittsylvania County
Farthing Dam	Unknown	Pittsylvania County
Ferrell Edmunds Dam	Unknown	Pittsylvania County
Fuzzys Dam	Unknown	Pittsylvania County
Gaddy Dam	Unknown	Pittsylvania County
Giles Dam	Unknown	Pittsylvania County
Gregory Dam	Unknown	Pittsylvania County
Gregory Dam	Unknown	Pittsylvania County
Gretna Dam	Unknown	Pittsylvania County
Grubb Dam	Low, Special	Pittsylvania County
Hammock Dam	Unknown	Pittsylvania County
Hood Dam	Unknown	Pittsylvania County
Industrial Authority Dam	Unknown	Pittsylvania County
Kendall Dam	Unknown	Pittsylvania County
Layton Bacon Dam	Unknown	Pittsylvania County
Lewis and Clark Dam	Low	Pittsylvania County
Lewis Nursery Dam #1	Unknown	Pittsylvania County
Lewis Nursery Dam #2	Unknown	Pittsylvania County
Lewis Nursery Dam #3	Unknown	Pittsylvania County
Lewis Nursery Dam #4	Unknown	Pittsylvania County
Lewis Nursery Dam #5	Unknown	Pittsylvania County
Mathena Large Pond Dam	Unknown	Pittsylvania County

Dam Name	Hazard Class	County
Mayhew - East Pond Dam	Unknown	Pittsylvania County
Mayhew - New Pond Dam	Unknown	Pittsylvania County
Moore Dam	Significant	Pittsylvania County
Mountain View Farms Dam #1	Unknown	Pittsylvania County
New Dam	Unknown	Pittsylvania County
NEW POND DAM	Unknown	Pittsylvania County
Oakes Dam	Unknown	Pittsylvania County
Old Bennett Farm Dam	Unknown	Pittsylvania County
Old Cabin Road Dam	Low, Special	Pittsylvania County
Old Stone Mill Dam	Unknown	Pittsylvania County
Owen Climax Road Pond Dam	Unknown	Pittsylvania County
Owen House Pond Dam	Unknown	Pittsylvania County
Paradise Lake and Campground Dam	Unknown	Pittsylvania County
Pine Dam	Unknown	Pittsylvania County
Pittsylvania Power Station Raw Water Storage Basin Dam	High	Pittsylvania County
Pritchett Dam	Unknown	Pittsylvania County
Ragsdale Large Dam	Unknown	Pittsylvania County
Remington Way Pond Dam	Unknown	Pittsylvania County
Reynolds New Dam	Unknown	Pittsylvania County
Rol Dam	Unknown	Pittsylvania County
Rolling Hills Park Dam	Unknown	Pittsylvania County
Sanders Dam	Low, Special	Pittsylvania County
Sellers Dam	Unknown	Pittsylvania County
Shedd Dam	Unknown	Pittsylvania County
Shelhorse Dam	Unknown	Pittsylvania County
Shop Pond Dam	Unknown	Pittsylvania County
Shorter Dam	Unknown	Pittsylvania County
South of Danville Dam	Unknown	Pittsylvania County
Stone Dam	Unknown	Pittsylvania County
Tate dam	Unknown	Pittsylvania County
Terry Large Pond Dam	Unknown	Pittsylvania County
Thorton Dam	Unknown	Pittsylvania County
Tuscarora CC - Pond 4 Dam	Unknown	Pittsylvania County
Watson Dam	Unknown	Pittsylvania County
Wells Dam	Unknown	Pittsylvania County
Wispering Pines Dam	Low, Special	Pittsylvania County
Yeatts New Pond Dam	Unknown	Pittsylvania County
Yeatts Small Pond Dam	Unknown	Pittsylvania County
Allen Dam	Unknown	Powhatan County
Anderson Dam	Unknown	Powhatan County
Bass Pond Dam	Low	Powhatan County
Bevins Pond Dam	Unknown	Powhatan County
Blazer Dam	Unknown	Powhatan County
Blenheim Road mid-E Dam	Unknown	Powhatan County
Blenheim Road SE Dam	Unknown	Powhatan County
Blenheim Road SW Dam	Unknown	Powhatan County
Boatwright Dam	Unknown	Powhatan County
Bridge Lake Dam	Unknown	Powhatan County
Butterwood Dam	Unknown	Powhatan County
Byers Dam	Unknown	Powhatan County
Byers Mill Dam	Unknown	Powhatan County

Dam Name	Hazard Class	County
Carneal Pond Dam	Low, Special	Powhatan County
Ciejek Dam	Unknown	Powhatan County
Crawford Dam	Unknown	Powhatan County
Dunivan Dam	Unknown	Powhatan County
Foundry Lake Dam	Low, Special	Powhatan County
Fralin Dam	Unknown	Powhatan County
Goodwyn Lake Dam	Unknown	Powhatan County
Graveyard Pasture Pond	Unknown	Powhatan County
Grigg Lake Dam	Unknown	Powhatan County
Hamilton Dam	Unknown	Powhatan County
Hewins Dam	Unknown	Powhatan County
Holly Hills Dam	Unknown	Powhatan County
Huguenot - St. Lukes	Unknown	Powhatan County
John L. Lewis Dam	Unknown	Powhatan County
Lake Shawnee Dam #2	Unknown	Powhatan County
Lake Shawnee Dam #3	Unknown	Powhatan County
Lakefront HOA Dam	Unknown	Powhatan County
Layman Dam	Unknown	Powhatan County
Layne Dam	Unknown	Powhatan County
Little Dam	Unknown	Powhatan County
Lower Byers Dam	Low	Powhatan County
Lower Powhatan Dam	Low	Powhatan County
Majors Pond	Unknown	Powhatan County
Malone Dam	Unknown	Powhatan County
Martin Dam	Unknown	Powhatan County
Mcgee Dam	Unknown	Powhatan County
Mcquade Dam	Unknown	Powhatan County
Mill Quarter Lake Dam	High	Powhatan County
Morrisette Dam	Unknown	Powhatan County
Moyer Pond Dam	Unknown	Powhatan County
Nixons Dam	Unknown	Powhatan County
No. 1 Pond Dam @ JRCC etc. (6)	Unknown	Powhatan County
Poland Farm	Unknown	Powhatan County
Quarter Mill Lake Dam	Unknown	Powhatan County
Rancks Dam	Unknown	Powhatan County
Ranson Dam	Unknown	Powhatan County
Ransons Dam - middle	Unknown	Powhatan County
Ransons Dam - south	Unknown	Powhatan County
Recreation Pond Dam	Low	Powhatan County
Redford Dam	Unknown	Powhatan County
Reid dam	Unknown	Powhatan County
Rosson's Dam	Unknown	Powhatan County
Seth Corp Dam	Unknown	Powhatan County
Shawnee Dam #1	Unknown	Powhatan County
Southern Service Corp. Dam	Unknown	Powhatan County
Sowers Dam	Unknown	Powhatan County
Spratley Leigh Dam	Low, Special	Powhatan County
Sunfish Pond Dam	Low, Special	Powhatan County
Tilmans Farm Dam No. 3	Unknown	Powhatan County
Tilmans Farm Dam No. 4	Unknown	Powhatan County
Upper Byers Dam	Low	Powhatan County
Upper Powhatan Dam	High	Powhatan County

Dam Name	Hazard Class	County
Walkers Dam	Unknown	Powhatan County
Walnut Creek Dam	Significant	Powhatan County
Walton Dam	Unknown	Powhatan County
Westlake Dam	Low	Powhatan County
Willis Dam	Unknown	Powhatan County
Woodberry Dam	Unknown	Powhatan County
Yates Dam	Unknown	Powhatan County
Ancel Dam	Unknown	Prince Edward County
Baker Mountain Tailings Pond Dam	Low	Prince Edward County
Borum Dam	Unknown	Prince Edward County
Bridge St. Lagoons Dam	Unknown	Prince Edward County
Briery Creek Lake Dam	High	Prince Edward County
Brisentine Dam	Unknown	Prince Edward County
Buffalo Creek Dam # 1	Significant	Prince Edward County
Buffalo Creek Dam # 2	Low	Prince Edward County
Buffalo Creek Dam # 3	Significant	Prince Edward County
Buffalo Creek Dam # 4	High	Prince Edward County
Buffalo Creek Dam # 5	Significant	Prince Edward County
Buffalo Creek Dam # 6	Significant	Prince Edward County
Buffalo Creek Dam # 7	Significant	Prince Edward County
Buffalo Creek Dam # 9	Significant	Prince Edward County
Buffalo Creek Dam #8	Significant	Prince Edward County
Bush River Dam # 12	High	Prince Edward County
Bush River Dam # 2	High	Prince Edward County
Bush River Dam # 4B	High	Prince Edward County
Bush River Dam # 5	Low	Prince Edward County
Bush River Dam # 6	Significant	Prince Edward County
Bush River Dam # 7	High	Prince Edward County
Carlton Dam	Unknown	Prince Edward County
Carter Dam	Unknown	Prince Edward County
Farmville Dam	Significant	Prince Edward County
Gentry Dam	Unknown	Prince Edward County
Goodwin Dam	Low	Prince Edward County
Herzig Dam	Unknown	Prince Edward County
Hines Dam	Unknown	Prince Edward County
McKenney Dam	Low	Prince Edward County
Miller Lake Dam	Unknown	Prince Edward County
Millwood Pond Dam	Unknown	Prince Edward County
Moores Dam	Unknown	Prince Edward County
Mottley Dam	Low	Prince Edward County
Murphy Dam	Unknown	Prince Edward County
Poplar Hill Dam	Low	Prince Edward County
Prince Edward County Dam # 10	Unknown	Prince Edward County
Prince Edward County Dam # 11	Unknown	Prince Edward County
Prince Edward County Dam # 12	Unknown	Prince Edward County
Prince Edward County Dam # 13	Unknown	Prince Edward County
Prince Edward County Dam # 14	Unknown	Prince Edward County
Prince Edward County Dam # 15	Unknown	Prince Edward County
Prince Edward County Dam # 16	Unknown	Prince Edward County
Prince Edward County Dam # 17	Unknown	Prince Edward County
Prince Edward County Dam # 2	Unknown	Prince Edward County
Prince Edward County Dam # 3	Unknown	Prince Edward County

Dam Name	Hazard Class	County
Prince Edward County Dam # 4	Unknown	Prince Edward County
Prince Edward County Dam # 5	Unknown	Prince Edward County
Prince Edward County Dam # 6	Unknown	Prince Edward County
Prince Edward County Dam # 7	Unknown	Prince Edward County
Prince Edward County Dam # 9	Unknown	Prince Edward County
Prince Edward Dam	Low	Prince Edward County
R. A. Smith Dam	Unknown	Prince Edward County
Sterling Lake Dam	Unknown	Prince Edward County
Watson Dam	Unknown	Prince Edward County
Wells Dam	Unknown	Prince Edward County
Whitetail Trails Dam # 1	Unknown	Prince Edward County
Whitetail Trails Dam # 2	Unknown	Prince Edward County
Wilsons Dam	Unknown	Prince Edward County
Afton Drive/Chappell Creek Dam	Unknown	Prince George County
Andrews Dam	Unknown	Prince George County
Bakers Dam	Unknown	Prince George County
Binford Dam	Unknown	Prince George County
Butterworth Dam	Unknown	Prince George County
Cain Dam	Unknown	Prince George County
Cerneys Dam	Unknown	Prince George County
Enochs Dam	Unknown	Prince George County
Hamlins Dam	Unknown	Prince George County
Hanzliks Dam	Unknown	Prince George County
Indian Swamp Dam	Unknown	Prince George County
Issac Walton Dam	Unknown	Prince George County
Jandls Dam	Low	Prince George County
Kings Dam	Unknown	Prince George County
Lake Fungs Dam	Unknown	Prince George County
Lees Dam	Unknown	Prince George County
Manns Dam	Unknown	Prince George County
Prince George Golf Course Dam	Unknown	Prince George County
Rolls Royce Dam	Unknown	Prince George County
Skalsky Pond # 1 Dam	Unknown	Prince George County
Skalsky Pond # 2 Dam	Unknown	Prince George County
Van Metre Dam	Unknown	Prince George County
Whelans Dam	Unknown	Prince George County
Woodys Dam	Unknown	Prince George County
Wright Dam	Unknown	Prince George County
ARC Redevelopment SWM Pond Dam	High	Prince William County
BR Golf Dam	Unknown	Prince William County
Buckland Dam	Unknown	Prince William County
Engh Dam	Unknown	Prince William County
Innovation at Prince William - Pond 3	High	Prince William County
Lake Jackson Dam	Significant	Prince William County
Lake Montclair Dam	High	Prince William County
Lake Plaza Prop Dam	Unknown	Prince William County
Locust Shade Park Dam	High	Prince William County
Market Center Pond 1 Dam	Significant	Prince William County
Meadows Dry Pond Dam	Low, Special	Prince William County
Meadows Wet Pond Dam	Low, Special	Prince William County
New Bristow Village Regional SWM Facility Dam	High	Prince William County

Dam Name	Hazard Class	County
North Fork Wetlands Bank Dam	High	Prince William County
NVCC Woodbridge Campus Dam	Significant	Prince William County
Occoquan Lower Storage Dam	High	Prince William County
Omisol Dam	High	Prince William County
Possum Point Ash Dam #D	High	Prince William County
Possum Point Ash Dam #E	Low	Prince William County
Possum Point Power Station Ash Pond ABC Dam	Low	Prince William County
Possum Point Power Station Oil Water Treatment Basin Dam	Low	Prince William County
Potomac Club Regional Pond Dam	Significant	Prince William County
Prince William Parkway Regional SWM	High	Prince William County
Rocky Branch Regional SWM Dam	High	Prince William County
Schumacher Dam	Unknown	Prince William County
Shirley Bell Dam	Unknown	Prince William County
Silver Lake Dam	High	Prince William County
Southern Shores Drive Dam	Significant	Prince William County
T. Nelson Elliott Dam	High	Prince William County
Upper Occoquan Dam	High	Prince William County
VA E&P Co Dam	Unknown	Prince William County
VC Conley Dam	Unknown	Prince William County
Gatewood Dam	High	Pulaski County
Hogan Dam	High	Pulaski County
Lake Powhatan Dam	High	Pulaski County
Ottari Scout Camp Dam #2	Low	Pulaski County
Pulaski County Dam #5	Unknown	Pulaski County
Thornhill Dam	Unknown	Pulaski County
Graage Dam	Unknown	Rappahannock County
Liverman Dam	Unknown	Rappahannock County
Margolis Dam	Unknown	Rappahannock County
Mt Airy Hunt Club Dam	Unknown	Rappahannock County
Rappahannock Dam #11	Unknown	Rappahannock County
Rappahannock Dam #13	Unknown	Rappahannock County
Rappahannock Dam #15	Unknown	Rappahannock County
Rappahannock Dam #17	Unknown	Rappahannock County
Rappahannock Dam #18	Unknown	Rappahannock County
Rappahannock Dam #2	Unknown	Rappahannock County
Rappahannock Dam #20	Unknown	Rappahannock County
Rappahannock Dam #21	Unknown	Rappahannock County
Rappahannock Dam #22	Unknown	Rappahannock County
Rappahannock Dam #23	Unknown	Rappahannock County
Rappahannock Dam #24	Unknown	Rappahannock County
Rappahannock Dam #25	Unknown	Rappahannock County
Rappahannock Dam #3	Unknown	Rappahannock County
Rappahannock Dam #4	Unknown	Rappahannock County
Rappahannock Dam #5	Unknown	Rappahannock County
Rappahannock Dam #7	Unknown	Rappahannock County
Rappahannock Dam #8	Unknown	Rappahannock County
Whippoorwill Dam	High	Rappahannock County
Chinns Dam	Unknown	Richmond County
Connellee Dam	Significant	Richmond County
Deland Dam	Unknown	Richmond County

Dam Name	Hazard Class	County
France Dam	Unknown	Richmond County
Garland Millpond Dam	Significant	Richmond County
Hogans Mill Dam	Unknown	Richmond County
Huggins Dam 1	Unknown	Richmond County
Huggins Dam 2	Unknown	Richmond County
Huggins dam 3	Unknown	Richmond County
Lanier-Davis Dam	Unknown	Richmond County
Mt. Airy Dam	Unknown	Richmond County
Omohundra Millpond Dam	Unknown	Richmond County
Clifford D. Craig Memorial Dam	High	Roanoke County
Hudick Dam	Unknown	Roanoke County
Loch Haven Lake Dam	High	Roanoke County
Roanoke College Dam	Unknown	Roanoke County
Woods End Dam	High	Roanoke County
Woods End Dam	High	Roanoke County
Woods End Dam	High	Roanoke County
Woods End Dam	High	Roanoke County
Cold Sulpher Springs Dam	Significant	Rockbridge County
Goshen Dam	High	Rockbridge County
Jordans Point Dam	Low, Special	Rockbridge County
Jordans Point Dam	Low, Special	Rockbridge County
Jordans Point Dam	Low, Special	Rockbridge County
Jordans Point Dam	Low, Special	Rockbridge County
Moores Creek Dam	High	Rockbridge County
Natural Bridge Dam # 5	High	Rockbridge County
Robertson Dam	High	Rockbridge County
Rockbridge County Dam	Unknown	Rockbridge County
Turner Pond Dam	High	Rockbridge County
Willow Lake Dam	Unknown	Rockbridge County
Broadway Town Dam	Unknown	Rockingham County
Johnson Dam	Unknown	Rockingham County
Knoll Meadow Dam	Unknown	Rockingham County
Lake Shenandoah Dam	High	Rockingham County
Lower North River # 22B	High	Rockingham County
Lower North River # 78	High	Rockingham County
Lower North River # 80	High	Rockingham County
Lower North River # 81C	High	Rockingham County
Lower North River # 82	High	Rockingham County
Lower North River # 83	High	Rockingham County
Massanutten Dam	Significant	Rockingham County
North Fork Shenandoah River Dam No. 2	Unknown	Rockingham County
Shoemaker River # 1A	High	Rockingham County
Shoemaker River # 3B	High	Rockingham County
Shoemaker River # 4C	High	Rockingham County
Clinch River Flyash Dam #1	High	Russell County
Clinch River Flyash Dam #2	High	Russell County
Gent Brothers Dam	Unknown	Russell County
Laurel Bed Dam	High	Russell County
Moss No. 3 Third Dam	Unknown	Russell County
Russell County Dam #8	Unknown	Russell County
Bark Camp Dam	High	Scott County
Scott County Dam #5	Unknown	Scott County

Dam Name	Hazard Class	County
Edinburg Dam	Unknown	Shenandoah County
John Moses Dam	Unknown	Shenandoah County
Lophaven Farms Dam	Unknown	Shenandoah County
Seven Fountains Dam	Unknown	Shenandoah County
Stony Creek Dam #10	High	Shenandoah County
Stony Creek Dam #9	High	Shenandoah County
Strasburg Dam	Significant	Shenandoah County
Woodstock Dam	High	Shenandoah County
Wunder Dam	Unknown	Shenandoah County
Billings Dam	Unknown	Smyth County
Hungry Mother Dam	High	Smyth County
Bishop Dam	Unknown	Southampton County
Camp Dam	Unknown	Southampton County
Cedar View/Cobb Branch Dam	Unknown	Southampton County
Colgate Darden Dam	Unknown	Southampton County
Cypress Cove Dam	Unknown	Southampton County
Dardens Dam	Significant	Southampton County
Johnson Dam	Unknown	Southampton County
McGraphs Dam	Unknown	Southampton County
Princes Dam	Unknown	Southampton County
Whitefield Dam	Unknown	Southampton County
Windbourne Dam	Unknown	Southampton County
Bowman Dam	Low	Spotsylvania County
Burgess Lane Dam	Unknown	Spotsylvania County
Chancellor West Dam	Unknown	Spotsylvania County
Cool Spring Dam	Low	Spotsylvania County
E.H. Mills Memorial Dam	Low	Spotsylvania County
Fawn Lake Dam	High, Special	Spotsylvania County
Flythe Dam	Low, Special	Spotsylvania County
Gordons Dam	Low	Spotsylvania County
Grant Lake Dam	Low	Spotsylvania County
Hazel Grove Dam	Low	Spotsylvania County
Hidden Trail Lake	Unknown	Spotsylvania County
Hunting Run Dam	High	Spotsylvania County
Indian Acres Dam	High	Spotsylvania County
Jennings Pond Dam	Low	Spotsylvania County
Lee Lake Dam	Low	Spotsylvania County
Motts Run Reservoir Dam	High	Spotsylvania County
Ni River Dam #1	High	Spotsylvania County
Rams Lake Dam	Low	Spotsylvania County
Sawhill Dam	Low, Special	Spotsylvania County
Spotsylvania County Dam #1	Unknown	Spotsylvania County
Spotsylvania County Dam #10	Unknown	Spotsylvania County
Spotsylvania County Dam #11	Unknown	Spotsylvania County
Spotsylvania County Dam #2	Unknown	Spotsylvania County
Spotsylvania County Dam #3	Unknown	Spotsylvania County
Spotsylvania County Dam #5	Unknown	Spotsylvania County
Spotsylvania County Dam #8	Unknown	Spotsylvania County
Spotsylvania County Dam #9	Unknown	Spotsylvania County
Stanard's Mill Dam	Low	Spotsylvania County
The Laurels Dam	High	Spotsylvania County
Towles Dam	Unknown	Spotsylvania County

Dam Name	Hazard Class	County
Wilderness Dam	High	Spotsylvania County
Wrights Pond Dam	Low	Spotsylvania County
AD Clark Dam	Unknown	Stafford County
Aquia Creek Dam	High	Stafford County
Augustine Golf Dam	Unknown	Stafford County
Celebrate Virginia Pond #12	Low	Stafford County
Chichester Dam	Unknown	Stafford County
Hartlake Dam No. 1	Low	Stafford County
Hartlake Dam No. 2	Unknown	Stafford County
Henderson Dam	Unknown	Stafford County
Hidden Lake Dam	Significant	Stafford County
JMC IV Dam	Unknown	Stafford County
Kennedy Dam	High	Stafford County
Lake Arrowhead Dam	High	Stafford County
Lake Curtis Dam	High	Stafford County
Lake Mooney Dam	High	Stafford County
Leeland Lake Dam	High	Stafford County
Little Lake Arrowhead Dam	Unknown	Stafford County
Potomac Creek Dam #1	High	Stafford County
Potomac Creek Dam #2	High	Stafford County
Pt. Stone Dam	Unknown	Stafford County
Rita Law Dam	Unknown	Stafford County
Rocky Pen Run #4A	Low	Stafford County
Rocky Pen Run Regional Pond 2A Dam	High	Stafford County
Seven Lakes Dam	High	Stafford County
Sheryl Brooks Dam	Unknown	Stafford County
Starkweather Dam	Unknown	Stafford County
Walden Ten No. 1 Dam	High	Stafford County
Yearly Dam	Unknown	Stafford County
Adkins Dam	Low	Surry County
Eastover Dam	Low	Surry County
Gray Dam	Low	Surry County
Low Point Dam	Low	Surry County
Sunken Meadow Dam	Low	Surry County
Surry Power Station Dredge Spoils Disposal Pond Dam	Low	Surry County
Airfield Pond Dam	Significant	Sussex County
Belsches Dam	Unknown	Sussex County
Brittles Dam	Unknown	Sussex County
Bryant Dam	Unknown	Sussex County
Carroll Dam	Unknown	Sussex County
Creath Dam	Unknown	Sussex County
Freemans Dam	Unknown	Sussex County
Game Reserve Dam	Unknown	Sussex County
Hargraves Dam	Unknown	Sussex County
Harrells Dam	Unknown	Sussex County
Harrells Pond Dam	Unknown	Sussex County
Honey Dam	Unknown	Sussex County
Horne Dam	Unknown	Sussex County
J. B. Harrell Dam	Unknown	Sussex County
Jenkins Dam	Unknown	Sussex County
Johnson Dam	Unknown	Sussex County

Dam Name	Hazard Class	County
Lewis Dam	Unknown	Sussex County
Magee Dam	Unknown	Sussex County
Mayes Dam	Unknown	Sussex County
Morgans Dam	Unknown	Sussex County
Nebletts Dam	Unknown	Sussex County
Parker No. 1 Dam	Unknown	Sussex County
Parker No. 2 Dam	Unknown	Sussex County
Parker No. 3 Dam	Unknown	Sussex County
Parsons No. 1 Dam	Unknown	Sussex County
Parsons No. 2 Dam	Unknown	Sussex County
Renneys Dam	Unknown	Sussex County
Rogers Dam	Unknown	Sussex County
Spiers Dam	Unknown	Sussex County
Spring Hill Dam	Unknown	Sussex County
White Dam	Unknown	Sussex County
Falls Mill Dam	High	Tazewell County
Mocomp Dam #1	Unknown	Tazewell County
Sportsman Club Dam	Unknown	Tazewell County
Upper Clinch River Dam #8	High	Tazewell County
Upper Clinch Valley Dam #1B	High	Tazewell County
Apple Mountain Lake Dam	Significant	Warren County
Apple Mountain Upper Lake Dam	Significant	Warren County
Bruce Turner Dam	Unknown	Warren County
Cooley Dam	Low	Warren County
Deer Lake Dam	Low	Warren County
Fortsmouth Inc Dam	Unknown	Warren County
Lake Front Royal Dam	High	Warren County
Lake John Dam	Unknown	Warren County
Lake of the Clouds Dam	High	Warren County
Loch Linden Dam	Significant	Warren County
North Fork Shenandoah River Dam No. 1	Unknown	Warren County
Spring Lake Dam	Significant	Warren County
Sullivan Dam	Unknown	Warren County
Sunlight Prop Dam	Unknown	Warren County
VA Tech Dam	Unknown	Warren County
Hidden Valley Lake Dam	High	Washington County
Chandler's Mill Dam	Significant	Westmoreland County
Flemmer Dam	Unknown	Westmoreland County
Gardy Millpond Dam	Low	Westmoreland County
Horners Dam	Unknown	Westmoreland County
Lake Independence Dam	Significant	Westmoreland County
Latanes Dam	Unknown	Westmoreland County
Marshall Creek Dam	Unknown	Westmoreland County
Morris Dam	Unknown	Westmoreland County
Placid Lake Dam	Low	Westmoreland County
Red Oak Dam	Significant	Westmoreland County
Thomas Branch Dam	Unknown	Westmoreland County
Travis Dam	Unknown	Westmoreland County
Weavers Dam	Unknown	Westmoreland County
Westmoreland County Dam #2	Unknown	Westmoreland County
Westmoreland County Dam #3	Unknown	Westmoreland County
Westmoreland County Dam #4	Unknown	Westmoreland County

Dam Name	Hazard Class	County
Bear Creek Dam	High	Wise County
Bens Branch Dam	High	Wise County
Big Cherry RCC Dam	High	Wise County
Black Creek Dam	Unknown	Wise County
Dominion Virginia City Dam #2	High	Wise County
Indian Ridge Pond Dam	Unknown	Wise County
McFall Fork Dam	Unknown	Wise County
Michael Cox Dam	Unknown	Wise County
Rimrock Lake Dam	Unknown	Wise County
Toms Creek Dam	Significant	Wise County
UVA Wise #1 Dam	High	Wise County
UVA Wise #2 Dam	High	Wise County
Wise County Dam #4	Unknown	Wise County
Kenneth Tibbs Dam	Unknown	Wythe County
Paul Riefenberg Dam	Unknown	Wythe County
Reed Creek Dam	Low	Wythe County
Rural Retreat Dam	High	Wythe County
Talley Farms Dam	Unknown	Wythe County
Harwood's Mill Dam	High	York County
Queens Lake Dam	Low	York County
Waller Mill Dam	High	York County
Water Country Dam	Low	York County
Williamsburg Country Club Dam	Unknown	York County
York Meadows Dam	Unknown	York County

Appendix F:

Gap Analysis

F.1 Introduction

Appendix F presents the results of a gap analysis of hazard mitigation capabilities. The objective of this analysis is to highlight effective hazard mitigation strategies that are utilized outside of Virginia. Appendix F is intended to provide new ideas and drive discussion and innovation in Virginia.

The gap analysis focused on identifying gaps in current mitigation capabilities across each hazard with respect to prevention, detection, and mitigation strategies. This process included a review of current state capabilities as outlined in the main body of the HMP, and a desired future state based on accomplishment of the mitigation vision, goals and objectives. This analysis identified potential mitigation strategies by identifying gaps in how mitigation works in Virginia with regard to the Commonwealth's citizens, governmental processes, hazard-related technologies and data, and structures or assets, with an emphasis on climate change and social equity.

This section examines state mitigation capabilities primarily from other Atlantic Coast states, such as Maryland, Massachusetts, North Carolina, and Pennsylvania. Some of the activities apply to individual cities or regions, rather than just state level programs.

Mitigation capabilities are divided by hazard. Each table includes a description of an existing program, the state that leads the capability, the agency or organization that administers the program, and external resources for more information on the program.

F.2 Drought

Pennsylvania Drought Resiliency Program	
Description:	A drought resiliency program focused on maintaining national and federal partnerships for drought management. The program centralizes several resources for residents and businesses, including links to the National Drought Resilience Partnership, EPA reports on water use and droughts, and funds for drought resilient water infrastructure projects. Drought status is tracked via a number of metrics including groundwater levels and precipitation. Resilience is measured using ability to persist during drought and recover after an event. Mitigations include conservation and improving access.
State:	Pennsylvania
Hazard(s) Addressed:	Drought
Lead Agency:	Department of Environmental Protection
Funding:	
Status:	Ongoing
Comments:	Data sources for drought status, precipitation, stream flow, ground water, burn bans, and soil moisture are provided.
Further Details: https://www.dep.pa.gov/Business/Water/PlanningConservation/Drought/Pages/Drought-Resiliency.aspx#:~:text=Drought%20resiliency%20focuses%20on%20preparing,help%20communities%20become%20more%20resilient.	

North Carolina Water Supply Planning	
Description:	A supply planning and demand management resource to coordinate local decisions at a state level. Local governments must prepare water supply plans and submit water usage data through an online portal. Current drought status for each region is provided along with recommended actions for each severity. Providing locality specific recommendations is expected to improve response compared to statewide recommendations. The threshold for increasing drought severity is a quarter of the land area in the region.
State:	North Carolina
Hazard(s) Addressed:	Drought
Lead Agency:	Department of Environmental Protection
Funding:	
Status:	Ongoing
Comments:	537 municipalities, counties, and other regional entities publish plans for water supply and shortage response.
Further Details: https://deq.nc.gov/about/divisions/water-resources/water-planning/water-supply-planning/water-use-reporting	

California Department of Water Resources Drought Funding	
Description:	The California Department of Water Resources provides funding for projects that combat the impacts of drought conditions. Eligible applicants include counties named in drought emergencies or in areas needing immediate action, public agencies and utilities, special districts, colleges and universities, Native American tribes and others. Of the authorized funds, 40% is authorized for small communities. Factors considered include human health and safety, fish and wildlife, and loss of supply. Funds for the 2022 cycle must be allocated by 2024 and projects completed by 2026.
State:	California
Hazard(s) Addressed:	Drought
Lead Agency:	California Department of Water Resources
Funding:	
Status:	Ongoing
Comments:	The department of water resources is also developed a methodology to assess local vulnerability and risk scoring along with recommendations for contingency planning in at risk areas.
Further Details: **https://water.ca.gov/Water-Basics/Drought/Drought-Funding**	

F.3 Earthquake

Alaska Seismic Hazards Safety Commission	
Description:	Recommends goals and priorities for seismic risk mitigation. The commission partners with federal organizations to identify schools that are at-risk of damage in the event of an earthquake. The commission outlines plans to perform seismic retrofits on at-risk buildings. Alaska also receives FEMA funding for earthquake resilience projects, including retrofitting the Port of Alaska, the construction of earthquake-resistant water transmission lines, grid and gas updates, and gas shut off valves. Remaining funds are allocated to schools and other critical facilities as part of the retrofit program
State:	Alaska
Hazard(s) Addressed:	Earthquake
Lead Agency:	Office of the Governor: Alaska Seismic Hazards Safety Commission
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://seismic.alaska.gov/ https://dggs.alaska.gov/webpubs/dggs/ic/text/ic088.pdf	

Earthquake Warning California	
Description:	California participates in ShakeAlert, an earthquake early warning system for the West coast.
State:	California
Hazard(s) Addressed:	Earthquake
Lead Agency:	USGS
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.shakealert.org/**	

Brace & Bolt Program	
Description:	The California Office of Emergency Services provides up to $3,000 to cover retrofitting costs for homeowners through the Brace and Bolt program. The California Residential Mitigation Program also provides grants and financial assistance to low income and vulnerable populations to retrofit and harden homes as mitigation for earthquakes.
State:	California
Hazard(s) Addressed:	Earthquake
Lead Agency:	California Residential Mitigation Program (CRMP)
Funding:	
Status:	Ongoing
Comments:	The California Earthquake Authority, a not-for-profit partnered with the Cal OES, provides earthquake insurance policies for homeowners and renters.
Further Details: https://www.earthquakebracebolt.com/	

Debris Removal Services	
Description:	Local governments are eligible for assistance with debris removal through the California Consolidated Debris Removal Program. Teams will inspect property and remove hazardous materials that pose a threat to human health and the environment.
State:	California
Hazard(s) Addressed:	Earthquake
Lead Agency:	California Office of Emergency Services
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.placer.ca.gov/DocumentCenter/View/55030/Debris-Removal-Program-Enrollment-and-Process-FAQ-2021?bidId=	

F.4 Erosion

Maryland Stormwater, Dam Safety, and Flood Management Program (SDSFM)	
Description:	"The Program Review division of SDSFM manages the stormwater and sediment and erosion control programs… The Plan Review Division reviews construction plans on State and federal projects for consistency with Stormwater Management regulations (SWM) and Erosion and Sediment Control (ESC) regulations, then issues approval." The SDSFM issues permits and directs local governments to reduce pollution and erosion from runoff due to construction activities. The SDSFM delegates oversight to some local governments and manages other regions directly.
State:	Maryland
Hazard(s) Addressed:	Erosion
Lead Agency:	Maryland Department of the Environment;
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://mde.maryland.gov/programs/Water/SSDS/Pages/index.aspx#:~:text=The%20SDSFM%20program%20consists%20of,and%20Compliance%2C%20and%20Flood%20Management.&text=The%20Program%20Review%20division%20of,sediment%20and%20erosion%20control%20programs.	

Massachusetts StormSmart Coasts Program	
Description:	The StormSmart Coasts Program "provides information, strategies, and tools to help communities and people working and living on the coast to address the challenges of erosion, flooding, storms, sea level rise, and other climate change impacts." The program provides tools for homeowners and local officials regarding strategies for reducing coastal erosion and storm damage while reducing impacts to shorelines. The program maintains the Barrier Beach Inventory Project, which maintains data on barrier beaches including recent changes, developments, damage, and other information critical for barrier beach management. The program includes the Coastal Resilience Grant program, which addresses challenges caused by sea level rise, storms, flooding, and erosion.
State:	Massachusetts
Hazard(s) Addressed:	Erosion
Lead Agency:	Massachusetts Office of Energy and Environmental Affairs, through the Office of Coastal Zone Management
Funding:	
Status:	Ongoing
Comments:	Other projects include planning, redesigns and retrofits, and shoreline restoration.
Further Details: **https://www.mass.gov/stormsmart-coasts-program#:~:text=The%20Massachusetts%20Office%20of%20Coastal,and%20other%20climate%20change%20impacts**.	

California Erosion Control Toolbox	
Description:	California provides an erosion control toolbox through Caltrans (California DOT), which provides "Landscape Architects with a single location that contains the information necessary to design successful, cost-effective and sustainable erosion control treatments"
State:	California
Hazard(s) Addressed:	Erosion
Lead Agency:	Caltrans (California DOT)
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://dot.ca.gov/programs/design/lap-erosion-control-design/tool-1-lap-erosion-control-toolbox#:~:text=The%20purpose%20of%20the%20Caltrans,Erosion%20Control%20Treatments** **https://dbw.parks.ca.gov/?page_id=28766**	

Public Beach Restoration and Shoreline Erosion Program	
Description:	The California Division of Boating and Waterways controls the Public Beach Restoration and Shoreline Erosion Program, which issues grants for the repair, redevelopment, and hardening of beaches at risk of major erosion. The Public Beach Restoration and Shoreline Erosion Program also provides workshops for potential applicants. The program will provide experts to survey shorelines regarding suitability for new projects.
State:	California
Hazard(s) Addressed:	Erosion
Lead Agency:	California Division of Boating and Waterways
Funding:	
Status:	Ongoing
Comments:	The program and its projects are beholden to standards outlined in the California Harbors and Navigation Code – Department of Boating and Waterways Code (ARTICLE 2.5. Beach Erosion Control [65 - 67.4])
Further Details: **https://www.grants.ca.gov/grants/division-of-boating-and-waterways-public-beach-restoration-program/** **https://dbw.parks.ca.gov/?page_id=28766**	

F.5 Extreme Cold

Pennsylvania Warming Centers	
Description:	Pennsylvania Department of Human Services provides information on a network of extreme cold warming centers through partnerships between the state, counties, and non-profit organizations. The service includes an interactive map and searchable database that provides information on warming center locations, hours, eligibility, intake procedures, capacity limits, alerts, and contact information.
State:	Pennsylvania
Hazard(s) Addressed:	Extreme Cold
Lead Agency:	Pennsylvania Department of Human Services
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.pa211.org/get-help/housing-shelter/extreme-cold-warming-centers/**	

Baltimore Code Blue	
Description:	Baltimore manages the Code Blue Extreme Cold program. When a Code Blue is declared, several responses are triggered to protect individuals experiencing homelessness. City-funded shelters will shelter-in-place to ensure any individual experiencing homelessness and wanting shelter will be accommodated. Private homeless shelters will be encouraged to extend their hours and keep individuals indoors.
State:	Maryland
Hazard(s) Addressed:	Extreme Cold
Lead Agency:	Baltimore City Health Department
Funding:	
Status:	Ongoing
Comments:	Homeless Services Outreach Workers provide cold weather education, encourage individuals experiencing homelessness to take shelter, and connect them to services as needed. On nights when Code Blue Extreme Cold has been declared, the Salvation Army FEEDMORE canteen provides hot drinks and other items to individuals experiencing homelessness.
Further Details: **https://health.baltimorecity.gov/emergency-preparedness-response/code-blue#:~:text=A%20Code%20Blue%20Extreme%20Cold%20declaration%20triggers%20several%20responses%20aimed,wanting%20shelter%20will%20be%20accommodated**.	

F.6 Extreme Heat

Virginia Regional Efforts	
Description:	Richmond, Southside Hampton Roads, and Northern Virginia have participated in urban heat island mapping exercises, outlining neighborhoods that are vulnerable to extreme heat conditions. These projects were undertaken by the cities themselves and are included in the U.S. Climate resilience toolkit
State:	Virginia
Hazard(s) Addressed:	Extreme Heat
Lead Agency:	Multiple
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://toolkit.climate.gov/case-studies/where-do-we-need-shade-mapping-urban-heat-islands-richmond-virginia** **https://www.adaptationclearinghouse.org/resources/citizen-science-mapping-urban-heat-islands-in-richmond-virginia.html#:~:text=The%20urban%20heat%20island%20mapping,design%20community%2Dscale%20adaptation%20plans**.	

Philadelphia Beat the Heat	
Description:	Many cities in Pennsylvania, including Philadelphia, provide toolkits and research to communities with recommendations on how to take community-level actions to combat the effects of extreme heat. The toolkits help communities in Philadelphia research their part of the city, establish heat teams, interview stakeholders, conduct surveys, organize the community, designate "Beat the Heat" ambassadors, create mobile stations, host workshops, promote tree planting, and build a heat relief network.
State:	Pennsylvania
Hazard(s) Addressed:	Extreme Heat
Lead Agency:	City of Philadelphia Office of Sustainability
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.phila.gov/departments/office-of-sustainability/beat-the-heat-toolkit/**	

Maryland Extreme Heat Emergency Plan	
Description:	Maryland utilizes an Extreme Heat Emergency Plan, which outlines sets of triggering events, organizations responsible for surveillance, and organizations responsible for actions. The primary organizations are the Maryland Department of Health and local health departments. Summers are divided into six phases: Pre-Summer, Pre-Event, Extreme Heat Event – Heat Advisory, Extreme Heat Event – Excessive Heat Warning, Complex Heat Emergency, and Post-Summer. During each phase, various organizations have different responsibilities. Responsibilities include timings for press releases, reports on heat and water use, responses to events such as power outages or water shortages, and actions to take post-event.
State:	Maryland
Hazard(s) Addressed:	Extreme Heat
Lead Agency:	Maryland Department of Health
Funding:	
Status:	Ongoing
Comments:	As extreme heat conditions worsen, state organizations mobilize various efforts to reduce harm to citizens. For example, local health departments will notify state agencies of hotspots in order to distribute resources during a heat advisory. During a Complex Heat Emergency (a heat event compounded by other factors such as power outages), the Maryland Department of Health will take an advisory role on outage plans and coordinate local emergency services.
Further Details: **https://health.maryland.gov/preparedness/Documents/MDH%20Extreme%20Heat%20Emergency%20Plan%202022.pdf**	

Massachusetts Extreme Heat Resources	
Description:	Many localities within Massachusetts have strategies for managing extreme heat. These may include the distribution of cooling care kits, fans, AC units, and wearable cooling devices. This is orchestrated at the community level with sponsorship from the state and regional planning councils. Strategies have been updated to accommodate Covid safety. Analysis of neighborhood vulnerability to extreme heat was assessed and results are available to support planning.
State:	Massachusetts
Hazard(s) Addressed:	Extreme Heat
Lead Agency:	Metropolitan Area Planning Council
Funding:	
Status:	Ongoing
Comments:	Hotels and motels are converted into safe areas for residents without in-home cooling. These organizations are compensated for temporarily housing affected individuals and families.
Further Details: **https://www.mapc.org/resource-library/extreme-heat-resources/**	

North Carolina Climate and Health Program	
Description:	The US CDC has issued a grant to North Carolina through the Climate-Ready States and Cities Initiative to operate the North Carolina Climate and Health program. The program "aims to serve elementary school students, farmworkers, local public health preparedness and emergency management staff, low-income earners, older adults requiring nutritional support, and young adults attending county parks”.
State:	North Carolina
Hazard(s) Addressed:	Extreme Heat
Lead Agency:	North Carolina Department of Health and Human Services
Funding:	
Status:	Ongoing
Comments:	The program has implemented heat-related illness syndromic surveillance and heat health alert systems in several counties across the state.
Further Details: **https://www.cdc.gov/climateandhealth/climate_ready.htm**	

New York City Heat Island Mapping	
Description:	New York City has participated in heat island mapping exercises. Factors included air pollution, human health, and nighttime cooling. There is greater risk to those at risk for severe Covid symptoms. After the heat island mapping exercise, NYC launched the NYC CoolRoofs program, an effort to train workers and install energy-saving reflective rooftops. The program also funds street tree planting in vulnerable neighborhoods.
State:	New York
Hazard(s) Addressed:	Extreme Heat
Lead Agency:	New York City Council
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://council.nyc.gov/data/heat/	

California Extreme Heat Worker Protections	
Description:	California utilizes legislation to protect workers from extreme heat and heat related illness while on the job. The law includes provisions for workers that mandate easy access to water, access to shade, new procedures for high heat days, emergency procedures, acclimatization, and training. Partial exemptions are provided for a number of industries including agriculture, construction, landscaping, and oil and gas extraction. Employers create an effective heat illness prevention plan. High-heat procedures are required above 95 degrees.
State:	California
Hazard(s) Addressed:	Extreme Heat
Lead Agency:	California Division of Occupational Safety and Health
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.dir.ca.gov/title8/3395.html**	

F.7 Flooding

Pennsylvania Flood Planning	
Description:	The Pennsylvania Department of Environmental Protection: Bureau of Waterways Engineering and Wetlands provides financial and technical assistance to various municipal sponsors to reduce the impact of floods or prevent floods entirely. The program includes funding for investigation of areas at risk for flooding and evaluating long-term solutions to flooding. This includes assessments of the magnitude and frequency of flooding, performing hydraulic analysis, evaluating flood control alternatives, estimating costs, assessing environmental impacts, performing a cost/benefit analysis, defining sponsors, and beginning to preparing designs. Protections may include concrete channels, concrete floodwalls, compacted earthen levees, channel improvements, or other alternatives Pennsylvania law encourages every community to participate in NFIP. Communities that choose not to participate in NFIP are ineligible for hazard mitigation non-disaster funds or other disaster funding streams.
State:	Pennsylvania
Hazard(s) Addressed:	Flooding
Lead Agency:	Pennsylvania Department of Environmental Protection
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.dep.pa.gov/Business/Water/Waterways/Flood-Protection/Pages/default.aspx**	

Florida Flood Protection Level of Service Program	
Description:	Parts of Florida utilize the Flood Protection Level of Service Program. This is an in-depth, regimented program dedicated to prioritizing flood mitigation projects in South Florida. The program utilizes Adaptive Resilience Planning to determine which mitigation actions are appropriate for flood-prone areas considering uncertain future conditions.
State:	Florida
Hazard(s) Addressed:	Flooding
Lead Agency:	South Florida Water Management District
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.sfwmd.gov/our-work/flood-protection-level-service#:~:text=The%20FPLOS%20program%20ensures%20a,additional%20%242%20million%20a%20year.**	

Florida QuickGuide for Floodplain Management	
Description:	Florida has a QuickGuide available to communities for their use in explaining floodplain management concepts at the permit counter.
State:	Florida
Hazard(s) Addressed:	Flooding
Lead Agency:	Florida Division of Emergency Management
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.floridadisaster.org/contentassets/5a671dfdfadf45ab9a2c61635e2a4fed/quick-guide-for-floodplain-management.pdf	

Florida State Assistance Information Hotline	
Description:	The Florida State Assistance Information Line is a toll-free hotline available for residents in the event of a flood, hurricane, or other disaster. Contacting the line will provide information on: "How to prepare before/during/after a hurricane, road closures and alternate routes, available/open shelters in host or impacted counties, shelters designed for special needs patients, hotels and motels that accept pets, boaters instructions for moving watercraft to safer ground, and re-entry information once it is safe to return to the affected area."
State:	Florida
Hazard(s) Addressed:	Flooding
Lead Agency:	Florida Division of Emergency Management
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.floridadisaster.org/planprepare/information-line/	

Florida Building Code	
Description:	The Florida Building Code is more strict than NFIP requirements and applicable statewide, regardless of the participation status of a community in the NFIP.
State:	Florida
Hazard(s) Addressed:	Flooding
Lead Agency:	Florida Department of Business and Professional Regulation
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://floridabuilding.org/c/default.aspx**	

Floodplain Administration Documents	
Description:	Many customized assistance documents for local floodplain administrators (guidance, ordinance amendment language and sample forms) available online from FDEM.
State:	Florida
Hazard(s) Addressed:	Flooding
Lead Agency:	Florida Division of Emergency Management
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.floridadisaster.org/dem/mitigation/floodplain/community-resources/	

F.8 Hurricanes

Maryland Block Grant Program	
Description:	The Maryland Department of Housing and Community Development provides funds for vulnerable communities in the event of a hurricane through the Community Development Block Grant Disaster Recovery Assistance program. Grants were issued by Congress in response to Hurricane Sandy. Maryland used all funds for recovery activities in the worst hit counties.
State:	Maryland
Hazard(s) Addressed:	Hurricanes
Lead Agency:	Maryland Department of Housing and Community Development
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://dhcd.maryland.gov/Communities/Pages/cdbg/CDBGSandyDisasterRecovery.aspx	

North Carolina Hurricane Preparedness	
Description:	The North Carolina Department of Public Safety partners with the National Weather Service to host an annual Hurricane Preparedness Week, a series of meetings and associated resources outlining how to prepare for hurricanes. One focus area of the awareness week is on people with disabilities, how these individuals should prepare for hurricanes, and how to accommodate people with disabilities in the event of evacuations.
State:	North Carolina
Hazard(s) Addressed:	Hurricanes
Lead Agency:	North Carolina Department of Public Safety
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.weather.gov/ilm/hurricaneprepnc	

NC State Centric Hazard Mitigation Pilot Program	
Description:	North Carolina also utilizes a State Centric Hazard Mitigation Pilot Program the first of its kind for FEMA HMGP, that allows the state to manage and pay for contract work to complete all grants awarded, and assists the counties by removing the financial and management burden of completing all the work awarded under each grant. What's more, the local government does not lose the management costs paid to the local government under the grant agreement. It only speeds the process for homeowners in need by centralizing the project management.
State:	North Carolina, Flooding, Others
Hazard(s) Addressed:	Hurricanes
Lead Agency:	North Carolina Department of Public Safety
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.ncdps.gov/our-organization/emergency-management/disaster-recovery/hazard-mitigation/state-centric-hazard	

Florida Hurricane Program	
Description:	The Florida Division of Emergency Management created the Hurricane Loss Mitigation Program that funds mitigation projects. Projects include retrofits to residential, commercial, and mobile home properties, increased public education programs, and hurricane research activities.
State:	Florida
Hazard(s) Addressed:	Hurricanes
Lead Agency:	Florida Division of Emergency Management
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.floridadisaster.org/dem/mitigation/hurricane-loss-mitigation-program/**	

Florida Hurricane Program	
Description:	Florida funds the Florida International University International Hurricane Research Center (IHRC). The IHRC focuses on research that reduces hurricane damage and loss of life through more effective mitigation.
State:	Florida
Hazard(s) Addressed:	Hurricanes
Lead Agency:	Florida International University
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.ihrc.fiu.edu/	

F.9 Impoundment Failure

Private Dam Financial Assurance Program

Description:	The Pennsylvania Department of Community and Economic Development administers the Private Dam Financial Assurance Program to ensure private dams meet and maintain safety standards. The loan amount cannot exceed 50% of the eligible project costs or $500,000, whichever is less. Eligible dam owners are anyone who owns, controls, operates, maintains, or manages a regulated private dam and is enrolled in the Private Dam Financial Assurance Program. This assistance largely takes the form of low interest loans for eligible dams.
State:	Pennsylvania
Hazard(s) Addressed:	Impoundment Failure
Lead Agency:	Pennsylvania Department of Community and Economic Development
Funding:	
Status:	Ongoing
Comments:	Virginia operates a similar program through the Department of Conservation and recreation, but with more strict eligibility requirements than the Pennsylvania program.

Further Details:

https://dced.pa.gov/programs/private-dam-financial-assurance-program-pdfap/

https://www.dep.pa.gov/Business/Water/Waterways/DamSafety/Pages/default.aspx

https://www.dcr.virginia.gov/dam-safety-and-floodplains/dsfpm-grants

Pennsylvania Dam Safety Program

Description:	Pennsylvania DEP includes several mitigation strategies in the Dam Safety Program, including several regulations (The Dam Safety & Encroachments Act; The Pennsylvania Dam Safety and Waterway Management Code; The Run-of-the-River Dam Act, and Hazards on the Water Fact Sheet), dam inspection guidelines and cadence, and permit management.
State:	Pennsylvania
Hazard(s) Addressed:	Impoundment Failure
Lead Agency:	Pennsylvania Department of Environmental Protection
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.dep.pa.gov/Business/Water/Waterways/DamSafety/Pages/default.aspx**	

Maryland Dam Breach Analysis	
Description:	The Maryland Department of the Environment provides several Dam Breach Analysis resources, including providing modeling software and other programs to outline dam performance and stress testing for dam safety. These include analysis methods for small ponds and dams, earthen dams, flooding, spillway, riser, and other hydrology approaches.
State:	Maryland
Hazard(s) Addressed:	Impoundment Failure
Lead Agency:	Maryland Department of the Environment
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://mde.maryland.gov/programs/water/damsafety/pages/dambreakguidelines.aspx**	

Massachusetts Dam Removal	
Description:	The Massachusetts Division of Ecological Restoration provides resources to help dam owners remove old, damaged, or outdated dams. The office manages the requirements for dam safety and maintains documentation of dam design documents. Dam owners must submit reports to the Office of Dam Safety. The Massachusetts Division of Ecological Restoration provides resources to help dam owners remove old, damaged, or outdated dams. The MA DER outlines the circumstances in which an individual would want to remove a dam, such as when maintenance costs are too high, legal liability changes, or the cost of repair is greater than the value of the dam. Further considerations are ecological – the DER can assess if a small dam is impacting local water quality as part of its process for determining which projects are funded. Massachusetts offers several programs that can assist with dam removal, including the "Dam and Seawall Repair or Removal Program, the Massachusetts Environmental Trust (MET) Grant Program, the Municipal Vulnerability Preparedness (MVP) Program, and DER's Priority Projects Program." The Priority Projects program is the only grant program administered by the MA DER, but the DER will work with applicants to secure other funding resources as necessary
State:	Massachusetts
Hazard(s) Addressed:	Impoundment Failure
Lead Agency:	Massachusetts Office of Dam Safety
Funding:	
Status:	Ongoing
Comments:	

Further Details:

https://www.mass.gov/river-restoration-dam-removal#:~:text=The%20Division%20of%20Ecological%20Restoration,Become%20a%20DER%20Priority%20Project%E2%80%9D.

Texas Dam Safety	
Description:	The Texas Commission on Environmental Quality manages a Dam Safety Program, specifically Dam Safety Workshops for Owners and Operators. These workshops assist owners and operators with understanding dam safety laws and regulations and enforcement, emergency action plans and maintenance issues for all areas on a dam, recommendations for correction, and results of the probable maximum precipitation study.
State:	Texas
Hazard(s) Addressed:	Impoundment Failure
Lead Agency:	Texas Commission on Environmental Quality
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.tceq.texas.gov/compliance/investigation/damsafetyprog.html#:~:text=The%20Dam%20Safety%20Program%20monitors,help%20them%20maintain%20safe%20facilities**.	

F.10 Karst (Sinkholes)

Pennsylvania Sinkhole Data	
Description:	The Pennsylvania Department of Conservation and Natural Resources provides resources for individuals who may have seen or been affected by a sinkhole. These include educational resources on: geological and human activities contributing to sinkholes, safety, repair, and prevention.
State:	Pennsylvania
Hazard(s) Addressed:	Karst (Sinkholes)
Lead Agency:	Pennsylvania Department of Conservation and Natural Resources
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.gis.dcnr.state.pa.us/pageode/ https://www.dcnr.pa.gov/Geology/GeologicHazards/Sinkholes/Pages/default.aspx	

Maryland Geological Survey	
Description:	The Maryland Geological Survey produces a step-by-step guide for individuals outlining what to do if one suspects they have encountered a sinkhole. The guide is available online, distributed through the Maryland Geological Survey newsletter, and in a series of videos posted to the MGS website. The article provides links for reporting sinkholes and contact information for the appropriate state and local agencies.
State:	Maryland
Hazard(s) Addressed:	Karst (Sinkholes)
Lead Agency:	Maryland Geological Survey
Funding:	
Status:	Ongoing
Comments:	
Further Details: http://www.mgs.md.gov/geology/geohazards/sinkhole_resources.html	

F.11 Landslides

Introduction to Landslides in North Carolina	
Description:	The North Carolina Department of Environmental Quality publishes worksheets and press releases on how to identify and respond to landslide conditions. NCDEQ hosts this information on a webpage that includes links to historical data, information on rock slope stability, and the increased risk of landslides during hurricanes or other severe weather events.
State:	North Carolina
Hazard(s) Addressed:	Landslides
Lead Agency:	North Carolina Department of Environmental Quality
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://deq.nc.gov/about/divisions/energy-mineral-and-land-resources/north-carolina-geological-survey/geologic-hazards/landslides**	

California Landslide Mapping	
Description:	The California Department of Conservation performs routine landslide mapping activities through the Seismic Hazards Program. New buildings, mines, and other construction activities are required to submit geotechnical reports on the land to the State Geologist. This data is added to the state geotechnical database and hazard maps.
State:	California
Hazard(s) Addressed:	Landslides
Lead Agency:	California Department of Conservation
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.conservation.ca.gov/cgs/sh/program#:~:text=The%20Seismic%20Hazards%20Program%20delineates,fault%20rupture%2C%20and%20tsunami%20inundation.**	

National Landslide Hazard Mitigation Strategy	
Description:	The United States Geological Survey maintains the "National Landslide Hazards Mitigation Strategy." Recommendations include: • Research - Developing a predictive understanding of landslide processes and triggering mechanisms • Hazard mapping and assessments - Delineating susceptible areas and different types of landslide hazards at a scale useful for planning and decision making • Real-time monitoring - Monitoring active landslides that pose substantial risk • Loss assessment - Compiling and evaluating information on the economic impacts of landslide hazards • Data Collection - Information collection, interpretation, and dissemination • Guidelines and training - Developing guidelines and training for scientists, engineers, and decisionmakers • Public awareness and education - Developing information and education for the user community • Implementation of loss reduction measures - Encouraging mitigation action • Emergency preparedness, response, and recovery - Building resilient communities
State:	Federal
Hazard(s) Addressed:	Landslides
Lead Agency:	United State Geological Survey
Funding:	
Status:	Ongoing
Comments:	

Further Details: **https://www.conservation.ca.gov/cgs/sh/program#:~:text=The%20Seismic%20Hazards%20Program%20delineates,fault%20rupture%2C%20and%20tsunami%20inundation.**

F.12 Land Subsidence

Pennsylvania Mine Subsidence Insurance	
Description:	Pennsylvania offers Mine Subsidence Insurance. Residential Coverage of $150,000 costs $41.25 a year. Depending on subsidence risk levels, coverage of up to $1,000,000 is available. The Pennsylvania Department of Environmental Protection administers the MSI program, providing an online portal to connect consumers with insurance providers. Private insurers apply to the PA DEP to become registered sellers of mine subsidence insurance. The MSI program publishes sales kits of the individual insurance providers and provides tips & tools to the insurance providers to maximize the return of sales efforts. The program provides information to homeowners, indicating which properties are located on top of abandoned mines
State:	Pennsylvania
Hazard(s) Addressed:	Land Subsidence
Lead Agency:	The Pennsylvania Department of Environmental Protection
Funding:	Agency Funds, Cost Sharing
Status:	Ongoing
Comments:	
Further Details: **https://www.dep.pa.gov/Citizens/MSI/Pages/default.aspx**	

Maryland Land Subsidence Monitoring Network	
Description:	The Maryland Geological Survey maintains the Land Subsidence Monitoring Network, a service that monitors land subsidence in at-risk areas of Maryland, especially near the Chesapeake Bay. The focus of the program is on isolating vertical land motion attributed to human activities (such as groundwater withdrawal). Data is gathered and analyzed annually.
State:	Maryland
Hazard(s) Addressed:	Land Subsidence
Lead Agency:	The Maryland Geological Survey, USGS
Funding:	
Status:	Ongoing
Comments:	
Further Details: **http://www.mgs.md.gov/groundwater/current/land_subsidence.html**	

California Aqueduct Subsidence Program	
Description:	The California Department of Water Resources manages the California Aqueduct Subsidence Program. The program studies areas at risk of subsidence due to aqueduct levels as part of the State Water Project. This projected yielded reports on areas at risk of damage due to aqueduct subsidence.
State:	California
Hazard(s) Addressed:	Land Subsidence
Lead Agency:	The California Department of Water Resources
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://water.ca.gov/Programs/Engineering-And-Construction/Subsidence**	

F.13 Non-Tornadic Wind

Nebraska Severe Weather Preparedness Guide	
Description:	The Nebraska Emergency Management Agency releases a Spring and Summer Severe Weather Preparedness Guide. While this largely focuses on thunderstorms and tornados, it also presents tips for other high-wind events such as how to identify and take action before a thunderstorm.
State:	Nebraska
Hazard(s) Addressed:	Non-Tornadic Wind
Lead Agency:	The Nebraska Emergency Management Agency
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://nema.nebraska.gov/operations/spring-and-summer-severe-weather-preparedness**	

Farming in Challenging Times Roundtable	
Description:	The Farming in Challenging Times roundtable recommends maintaining up-to-date insurance policies, paying particular focus to the age and structural integrity of properties. Further considerations include proximity to trees, fences, and electrical wiring.
State:	Private Sector
Hazard(s) Addressed:	Non-Tornadic Wind
Lead Agency:	Nationwide Insurance
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://www.agweb.com/news/business/farmland/derecho-response-wind-and-storm-mitigation-your-farm	

NOAA Guidelines	
Description:	NOAA recommends that individuals set aside emergency supplies such as food, water, batteries, and flashlights when high-wind conditions are expected. Further, power outages and infrastructure damage may make it difficult to reach gasoline for transportation and to power generators.
State:	Federal
Hazard(s) Addressed:	Non-Tornadic Wind
Lead Agency:	National Oceanic and Atmospheric Administration
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.spc.noaa.gov/misc/AbtDerechos/derechofaq.htm**	

Center for Disaster Philanthropy	
Description:	The Center for Disaster Philanthropy provides information on how to recover from high-wind and derecho conditions. Low-cost short and long-term housing is needed to support those with no familial support in affected areas. Mental health services are necessary to support the long-term resilience of affected regions.
State:	Private Organization
Hazard(s) Addressed:	Non-Tornadic Wind
Lead Agency:	The Center for Disaster Philanthropy
Funding:	
Status:	Ongoing
Comments:	
Further Details: https://disasterphilanthropy.org/disasters/midwest-derecho/	

Iowa State University Lessons Learned	
Description:	Iowa State University provides a set of lessons-learned from derecho tree breaks and has outlined recommendations for preventing and reducing damage due to treefalls. When planting trees on a new site, select species that are native to the area. Engage in proper tree-pruning practices to increase tree strength and health. Utilize proper planting techniques, including site prep, correct depth of planting, appropriate planting times, and post-planting maintenance activities. Constantly assess the health and quality of trees, inspecting for damage, disease, or other abnormalities.
State:	Iowa
Hazard(s) Addressed:	Non-Tornadic Wind
Lead Agency:	Iowa State University
Funding:	
Status:	Ongoing
Comments:	Virginia may consider utilizing these recommendations as instructions for residents and other organizations.
Further Details: **https://www.spc.noaa.gov/misc/AbtDerechos/derechofaq.htm**	

F.14 Pandemic

Maryland Communicable Disease Program	
Description:	The Maryland Department of Health Infectious Disease Bureau utilizes the Communicable Disease Program, which provides free immunizations, screenings, and treatments to eligible populations. These services are managed at the state level but administered by local health departments. The program also conducts disease surveillance and provides educational resources.
State:	Maryland
Hazard(s) Addressed:	Pandemics
Lead Agency:	Maryland Department of Health, Infectious Disease Bureau
Funding:	
Status:	Ongoing
Comments:	The Virginia Department of Health provides several similar services, including immunization for tuberculosis and some STIs. Some major gaps include HIV treatment and care, Adult Viral Hepatitis prevention, and a center for Zoonotic and Vector-borne Diseases.
Further Details: **https://health.maryland.gov/phpa/pages/infectious-disease.aspx**	

Massachusetts Disease Control & Prevention Resources	
Description:	The Massachusetts Health & Social Services Disease Control and Prevention program maintains a set of resources available to residents, distributed online and through pamphlets given to healthcare providers. Resources include information and fact sheets on infectious diseases, data on flu seasons, Asthma risks, tick-borne diseases, risk factor surveillance, and information on cancer & cancer screenings.
State:	Massachusetts
Hazard(s) Addressed:	Pandemics
Lead Agency:	Massachusetts Department of Health & Social Services
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.mass.gov/topics/disease-control-prevention**	

North Carolina Safety Net Dental Clinics	
Description:	The North Carolina Department of Health and Human services maintains a list of Safety Net Dental Clinics for low-income individuals. Eligibility varies across clinics. Covered services include fluoride mouth rinse and dental sealant projects; dental assessments, screenings, and referrals; education services; and consultation services. Further, the program includes a focus on perinatal oral health to improve the overall standard of care during pregnancy. Additionally, the N.C. Oral Health Section helped local agencies to expand and maintain their Safety Net Dental Clinics.
State:	North Carolina
Hazard(s) Addressed:	Pandemics
Lead Agency:	North Carolina Department of Health and Human Services, Division of Public Health
Funding:	
Status:	Ongoing
Comments:	While not a direct pandemic mitigation, increasing access to care and reducing disparities in health is a way to mitigate the impacts of a pandemic scenario. Virginia has Safety Net clinics, including dental clinics, but lacks the targeted publicity campaign of North Carolina.
Further Details: **https://www.dph.ncdhhs.gov/oralhealth/services/safety-net.htm** **https://www.vhcf.org/who-and-how-we-help/medical/health-safety-net-providers/**	

F.15 Tornado

Pennsylvania StormReady Participation

Description:	The National Weather Service administers the StormReady service, which outlines a set of activities that a county must perform to attain StormReady Status, helping communities establish plans of action to prevent damage and recover from severe weather, including tornadoes. Pennsylvania has pushed for all counties in the state to reach the "StormReady" status, and is one of six states to have all counties participating. PEMA actively encourages cities and counties to participate in the program.
State:	Pennsylvania
Hazard(s) Addressed:	Tornado, Hurricanes, Flooding, Non-Tornadic Wind
Lead Agency:	National Weather Service, Pennsylvania Emergency Management Agency
Funding:	
Status:	Ongoing
Comments:	

Further Details:

https://www.weather.gov/StormReady

https://www.ready.pa.gov/pages/stormready.aspx

Oklahoma SoonerSafe Safe Room Rebate

Description:	The Oklahoma Office of Emergency Management operates the SoonerSafe Safe Room Rebate program that provides reimbursement for homeowners that install tornado shelters. The safe rooms may be installed in new or existing homes, in interior rooms or under the first floor of the home, or a detached above-ground safe room within 100 feet of the home. The program is funded through HMGP funds, with a maximum rebate of $2,000 and not exceeding 75% of the actual cost of the safe room. Oklahoma law allows for 100 sq. ft. of new safe room to be exempt from property taxation. Only residential single-family homes are eligible; mobile home owners are eligible for single safe room only.
State:	Pennsylvania
Hazard(s) Addressed:	Tornado
Lead Agency:	Oklahoma Department of Emergency Management and Homeland Security
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://oklahoma.gov/oem/programs-and-services/soonersafe-safe-room-rebate-program.html**	

F.16 Wildfires

Community Wildfire Prevention Grants Program	
Description:	The Wildfire Prevention Grants Program seeks to reduce the risk factors associated with wildfires. The grants can be used to clear debris and brush, reduce the presence of other hazardous fuels, develop community plans for wildfire mitigation, and provide educational materials. Organizations or communities may apply for grants for hazardous fuels reduction, wildfire prevention planning, wildfire education, and forest health revitalization projects.
State:	California
Hazard(s) Addressed:	Wildfires
Lead Agency:	The Department of Forestry and Fire Protection
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.fire.ca.gov/grants/wildfire-prevention-grants/**	

Colorado Strategic Wildfire Action Program (COSWAP)	
Description:	COSWAP funds workforce development for combating wildfires, the creation of State Wildland Inmate Fire Teams (SWIFT), investment into landscape resilience, projects, and establishing state, local, and commercial partnerships to fund future mitigation projects. The COSWAP program funds workforce development grants for training teams to prevent and combat wildfires. COSWAP also assesses the state for Strategic Focus Areas – regions of Colorado that are at particularly high risk of wildfire damage. Colorado Correctional Industries (CCi) contributes wildland fire teams. The SWIFT crews are housed at various correctional facilities in Colorado. Currently, the base locations are at the Four Mile Correctional Center in Canon City, the Rifle Correctional Center in Rifle and the Buena Vista Correctional Center in Buena Vista, Colorado. CCi makes SWIFT crews available to Colorado State Forest Service (CSFS) and other agencies to assist in fighting fires within Colorado by dispatch through normal dispatch centers. CSFS has routinely provided a crew liaison when crews have been dispatched to wildland fires. The crews are self-sufficient and come with supervisors, basic tools and equipment, and transportation. To ensure that the crews function well, the personnel train together and are maintained as crews throughout the year. They are available year-round for assistance with non-fire, woods-related programs and projects.
State:	Colorado
Hazard(s) Addressed:	Wildfires
Lead Agency:	Colorado Department of Natural Resources, Colorado Correctional Industries
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://dnr.colorado.gov/divisions/forestry/co-strategic-wildfire-action-program**	

F.17 Winter Weather

New York Winter Preparedness Guide	
Description:	The New York Winter Preparedness Guide is an online resource that provides information on energy pricing, consumer protections, tips for managing heating costs, tips for energy conservation, and data about winter safety such as how to properly use heaters. The tool also provides links to other services such as efficient energy programs, home energy assessments, federal and local bill assistance programs, community workshops, and legal assistance.
State:	New York
Hazard(s) Addressed:	Winter Weather, Extreme Cold
Lead Agency:	New York Department of Public Service
Funding:	
Status:	Ongoing
Comments:	The guide focuses on the legal rights of residents to regarding utility shutoffs, limits to fuel price changes, and payment programs.
Further Details: https://www3.dps.ny.gov/W/AskPSC.nsf/All/2A2468643DFEC059852581CB005C16A8?OpenDocument	

Wisconsin Electronic Disease Surveillance System

Description:	The Wisconsin Department of Health Services administers the Wisconsin Electronic Disease Surveillance System (WEDSS), a web-based syndromic surveillance system that collects and processes data from several clinical systems. This system assists public health officials to better assess the impacts of, for example, cold snaps and infectious disease. This improves resource deployment during disaster events. The program also funds interactive courses for public health staff, clinical laboratories, clinics, and other disease reporters.
State:	Wisconsin
Hazard(s) Addressed:	Pandemics, Winter Weather, Extreme Cold
Lead Agency:	Wisconsin Department of Health Services
Funding:	
Status:	Ongoing
Comments:	Health care providers are legally compelled to report any patient they treat who is suspected of having a communicable disease.
Further Details: https://www.dhs.wisconsin.gov/wiphin/wedss.htm	

California Wildfire Mitigation Program (CWMP)

Description:	The California Office of Emergency Services administers the California Wildfire Mitigation Program. Homes at risk of wildfire damage are eligible for grants to be hardened and retrofitted to resist wildfires. This includes building with flame resistant materials, redeveloping land to resist fire, and development of defensible space. Homeowners apply for the grant online. Socially vulnerable populations such as residents over 65, in poverty, living with disabilities, with limited English, or without vehicles are prioritized. Homes in high-risk areas are also given precedence over lower-risk homes.
State:	California
Hazard(s) Addressed:	Wildfires
Lead Agency:	California Office of Emergency Services, California Department of Forestry and Fire Protection
Funding:	
Status:	Ongoing
Comments:	
Further Details: **https://www.caloes.ca.gov/cal-oes-divisions/recovery/disaster-mitigation-technical-support/california-wildfire-mitigation-program**	

Appendix G:

Training Workshop Attendance Records

Workshop Attendance

Workshop	Attendees
G393, February 2018	Christopher Dean
	Andy John
	Colten Lotts
	Danielle Progen
	Jonathan Simmons
	Regan Underwood
G393, July 2018	Courtney Hose
	Brian Russell
	Justin Weston
G329, September 2021	Trina Addison
	Briant Atkins
	Michael Barber
	Chris Bruce
	Amy Howard
	Alexander Krupp
	Debbie Messmer
	Rich Mortimer
E0276, August 2018	Trina Addison
	Robin Bellamy
	Lewis Campbell
	James Canning
	Sharon Chamberlin
	Danielle DeHart
	Alex Eguiguren
	Marie Grant
	Paul Helmuth
	Kim Hobert
	Amy Howard
	Cam Johnson
	Katie Kitzmiller
	Kaleen Lawsure
	Brian Lichty
	Debra Messmer
	Tonya O'Connell
	Lindsey Olinger
	Lisa Perry
	Jennifer Peterman
	Sheila Reeves
	Derrick Ruble
	Liz Scheessele
	Bruce Schwenneker
	Stuart Spatz
	Christy Straight
	Maribel Street
	Laura Tessier
	Horace Wade III
Hazard Mitigation Pre-Application Assistance, 2018	Steve Dishman
	Richard Hartman
	Richard Mortimer
	Michael Pruitt
	Steven Pyle
	Jonathan Simmons
	Jessica Beverley
	Linda Botts
	Sharon Chamberlin
	Christina Condon
	William Crawford
	Todd Fortune
	Charles Grant

Workshop	Attendees
	Michael Guzo
	Mary Sands
	Harold Smith
	Glenn Wells
	Trina Addison
	Robin Bellamy
	Susan Collins
	Christina Condon
	Dwayne D'Ardenne
	Allison Farole
	David Garris
	Marie Grant
	Jared Hoernig
	David Hudson
	Katie Kitzmiller
	Natalie Mackie
	Gene Reams
	Sheila Reeves
	Amanda Reidelbach
	Thomas Roberts
	John Sadler
	Maribel Street
	Laura Tessier
	Deidra Winterburn
	Denise Wyatt
Hazard Mitigation Application Assistance, 2018	Robin Bellamy
	Justin Haga
	Sheila Reeves
	Mary Sands
	Gene Stewart
	Maribel Street
	Laura Tessier
	Michael Dodson
	Robert Gelormine
	Gwendolyn Pointer
	Harold Smith
	Kimberley Tempesco
	Kathryn Archie
	Sharon Chamberlin
	Dwayne D'Ardenne
	Steve Dishman
	Jack Ellinwood
	Todd Fortune
	Robert Gelormine
	Paul Helmuth
	Jared Hoernig
	Richard Mortimer
	Steven Pyle
	Amanda Reidelbach
	Mohammad Shar
	Lucy Carter Smith
	Leigh Anne Weitzenfeld
Hazard Mitigation Assistance Stakeholder Workshop, August 20, 2020	
	Trina Addison
	Forest Andrews
	Jeff Berger
	Chris Bruce
	Robbie Coates
	Gine Diccico
	Jenna Dunn
	Lisa Foley

Workshop	Attendees
	Doug Gagnon
	Sara Harrington
	Matt Heller
	Amy Howard
	Catherine Hughes
	Whitney Katchmark
	Jake Kezele
	Kaleen Lawsure
	Steve Lynd
	Debbie Messmer
	Katie Moody
	Seamus Mooney
	Kristin Owen
	Gwen Pointer
	Mike Pruitt
	Theresa Scott
	Jonathan Simmons
	Debbie Smith
	Marc Stone
	Jessica Swinney
	Kim Tempesco
	James Turner

Appendix H:

VDEM Administrative Plan

Administrative Plan

4644-DR-VA, Virginia Severe Winter Storm and Snowstorm

Incident Period: Jan. 2, 2022 – Jan. 3, 2022
Declared: March 11, 2022

Contents

1) EVENT DETAILS

The President declared on March 11,2022 that a major disaster exists in the Commonwealth of Virginia. This declaration was based on the severe winter and snowstorm beginning on January 2, 2022, through January 3, 2022.

Timeline of events:

Incident Period	Jan. 2, 2022 – Jan 3, 2022	Commonwealth of Virginia Severe Winter Storm and Snowstorm
Major Declaration DR-4644-VA	March 3, 2022 (Governor) March 11, 2022 (President)	On March 3, 2022, The Commonwealth of Virginia Governor Glenn Youngkin requested a major disaster declaration due to a severe winter storm and snowstorm. The Governor requested a declaration for Public Assistance for 28 areas, snow assistance for two areas, and Hazard Mitigation for the entire Commonwealth due to the severity and magnitude of the disaster being beyond the capabilities of the Commonwealth. On March 11, 2022, President Biden declared that a major disaster did exist in the Commonwealth of Virginia. This declaration made the Public Assistance requested by the Governor through Federal funding is available to the state, eligible local and tribal governments and certain private nonprofit organizations on a cost-sharing basis for emergency work and the repair or replacement of facilities in Albemarle, Amelia, Appomattox, Bedford, Buckingham, Caroline, Charlotte, Culpeper, Cumberland, Essex, Fauquier, Fluvanna, Goochland, Greene, Hanover, King George, King William, Louisa, Madison, Nelson, Orange, Powhatan, Prince Edward, Rappahannock, Spotsylvania, Stafford and Westmoreland counties and the independent City of Fredericksburg.

2) PURPOSE

This appendix establishes the procedures for administration of the Hazard Mitigation Grant Program (HMGP) and for project management of the mitigation measures to be funded under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (the Act) as amended. It also establishes an independent grant program for hazard mitigation and is closely tied to the post-disaster hazard mitigation plan required by Section 322 of the Act as a condition of assistance. This Plan outlines the administrative procedures for the Hazard Mitigation Grant Program (HMGP) for DR-4644-VA. The intent of this plan is to:

- Outline the basic administrative procedures for the HMGP;
- Establish basic responsibilities between the Commonwealth of Virginia, The Virginia Department of Emergency Management (VDEM), and the Federal Emergency Management Agency (FEMA) and;
- Provide an easy-to-read document detailing how the HMGP is administered within the Commonwealth of Virginia for a disaster declaration.

The Virginia Department of Emergency Management (VDEM) will update this plan as necessary to include all relevant procedural changes throughout the Period of Performance (POP) of this disaster program.

VDEM has incorporated this plan into the Commonwealth of Virginia's Standard Hazard Mitigation Plan as an appendix and incorporated the Standard Hazard Mitigation Plan into the Commonwealth of Virginia Emergency Operations Plan (EOP). FEMA approved the Commonwealth's Standard Hazard Mitigation Plan on March 11, 2018, and it will expire on March 11, 2023.

The Commonwealth of Virginia has established an interagency mitigation team that contributes to the identification of the hazards the Commonwealth is in jeopardy of facing, as well as the revision process and implementation of the Commonwealth of Virginia's Standard Hazard Mitigation Plan. The team includes the following:

- Department of Emergency Management.
- Department of Environmental Quality.
- Department of Agriculture and Consumer Services.
- Department of Transportation.
- Department of Health.
- Department of Conservation and Recreation
- Department of Forestry.
- Department of Mines, Minerals and Energy.
- Department of Housing and Community Development.
- Department of Historic Resources.
- State Corporation Commission (Bureau of Insurance).

- Department of General Services

The Commonwealth of Virginia Standard Hazard Mitigation Plan designates the State Hazard Mitigation Officer (SHMO) as the responsible individual for matters related to HMGP for the Commonwealth of Virginia. The executed FEMA State Agreement (FSA) for this disaster declaration also documents this.

3) DECLARATION PROCESS

Following a major disaster event, the Governor of the Commonwealth of Virginia may seek Federal Financial Assistance by requesting a Presidential Declaration when the recovery process is beyond the capacity, capability, and resources of the Commonwealth of Virginia and local communities. The Presidential Declaration applies to specific counties and communities in the Commonwealth of Virginia; however, the opportunity to participate in HMGP is available to all within the Commonwealth of Virginia.

To participate, the Commonwealth of Virginia must provide a Letter of Intent (LOI) within 15 days of the disaster declaration that informs FEMA of the Commonwealth of Virginia's interest. If the Governor requests to use the HMGP in the declaration request, this satisfies the LOI requirement. FEMA may extend the 15-day Letter of Intent deadline after consideration of a formal extension request with justification from the Governor and approval given from the Regional Administrator.

4) RESPONSIBILITIES

The Federal Emergency Management Agency (FEMA) is responsible for the following activities:

- Appointing a Hazard Mitigation Lead for each disaster to manage and monitor hazard mitigation programs and activities;
- Informing the Commonwealth of Virginia of anticipated and final funding available by issuing a 30-day funding estimate, a 6-month funding estimate and then a final 12-month lock-in total;
- Assisting the Commonwealth of Virginia in setting priorities for the use of HMGP funds;
- Assisting the Commonwealth of Virginia with project applications, specifically Environmental and Historic Preservation (EHP), planning and floodplain management considerations and project cost effectiveness;
- Managing appropriate FEMA systems access;
- Reviewing and evaluating submitted applications or project summaries and the Commonwealth's determination of eligibility;
- Conducting EHP reviews resulting in decision documents based on information submitted by the subrecipient and the Commonwealth of Virginia.
- Coordinating with the Commonwealth of Virginia on the development and distribution of Hazard Mitigation Technical Assistance Program (HMTAP) task orders and related technical assistance reports;
- Coordinating with the Commonwealth of Virginia on the dissemination of Mitigation Outreach and Education materials;

- Notifying the Commonwealth of Virginia in writing of the approval or denial of project applications for funding;
- Notifying the Commonwealth of Virginia in writing of the approval or denial of changes in scope or extension of deadlines when requested;
- Performing programmatic and financial reviews as required by Federal Regulations;
- Ensuring that the Commonwealth of Virginia complies with all Federal laws, regulations, and guidance;
- Providing technical assistance to the Commonwealth of Virginia and local governments on mitigation activities;
- Coordinating with the Commonwealth of Virginia and local governments to ensure that mitigation commitments are fulfilled, and take action when necessary, including recovery of funds or denial of future funds if mitigation commitments are not fulfilled;
- Coordinating and conducting final reconciliation of project activities to close disaster funded projects; and
- Coordinating with the Commonwealth of Virginia to reconcile and close the overall disaster grant.

The Virginia Department of Emergency Management (VDEM) is responsible for the following activities:

- Acting as the recipient agency for the Commonwealth of Virginia to administer the Hazard Mitigation Grant Program (HMGP);
- Appointing a Commonwealth of Virginia State Hazard Mitigation Officer (SHMO), who serves as the point of contact for all matters related to Section 404 HMGP and Section 406, where appropriate;
- Ensuring the Commonwealth of Virginia has an approved Standard Hazard Mitigation Plan pursuant to 44 Code of Federal Regulations (C.F.R.) Part 201.4 in order to receive federal financial assistance under the Stafford Act;
- Coordinating with the appropriate interagency mitigation team members to revise the existing Commonwealth of Virginia Standard Hazard Mitigation Plan as required pursuant to 44 Code of Federal Regulations (C.F.R.) Part 201.4(d)
- Updating the Commonwealth of Virginia Section 404 Administrative Plan and submit to FEMA within 90 days of the date of the disaster declaration;
- Assisting staff at the local government/community to ensure Hazard Mitigation Plans are current and assisting with expired plans;
- Ensuring all of the Commonwealth of Virginia initiated actions or projects conform with the Commonwealth’s Standard Hazard Mitigation Plan under 44 C.F.R. § 201.4(c)(3)(iii) and § 201.5;
- Conducting a post-disaster assessment of the damages incurred and provide recommendations on updating relevant Local Mitigation Strategies with FEMA and local government participation;
- Providing a staffing plan within 120 days of the declaration of HMGP assistance being available that lists those staff positions and responsibilities to help administer the HMGP;
- Notifying affected entities of the availability of hazard mitigation grant funds.
- Scheduling and participating in HMGP applicant briefings to ensure that the invested parties and potential applicants are aware of the application requirements and procedures, program eligibility, and key deadlines;
- Collecting and managing all relevant documents related to the current disaster;
- Supplying additional information in a timely manner in response to Requests for Information (RFI);
- Managing appropriate FEMA systems access;

- Requesting and maximizing the use of Management Cost funding pursuant to FEMA Interim Policy $104-11-1;
- Coordinating all of the Commonwealth of Virginia and local responsibilities regarding hazard mitigation;
- Providing technical assistance to local governments and/or subrecipients as required and requested;
- Assisting applicants with project applications, specifically with Environmental and Historical Preservation (EHP) review requirements, planning, floodplain management, and project cost effectiveness considerations;
- Reviewing and evaluating submitted applications or project summaries and developing the Commonwealth of Virginia determination of eligibility for submission to FEMA;
- Managing HMGP funds;
- Assuring that the Subrecipient complies with all Federal and Commonwealth of Virginia laws, regulations, and guidance;
- Monitoring and submitting quarterly reports to FEMA;
- Ensuring applicants meet HMGP cost match requirements according to the project award documents;
- Sharing proper closeout procedures with subrecipients and ensuring that subrecipients follow these procedures;
- Maintaining documentation according to record retention policies outlined by the Commonwealth of Virginia.
- Determine staffing requirements and adjust as necessary following each declaration, based on the scope and magnitude of the disaster and available resources – 44 CFR 206.437(b)(3).
- VDEM has the authority to monitor for the conditions set in the grant agreement, investigate and address subrecipient non-compliance with grant requirements, and provide opportunities for the subrecipient to bring the grant into compliance (2CFR 200.207 and CFR 200.338).

The Subrecipient is responsible for the following activities:

- Participating in HMGP applicant briefings;
- Requesting technical assistance for application development when needed;
- Developing and submitting a project application with all required supporting documentation;
- Supplying additional information in a timely manner in response to Requests for Information (RFI);
- Complying with Environmental and Historic Preservation (EHP) review and determination requirements;
- Understanding and ensuring compliance with relevant Federal and Commonwealth of Virginia laws, regulations, and guidance;
- Complying and adhering to local licensing, permitting, and building code requirements;
- Requesting technical assistance for post award activity requirements when needed;
- Ensuring that work progresses according to the approved scope of work and the milestone schedule;
- Ensuring completion of project as awarded or requesting a change to the original award in a timely manner;
- Maintaining access to the Commonwealth of Virginia's grants management system(s);

- Completing and submitting quarterly reports on time with an accurate status of activities;
- Ensuring proper use of HMGP funds;
- Retaining appropriate documentation for monitoring or audit requests;
- Submitting a complete and timely closeout package;
- Maintaining documentation according to the federal record retention requirements in 2 CFR 200. 334.

5) PROGRAM ELIGIBILITY REQUIREMENTS

Eligible Applicants: (44 CFR Part 206.434(a)) The following are eligible to apply for the HMGP:

- State and Local governments, as defined at 44 CFR 206.2(16), who have an approved State or local Mitigation Plan;
- Private not-for-profit organizations, as defined at 44 CFR 206.221(f), that own or operate private not-for-profit facility as defined at 44 CFR 206.2219 (e);
- A qualified conservation organization, as defined at 44CFR 80.3(h), which is the only private not-for-profit organization eligible to apply for acquisition or relocation for open space projects. Houses of Worship are also included in this definition, per FEMA policy clarification dated May 2, 2018;
- Indian tribes or authorized tribal organizations.

The Virginia Department of Emergency Management (VDEM) will determine subrecipient eligibility.

Project Eligibility Criteria: (44 CFR Part 206.434(c)) "*Minimum project criteria*. To be eligible for the Hazard Mitigation Grant Program (HMGP), a project must:

- Conform with the Commonwealth of Virginia Mitigation Plan and Local Mitigation Plan approved under 44 CFR 201;
- Have a beneficial impact upon the designated disaster area, whether or not located in the designated area;
- Conform with 44 CFR Part 9, Floodplain Management and Protection of Wetlands, and Internal Directive 108.1;
- Solve a problem independently or constitute a functional portion of a solution where there is assurance that the project as a whole will be completed. Projects that merely identify or analyze hazards or problems are not eligible, although these could be considered for advanced assistance or planning projects.
- Be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering resulting from a major disaster. The recipient must demonstrate this by documenting that the project:
    - Addresses a problem that has been repetitive, or a problem that poses a significant risk to public health and safety if left unsolved,

- Will not cost more than the anticipated value of the reduction in both direct damages and subsequent negative impacts to the area if future disasters were to occur,
- Has been determined to be the most practical, effective, and environmentally sound alternative after consideration of a range of options,
- Contributes, to the extent practicable, to a long-term solution to the problem it is intended to address,
- Considers long-term changes to the area and entities it protects and has a manageable future maintenance and modification requirements."

6) NOTIFICATION PROCEDURES

Pre-Disaster Awareness Notification:

Methods for disseminating information to local governments concerning the HMGP include, but are not limited to, the following:

- Technical assistance to Local Mitigation Strategy Working Groups;
- Identification of the HMGP in the Hazard Recovery and Mitigation components of Local Government Comprehensive Emergency Management Plans and through the development of local mitigation strategies;
- Outreach by regular scheduled technical assistance visits (in-person or virtual) to local governments;
- Distribution of written information at meetings, through telephone requests, published information on the VDEM internet site, email, and other methods available;
- Explanation of the program at disaster assistance workshops, seminars, and meetings;
- Host Hazard Mitigation Plan Implementation and Grant Development (PIG-D) sessions to convey application requirements, eligible project types, application process, availability and use of Management Costs, Environmental & Historic Preservation requirements, and key deadlines.

Post-Disaster Notification:

In the aftermath of a disaster, the Commonwealth of Virginia may implement the following methods to notify eligible applicants:

- Verbal and/or written dissemination of information to local government officials during preliminary damage assessments visits;
- Verbal and/or written dissemination to Local Mitigation Strategy Working Groups;
- Letters and/or electronic mail to local governments;
- Identification of hazard mitigation issues at the initial Commonwealth of Virginia coordination meeting;
- An explanation and description of the program at the applicant's briefing for the Section 406 Public Assistance Program;
- Dissemination of information to affected local governments through press releases from the Public Information Officer (PIO);
- An explanation and description of the program at applicant briefings, Hazard Mitigation Plan Implementation and Grant Development (PIG-D) sessions or other methods for the HMGP to ensure the Commonwealth of Virginia provides potential applicants with information on the

application process, program eligibility, availability of Management Costs, Environmental & Historic Preservation requirements, and key deadlines;
- Use of county and city emergency managers to notify their respective jurisdictions and coordinate with local media;
- Notification to the appropriate regional planning councils and water management districts;

Complete applications must be submitted to VDEM by: October 15, 2022

- State Hazard Mitigation staff review prepare applications for review:
    - October 15, 2022, through February 24, 2023
- Virginia State Hazard Mitigation Application Team review applications:
    - February 24, 2023, through March 10, 2023
- State applications submitted to FEMA Region III (entered into NEMIS):
    - March 10, 2023

7) APPLICATION PROCEDURES

Application for Federal Assistance: The VDEM will submit a Standard Form 424 (SF-424), which includes HMGP, to FEMA within ninety (90) days of each disaster authorization or within the extended deadlines.

Amounts of Federal Financial Assistance: The total Federal contribution of funds is based on the estimated aggregate grant amount to be made under the Stafford Act for the major disaster (less associated administrative costs). FEMA will base the estimates of Federal assistance on the Regional Administrator's estimate of all eligible costs, actual grants, and appropriate mission assignments.

Every state, tribe, and territory that received a major disaster declaration in response to the severe winter storm and snowstorm will be eligible to receive 15% of those disaster costs to invest in mitigation projects that reduce risks from natural disasters.

Cost Sharing: All mitigation measures approved under the Commonwealth of Virginia grant will be subject to the cost sharing provisions established in the FEMA-State Agreement (FSA). FEMA may contribute up to 75-percent of the cost of measures approved for funding under the Hazard Mitigation Grant Program for major disasters declared on or after June 10, 1993. The non-federal share may exceed the Federal share. FEMA will not contribute to costs above the Federally approved estimate. The Commonwealth of Virginia is not obligated to provide match for this program. If the Commonwealth of Virginia does not accept the match responsibility, it is then a requirement of the eligible applicant to identify how the applicant will fund the match requirement. Eligible match/cost sharing options include but are not limited to cash match, in-kind, Global Match, Increased Cost of Compliance (ICC), Treasury Funds identified as losing their federal identity, and capital loans.

Application Period: The Commonwealth of Virginia will have 12-months from the date of the disaster declaration/authorization to submit all eligible HMGP project applications to FEMA for funding. The Commonwealth of Virginia will continually assess progress made in submitting project applications to determine if the Commonwealth of Virginia needs an extension. The Commonwealth of Virginia must submit any request for extension to FEMA at least sixty (60) days prior to project application deadline in accordance with 44 CFR 206.436(e).

- Application Period Extension: The Commonwealth of Virginia may request the Regional Administrator to extend the application time limit by 30 to 90-day increments, not to exceed a total of 180 days. The request must include justification for the additional time.

Process for project submission: The process from pre-application briefings through closeout, as well as application timelines. Identified in this process are the typical roles and responsibilities of the VDEM's staff. The following is a brief list of the application process:

- Promote the program and hold grant application workshops for the affected communities, offering technical assistance as needed;
- Receive applications developed and submitted by sub-recipient;
- Ensure sub-applicant's county has a FEMA- approved Local Mitigation Strategy and that the community has adopted their approved plan;
- Verify NFIP status of sub-applicant;
- Notify the sub-applicant with the name and telephone number of the State/Commonwealth's Point of Contact;
- Verify that the sub-applicant meets the definition of the eligible subrecipient type they claim to be;
- Verify eligibility of the sub-applicant's proposed project type;
- Identify potential of project type for 406 Mitigation funding and requirements;
- Review supporting hazard, environmental, and cost data for completeness;
- Review for additional information necessary to evaluate environmental considerations;
- Coordinate with the Virginia Department of Historic Resources (VDHR) for appropriate review and clearances;
- Review letters from appropriate Commonwealth of Virginia and Federal agencies including whether sub-applicant will require permits;
- Conduct site visits to verify environmental and engineering information;
- Prepare the benefit cost analysis using data and information provided by the sub-applicant or collection by the technical specialist.
- Prepare engineering and environmental reports and recommend for project funding;
- Complete a potential subrecipient risk analysis that includes understanding of programmatic and financial management systems, outstanding debt to the Federal government, etc., to determine if the Commonwealth of Virginia will require additional conditions to ensure the successful completion of the project;
- Ensure sub-recipient meets compliance with debarment and suspension requirements as outlined in 2 CFR 200.213;
- Enter projects into NEMIS and submit complete project application package to FEMA for review, concurrence, and obligation of funds.
- Provide notice from the delegated Governor's Authorized Representative (GAR) to FEMA of the projects submitted for further review and funding.

Project Application Requirements: The Commonwealth of Virginia will submit its HMGP application to the FEMA Regional Administrator. The application will identify one or more mitigation measures for which the Commonwealth of Virginia requests funding. The application must include the following Federal requirements:

- Standard Form 424, Application for Federal Assistance,
- Standard Form 424D, Assurance for Construction Programs, if appropriate,
- Narrative that contains any pertinent project management information and identifies the specific mitigation measures, and also includes the following:
  - Name of subrecipient,
  - Commonwealth of Virginia or local contact for the measure,
  - Location of the project,
  - Description of the measure,
  - Cost estimate for the measure,
  - Analysis of the measure's cost-effectiveness and substantial risk reduction through the BCA process,
  - Work schedule,
  - Justification for selection,
  - Alternative considered,
  - Environmental information consistent with 44 CFR Part 9, Floodplain Management and Protection of Wetlands, and other applicable environmental and historic preservation laws, regulations, Executive Orders, and agency policy,
  - Historic preservation information consistent with Federal, Commonwealth of Virginia, or local historic preservation guidelines to include the National Historic Preservation Act review,
  - Coordination with the US Army Corps of Engineers (USACE) and the Virginia Department of Transportation to ensure no planned projects are currently under consideration that would impact proposed mitigation projects or locations,
  - Assurance of project maintenance,
  - All applicable maps of project locations,
  - Other pertinent information necessary
    - Completed property owner participation forms/documentation
    - Property substitution list
  - Documentation of meeting local plan requirements,
  - Proof of acceptance or declination by sub-applicant for sub-recipient management costs.

Project Approval Process: After FEMA has approved a submitted project, VDEM will provide a sub-recipient grant agreement to the sub-applicant for final review and signature. The sub-applicant will then have ninety (90) days from the date of the letter to sign the funding agreement and return it to VDEM. If the sub-applicant does not return this funding agreement within ninety (90) days, VDEM has the right to withdraw the agreement and reallocate the funds.

Project Changes: After FEMA has approved a project, the sub-recipient must formally submit any requests for a change (amendment) in the scope of work (SOW) or budget to the VDEM State Hazard Mitigation Officer (SHMO) in writing. Both VDEM and FEMA must approve this amendment per 2 CFR 200.308.

Pre-Award Costs: VDEM, in coordination with FEMA, will entertain requests from eligible applicants for approval of eligible Pre-Award costs pursuant to 44 CFR 206.439(c). To request Pre-Award costs, the sub-applicant will identify any costs within their application, and those costs will be listed in the grant agreement. Once the grant agreement has been signed, the sub-applicant may request pre-award costs through the reimbursement process.

8) PROJECT SELECTION PROCESS

Commonwealth of Virginia Multi-Hazard Mitigation Plan Priorities: The approved Multi-Hazard Mitigation Plan lists the priorities identified by the various community members within the Commonwealth of Virginia. The primary priorities are:

Priority 1: Prevention of future risk
Priority 2: Protection of the built environment
Priority 3: Natural resource protection
Priority 4: Hazard modification through construction
Priority 5: Emergency Services
Priority 6: Public Education and Awareness
Priority 7: Risk Analysis

4644DR-VA-DR Specific Priorities: The priorities for this event are those that relate to this specific event or needs for the overall benefit of the communities within the Commonwealth of Virginia. For this event, the priorities listed below outline the Mitigation measures that will be addressed with the HMGP funds available:

- The Commonwealth of Virginia's priority is to direct the funding from this disaster to the communities that were directly affected by this disaster.
- The secondary priority will be to work directly with any locality identified as vulnerable through the Health 360 tool. There are 40 localities that are considered the most vulnerable, with other localities with highly vulnerable census tracts.

Project Prioritization: Each event presents or highlights specific needs of the community. The Commonwealth of Virginia may determine prioritization of the projects submitted under numerous criteria types such as cost effectiveness, expiration date, project type, program emphasis on project type, equity, etc. The prioritization plan for this event is outlined below in accordance with 44 CFR 206.435.

- Projects will be prioritized based on a tiered approach, with a focus on protecting the most vulnerable populations that will be disproportionally impacted from the next disaster.

Project Selection: VDEM will establish procedures and priorities for the selection of mitigation measures and the process by which the Commonwealth of Virginia will notify applicants of their project submission status. This process may alter based on the event needs. At a minimum, the process must be consistent with the criteria in 44 CFR 206.434(c) and include:

- Measures that best fit within an overall plan for development and/or hazard mitigation in the community, disaster area within the Commonwealth of Virginia.
- Measures that, if not taken, will have a severe detrimental impact on the applicant, such as potential loss of life, loss of essential services, damage to critical facilities, or economic hardship on the community;
- Measures that have the greatest potential impact on reducing future disaster losses;
- Measures that are designed to accomplish multiple objectives including damage reduction, environmental enhancement, and economic recovery, when appropriate.

9) PROJECT FUNDING

Management Costs: Management costs are any indirect, direct administrative, or any other administrative expenses that a recipient incurs due to the administration of the award or subaward, and any other administrative expense associated with a specific project under a major disaster, emergency or disaster preparedness or mitigation activity or measure.

- Management Costs are additional funds on top of the Federal funds available to support project implementation and completion for the recipient and sub-recipient to successfully manage all aspects of the grant award. Management costs are 100% Federally funded with no match/cost sharing requirement.
- FEMA will provide up to 15-percent of the total HMGP award amount for Management Costs: not more than 10-percent may be used by the recipient and 5-percent by the sub-recipient.
- The recipient must provide the sub-recipient management cost funding for documented actual costs, up to 5-percent of the total HMGP grant award. If the sub-recipient decides not to use or accept the Management Costs offered to them at the time of application, the recipient must document the desire of the sub-recipient in writing from an authorized official and retain in the program files in case requested by FEMA.
- FEMA will obligate all Management Costs provided in increments sufficient to cover recipient and subrecipient needs for no more than one (1) year unless contractual agreements require additional funding. The recipient will reconcile sub-recipient Management Costs against actual costs of the total award on a quarterly basis. FEMA will de-obligate any unused management costs at closeout following the final payment.
- The Commonwealth of Virginia will track management costs by using their vdem.emgrants.com grants system which creates a separate project for each sub-recipient who received an approved project award. A separate reimbursement is completed for management costs and paid separately from project costs.
- For this event, Management Costs to be covered include the following:
    - Staff Support (Grants Administration) – salaries, benefits, travel/training, and direct overhead costs (facility, IT, phone)
    - Grant Management System (for project application and grants management) Support
    - Contract Support for technical assistance
    - Loss Avoidance Studies
    - Open Space Reporting
    - Awareness/Reports on Mitigation Projects from this disaster

	Commonwealth of Virginia, tribes, and territories with standard mitigation plans
30-day estimates	apply for up to 25 percent *
6-month estimates	apply for up to 50 percent *
FEMA will withhold a percentage of funds until closeout	3 percent of the recipient management costs
Subrecipient can claim management costs	Early as 180 days after work is completed or up to recipients Management Cost closed out
Recipient can claim management costs	Early as 180 days after work is completed or 8 years from DR declaration
Management Cost awards over $6 million	FEMA will develop an agreement with the recipient that outlines the release of funding on an incremental basis.
* Based on eligible management costs	

Cost Share/Match Requirements: The HMGP traditionally requires a cost share match of 25% of the total project costs with 75% of the total project costs being covered by the Federal funds obligated. Cost sharing or match must comply with guidelines and requirements outlined in 2 CFR 200.306.

All cost share/match contributions must meet the following criteria:

- Are verifiable from the non-Federal entity's records.
- Are not included as contributions for any other Federal award,
- Are necessary and reasonable for accomplishment of project or program objectives,
- Are allowable under 2 CFR 200.306,
- Are not paid by the Federal Government under another Federal award, except where the Federal statute authorizing a program specifically provides that Federal funds made available for such program can be applied to matching or cost sharing requirements of other Federal programs,
- Are provided for in the approved budget, and
- Conform to other provisions, as applicable.

Type of match options available for consideration and use include:

- <u>Global Match</u>: If he Commonwealth of Virginia desires to implement the project global match process, it will coordinate it with and obtain approval from the FEMA Regional office in advance. Once FEMA and the Commonwealth of Virginia execute the process, the Commonwealth of Virginia will notify counties that the global match is available to all who are interested and ensure that it applies the process in a fair and impartial manner to all sub-applications. Note: Grant applications submitted as "match" must meet all HMGP eligibility criteria as stipulated in Page 44 CFR 206.434(c), must meet the same Period of Performance time constraints as the HMGP projects, will be managed in every way like all other applications, and must be approved by FEMA prior to implementation.

- Cash Match: Cash match is the most common. Cash match is the utilization of dollars budgeted and spent on eligible activities in the approved project award. The Commonwealth of Virginia does intend on allowing the use of cash match for this disaster by the subrecipient(s).
- In-Kind Match: The Commonwealth of Virginia does intend on allowing the use of in-kind match for this disaster by the subrecipient(s). The sub-recipient must document fair market value of goods and services and, to the extent feasible, support this by the same methods used internally by the non-Federal entity. Goods and services used for this purpose must comply with eligible project types in the approved project award.
- Increased Cost of Compliance (ICC): ICC coverage is one of several resources for flood insurance policyholders who need additional help repairing the structure after a flood. It provides up to $30,000 to help cover the cost of mitigation measures that will reduce flood risk. ICC coverage is a part of most single-family insurance policies available under the NFIP. When a community or other eligible sub-recipient receives FEMA HMA grant funds for an awarded mitigation project, they may be eligible to use ICC claim payments to contribute to the non-Federal cost-share requirements, so long as the claim is made within the timelines allowed by the NFIP. The sub-recipient or the individual homeowner typically provides the non-Federal cost share. The Commonwealth of Virginia does intend on allowing the use of ICC match for this disaster by the subrecipient(s).
- Capital loans: The Commonwealth of Virginia is interested in pursuing Capital Loans for this event.
- Treasury Funds that lose Federal Identity: The Commonwealth of Virginia has not identified Treasury Funds to utilize for the match requirements of this disaster.

Eligible Activities:

- Planning- The recipient may use up to seven (7) percent of the Commonwealth of Virginia HMGP award to develop the Commonwealth of Virginia, Tribal, and/or local mitigation plans to meet the planning criteria outlined in 44 CFR Part 201.
    - Plans that identify and analyze mitigation problems and include funded, scheduled programs for implementing solutions;
    - Development of State/Commonwealth and Local mitigation standards (building codes); and
    - Development of comprehensive mitigation programs with implementation as an essential component.

- 5-percent Initiative- These projects provide an opportunity to fund mitigation actions that are consistent with the goals and objects of the Commonwealth of Virginia, or Tribal (Standard or Enhanced) and local mitigation plans and meet all HMGP requirements, but for which it may be difficult to conduct a standard benefit cost analysis to prove cost-effectiveness. This funding does not need to be submitted as one project. The sub-recipient must submit the project application for review along with a narrative that indicates that there is a reasonable expectation that the activity will reduce or prevent future damage or loss of life or injury. Examples of project types to be considered under this funding allotment include the following;

- Outreach activities;
- Public Awareness Campaign;
- Warning Signs/Notification System;
- Adopting and enforcing the latest International Building Code/International Residential Code;
- Improving a Building Code Effectiveness Grading Schedule (BCEGS) score;
- Upgrading existing code to incorporate disaster-resistant code provisions;
- Integrating flood-resistant elements of the building code into local floodplain management ordinances;

*NOTE: This project type category can in increased to 10% of the total project costs at the discretion of the Recipient to promote disaster-resilient codes for all hazards. To qualify for this increase in funding, the Recipient or subrecipient must agree to adopt and promote disaster-resistant codes or improve their BCEGS rating during the POP. The Recipient must document the increase in BCEGS prior to the closeout of the project award.

- Advanced Assistance- Section 1104 of the Sandy Recovery Improvement Act (SRIA) authorizes the use of Advanced Assistance to accelerate the implementation of HMGP. Applicants and sub-applicants may use Advanced Assistance to develop mitigation strategies and obtain data to prioritize, select, and develop complete HMGP applications in a timely manner. Advanced Assistance may utilize up to 25-percent of the HMGP ceiling or $10 million (whichever is less) to applicants and/or sub-applicants. Examples of project types to be considered under this funding allotment include the following;
    - Project scoping;
    - National Environmental Policy Act (NEPA) Coordination;
    - Hydrology and Hydraulic (H&H) Study;
    - Architectural & Engineering Designs;
    - Benefit Costs Analysis (BCA) assistance.

- Other Projects- Projects may be of any nature that will protect public or private property. Activities for which the sub-recipient has begun or completed implementation are not eligible for funding. Examples of project types considered under this funding allotment include the following;
    - Construction activities that will result in protection from hazards;
    - Retrofitting of existing facilities that will result in increased protection from hazards;
    - Elevation of flood prone structures;
    - Vegetative management/ soil stabilization;
    - Infrastructure protection measures;
    - Safe Room construction;
    - Generators;
    - Dry Floodproofing of non-residential structures;
    - Stormwater management/ flood control projects;
    - Property acquisition or relocation;
    - Structural hazard control or protection projects such as soil stabilization, stormwater management;

- Construction activities that will result in protection from hazards such as elevation, reconstruction, generators;
- Climate Resilient Mitigation Activities, such as Aquifer Storage and Recovery, Flood Diversion and Storage, Floodplain and Stream Restoration;
- Retrofitting of facilities;
- Property acquisition and demolition or relocation (must comply with requirements outlined in 44 CFR Part 80)

Non-participating communities in the National Flood Insurance Program (NFIP) may submit projects to the HMGP only if the projects are in unmapped areas or areas outside the Special Flood Hazard Area (SFHA).

Any HMGP construction project located within the Special Flood Hazard Area must comply with the minimum NFIP standards for such project under the current building code at the time of the project.

- Duplication of Programs: Section 404 funds cannot be used as a substitution or replacement to fund projects or programs that are available under other Federal authorities, except under limited circumstances in which there are extraordinary threats to lives, public health or safety or improved property.

- Packaging of Programs: Section 404 funds may be packaged or used in combination with other Federal, Commonwealth of Virginia, local or private funding sources when appropriate to develop a comprehensive mitigation solution, though Section 404 funds cannot be used as a match for other Federal funds.

NOTE: Activities that are already initiated or completed are not eligible for funding. If the project site is in a designated Special Flood Hazard Area that has been identified for at least one year and the community is not participating in the National Flood Insurance Program (NFIP), HMGP funds cannot be given for acquisition or construction purposes. This includes communities suspended from participation.

10) GRANT ADMINISTRATION

Recipient Responsibility: The Virginia Department of Emergency Management (VDEM), as the recipient, has primary responsibility for project management and accountability of funds as indicated in 2 CFR 200 and 44 CFR 206 and for ensuring that all applicants meet all program and administrative requirements as indicated in 2 CFR 200, 3002, 44 CFR 206, and the Hazard Mitigation Assistance Unified Guidance.

Funds Management: VDEM will account for grant funds in accordance with State/Commonwealth laws and procedures for expending and accounting for funds. Accounting procedures and fiscal controls of the recipient and sub-recipient must be sufficient to permit preparation of reports required by 2 CFR 200, and the tracing of funds at a level to establish that such funds have not been used in violation of the restrictions and prohibitions of applicable statutes.

VDEM will reconcile project expenditures by grant through coordination between the business, budgetary, and programmatic functions of VDEM on a regular basis. The State/Commonwealth will use the reconciliation results to submit quarterly financial reports to FEMA via the Standard Form 425 (SF-425), Federal Financial Report.

VDEM will manage cash draw downs, disbursements, and all other applicable financial aspects with an emphasis on avoiding duplication in processes.

Project Period of Performance (POP)

To use HMGP funds more efficiently and effectively, VDEM will disburse all funds to sub-recipients, and sub-recipients will complete all activities within the awarded Period of Performance (POP). To request a POP extension, the sub-recipient will submit a formal written request to the Commonwealth of Virginia Department of Emergency Management (VDEM) no later than 75 days prior to the expiration of the POP. This request will include a justification for the extension and an adjusted plan (scope of work, milestones, budget changes clearly articulated). This justification must demonstrate that work is in progress and that the sub-recipient can complete it within the proposed new POP end date.

VDEM will review the extension request. If the VDEM determines that unusual circumstances exist, the VDEM may extend the POP to a period not to exceed the end of the grant POP. As a result of this policy and in keeping with program regulations in 2 CFR 200.343, the recipient will de-obligate and return to FEMA any funds not disbursed by the recipient within the approved POP of the grant.

Payments: VDEM has access to available funds obligated for the entire approved project costs or funds available in incremental obligations as outlined in the Strategic Funds Initiative to be good stewards of the Federal funds awarded. The FEMA award letter for each project will identify how many funds are available. Funds will be available in the payment system, SMARTLINK.

- Reimbursement is the payment process which requires the sub-recipient to submit their reimbursement request and supporting documentation for each request for project-related funds. A sub-recipient may have more than one payment request over the life of the project. VDEM will process reimbursement requests in a timely and effective manner in compliance with 2 CFR 200 and the Treasury-Commonwealth of Virginia Cash Management Improvement Act (CMIA) agreements and default procedures codified at 31 CFR Part 205 and the Treasury Financial Manual (TFM) 4A-2000, "Overall Disbursing Rules for All Federal Agencies."
- Advance Payment (2 C.F.R. 200.305) Is a payment that a Federal awarding agency or pass-through entity makes by any appropriate payment mechanism, including a predetermined payment schedule, before the non-Federal entity disburses the funds for program purposes. Sub-recipients must submit advance funds payment request with appropriate justification to VDEM and these may not exceed the expected cash needs of the sub-recipient within the first three (3) months. Utilization of this payment method is at the discretion of VDEM and the process is outlined below:
    - Localities will submit the reimbursement form and supporting documentation for each reimbursement.

- Localities will submit proof of payment for all reimbursements and advance of funds (once paid)
- The SHMO or other authorized personnel will review the request and reach concurrence of the submitted request.
- The SHMO or other authorized personnel notifies the sub-recipient upon completion of the processed request and issues the funding.
- Only grant eligible expenses will be reimbursed

Cost overruns: During the execution of work on an approved mitigation measure, the sub-recipient or recipient may identify that the costs to complete the project exceed the approved budget estimates. The Regional Administrator will provide determinations in writing on requests submitted to FEMA. All requests not justified must be denied by VDEM. In no case will the total amount obligated to VDEM exceed the funding limits set forth in 44 CFR 206.432(b). The recipient has the options identified below to address this situation:

- The recipient can meet cost overruns without Federal funds, or they by offsetting cost underruns on other projects. In either case, the recipient should submit a description of the changes to FEMA.
- Cost overruns that exceed the Federal funds obligated and require additional Federal funds require VDEM to evaluate each cost overrun and submit a request for additional funds with a recommendation to the Mitigation Division Director for a determination. The sub-recipient's justification for additional costs and other pertinent material must accompany the request.

Reporting: The recipient must submit quarterly reports to indicate financial and programmatic progress to FEMA. Report submission is a requirement per 2 CFR 200.328 and 2 CFR 200.329.

- Financial Reporting: The SF-425 is the Standard Form, Federal Financial Report which submits aggregated financial data for the entire grant award or disaster on funds obligated, drawn down, expended, incurred, program income realized, and match requirements.
- Programmatic Reporting: The sub-recipient must submit quarterly Programmatic Progress Report (PPR) for each project awarded to VDEM. These inform of the progress made during the quarter, any issues or circumstances that would impact project completion, expectations for the future quarter, funds expended, funds awarded, and specific project details such as project number, period of performance dates for the project, and sub-recipient's name.
- Schedule:

Reporting Period	Report Due to State/Commonwealth	Report Due to FEMA
January 1 – March 31	No later than April 15	No later than April 30
April 1 – June 30	No later than July 15	No later than July 30
July 1 – September 30	No later than October 15	No later than October 30
October 1- December 31	No later than January 15	No later than December 30

Time Extensions: The standard maximum period of performance for a HMGP project is three (3) years.

- VDEM and FEMA may consider requests for additional time to complete approved scope of work activities in the Commonwealth of Virginia. Sub-recipients must submit requests in writing to the VDEM (the recipient).
- If the proposed additional time exceeds the period of performance for the overall grant award, the Governor's Authorized Representative (GAR) or Alternate GAR for the Commonwealth of

Virginia must submit the sub-recipient's request and a signed a letter of concurrence from the Commonwealth of Virginia to FEMA for review and determination.

- Time extension requests must include but are not limited to the following:
  - Federal HMGP Project Identification Number,
  - Reason(s) for delay,
  - Current project completion status, to include funds spent to date,
  - Original scheduled completion dates,
  - New scheduled completion dates or milestones, and
  - Dates and provisions of any previous extensions.
- The recipient must submit requests to FEMA at least sixty (60) days prior to the end of the project's period of performance.

Scope of Work or Budget Change Requests: The sub-recipient must submit any perceived or necessary changes to the approved scope of work or budget to VDEM and ultimately to the FEMA Mitigation Division Director for consideration and determination. VDEM will evaluate the request from the sub-recipient within the Commonwealth of Virginia and if necessary, request technical engineering review from FEMA prior to submitting the request. If VDEM the concurs on the request, the GAR will submit a letter of concurrence in writing to accompany the sub-recipient's request.

- The sub-recipient's request must include but is not limited to the following:
  - Federal HMGP Project Identification Number,
  - Reason(s) for delay,
  - Current project completion status, to include funds spent to date,
  - Original scheduled completion dates,
  - New scheduled completion dates or milestones, and
  - Dates and provisions of any previous extensions.

Technical Assistance: VDEM is available to provide technical assistance to the sub-recipient throughout the life of the project. Technical assistance can be in the form of outreach, community engagement, and direct assistance for applications and project implementation. Outreach will also include facilitating local mitigation plan amendments and approvals, preliminary engineering reports/designs, and benefit cost analysis. VDEM will review the request and identify the best method to meet the need of the request and will communicate to the sub-recipient of their understanding and determination of the request in writing within 90 days of the request.

Technical assistance can be requested through the following methods:

- Emails to the State Hazard Mitigation Officer (SHMO) or the Chief Regional Coordinator
- Letter to the State Hazard Mitigation Officer (SHMO)

11) APPEALS

The applicant, recipient, or sub-recipient may appeal any determination made related to an application for or the provision of Federal assistance according to the provisions in 44 C.F.R. Part 206.440 Appeals.

- The recipient must submit first appeals in writing to the Regional Administrator. The recipient must make second appeals to the Assistant Administrator for the Mitigation Directorate in writing.

- Appeals must be made within 60 days after receipt of notice of the action being appealed.
- Recipient shall review and evaluate all sub-recipient appeals before submission to FEMA. Recipient shall forward appeals to FEMA with a written recommendation within 60 days of receipt of the appeal.
- The Regional Administrator will notify the recipient in writing of the disposition of the appeal, or of need for additional information, within 90 days following receipt of the appeal.
- For appeals regarding highly technical issues, the Regional Administrator may submit the appeal to an independent scientific or technical person or group with expertise in the subject matter for advice or recommendation.

12) AUDIT PROCEDURES

VDEM will comply with the uniform audit requirements as set forth in 2 CFR parts 200.500 and 3002 and 44 CFR Part 206.16 apply to all grant assistance provided under the HMGP. FEMA may elect to conduct a Federal audit on the disaster assistance award or on any of the subawards. These requirements apply to the recipient and sub-recipient as follows:

- The Commonwealth of Virginia Auditor of Public Accounts will ensure that audits are performed under the Single Audit Act of 1996. VDEM will review audits completed for each sub-recipient and resolve any audit discrepancies. The process to review and track to resolution of audit discrepancies is as follows:
    - Each year, VDEM pulls sub-recipient single audits from the Auditor of Public Accounts as a part of the sub-recipient monitoring Risk Assessment.
    - VDEM performs a risk assessment to determine sub-awards that require monitoring.
    - VDEM may include special terms and conditions in a sub-award to account for any unresolved audit findings.
    - An audit finding is concluded with the following year’s review to determine if the finding has been resolved.

All recipients and subrecipients of federal funds are subject to the accounting and audit requirements as found in 2 CFR 200, subpart F – Audit Requirements. A non-Federal entity that expends $750,000 or more during the non-Federal entity's fiscal year in Federal awards must have a single or program-specific audit conducted for that year in accordance with the provisions of the 2 CFR 200 Subpart F. A non-Federal entity that expends less than $750,000 during the non-Federal entity's fiscal year in Federal awards is exempt from Federal audit requirements for that year, but records must be available for review or audit by appropriate officials of the federal agency, pass-through entity, and Government Accountability Office (GAO).

VDEM reserves the right to require an audit and to examine and/or audit any financial records of any subrecipient during the project period and within a five-year period following the conclusion of the final financial audit that covered the grant award period. In cases of continued inability or unwillingness on the part of the subrecipient to conduct or supply a proper audit, VDEM reserves the right to impose any sanctions, as described in 2 CFR 200, upon the subrecipient until such time a proper audit is received by VDEM.

13) CLOSEOUT PROCEDURES

Closeout Plan is a document and agreement, jointly developed between FEMA and VDEM to set expectations and monitor progress on projects awarded under this disaster to ensure disaster grant closeout occurs within the Disaster Closeout Deadline (DCD) of 8-years for the disaster program. The Closeout Plan development begins at the end of the Period of Availability (at the 12-month mark of the disaster) and should be completed within 6 months after the Period of Availability ends (or 18-months after the Period of Performance start date). This agreement will be signed by FEMA and the VDEM.

Project Closeout process will be initiated by the sub-recipient notifying the State Hazard Mitigation Officer (SHMO) when they consider the project complete. The SHMO may also determine that the progress submitted in quarterly reports, on-going coordination, or the performance period or non-performance of the grant required project closeout actions and suggest project closeout or submission of an amendment to FEMA.

Steps to close a project are:

- Agreement between VDEM and the Sub-Recipient that the project is ready to be closed. Should either not agree, the Project Manager or SHMO would request an extension, in writing, outlining the request justification.
- The Sub-Recipient, VDEM (Recipient) and FEMA will coordinate to ensure that funds advanced through the program balance with funds expended by the recipient and subrecipient. If there is disagreement between the expended funds and the grant amount, FEMA and VDEM will take steps to reconcile and adjust final project expenditures and Recipient Management Costs.
- The Recipient will conduct a final site visit to verify that the sub-recipient completed all project work and record the date of the final visit for the closeout letter.
- FEMA and VDEM will coordinate their financial systems to record the amount and date of the final payment(s). FEMA and VDEM will close financial files, and de-obligate excess funds.

Program Closeout is the process to close the overall grant award or HMGP disaster grant. The State/Commonwealth must conclude program closeout no later than 120 days after the Period of Performance by ensuring that sub-recipients have completed all projects under the award and satisfied requirements; then submitting a Request to Close letter signed by the GAR to the Regional Administrator requesting closeout and de-obligation of unused funds.

FEMA and/or the recipient must ensure completion of the following as part of the closeout process:

- Close out of any mission assignments and technical assistance contracts.
- The recipient and FEMA agree on the final claim amount and concurrence date. The Recipient will submit a concurrence letter and sign FEMA Form 425.
- FEMA will close the HMGP in program and financial systems.

- FEMA and the Commonwealth of Virginia Hazard Mitigation Officer will ensure that Federal and VDEM's records are available in the event of an audit.
- VDEM will retain the project records for a minimum of 3 years from the date of program closure.
- VDEM will retain records for up to 3 years from the date of the FEMA program concurrence letter as required by Commonwealth of Virginia statutes.

14) SIGNATURES

Name **Title**	**Signature/ Date**
April Cummings Director, Mitigation Division	
James Quarles Hazard Mitigation Branch Director	
Debbie Messmer State Hazard Mitigation Officer	Debbie Messmer 8/8/2022
Cheryl Adkins Governor’s Authorized Representative	Cheryl Adkins 8/8/2022
Catherine Fan Federal Coordinating Officer	

Appendix I:

State Adoption Letter

COMMONWEALTH OF VIRGINIA
Department of Emergency Management

9711 Farrar Court, Suite 200, North Chesterfield, Virginia 23236
TEL 804.267.7600 TDD 804.674.2417 FAX 804.272.2046

SHAWN G. TALMADGE
State Coordinator of
Emergency Management

MICHELLE OBLINSKY
Acting Chief Deputy State Coordinator
of Emergency Management

February 21, 2023

Dear State Coordinator Talmadge,

Section §44-146.16 of the *Code of Virginia* defines hazard mitigation as any action taken to reduce or eliminate the long-term risk to human life and property from natural hazards. The Virginia Department of Emergency Management has been tasked with the responsibility of promulgating plans and programs conducive to adequate disaster mitigation, preparedness, response, and recovery programs through section §44-146.18 of the *Code of Virginia*.

We are pleased to submit and request your review, approval, and adoption of the 2023 Commonwealth of Virginia Hazard Mitigation Plan for implementation. This plan plays an instrumental role in accomplishing the hazard mitigation tasks assigned to the Governor of Virginia in §44-146.22 to prevent or reduce the harmful consequences of disasters.

In accordance with FEMA guidelines, the VDEM Planning Division worked closely with other VDEM divisions and dozens of stakeholders across the Commonwealth to create a plan that identifies and assesses the risks that make us vulnerable and outlines the mitigation strategies necessary to meet the needs of Virginia citizens. The Hazard Mitigation Planning Team is grateful for your support during the development of this update, and we look forward to its adoption and implementation.

Sincerely,

Stacy McKinley
Hazard Mitigation Planner, Planning Division, VDEM
804-385-3747 (cell)
Stacy.mckinley@vdem.virginia.gov

Cc Thomas H. Berry, Planning Division Director, VDEM
Jennifer E. Sharpe, Acting State Coordinator & Chief of the VEST, VDEM

Approved and Adopted:

#10

Shawn G. Talmadge
State Coordinator and Deputy Homeland Security Advisor
Virginia Department of Emergency Management

Appendix J:

FEMA Approval Memo

U.S. Department of Homeland Security
Federal Emergency Management Agency
Region 3

One Independence Mall
615 Chestnut Street, 6th floor
Philadelphia, PA 19106-4404

FEMA

March 10, 2023

Mr. Shawn Talmadge
State Coordinator
Virginia Department of Emergency Management (VDEM)
9711 Farrar Court, Suite 200
North Chesterfield, Virginia 23236-3713

Dear Mr. Talmadge:

I am pleased to announce that the Commonwealth of Virginia Hazard Mitigation Plan ("Plan") has been approved. The Plan meets mitigation planning requirements authorized under the Disaster Mitigation Act of 2000 that are implemented in Title 44 Code of Federal Regulations, Part 201.

Specifically, FEMA has determined that the Commonwealth's Plan adequately addresses the following elements required under 44 C.F.R. 201.4which include planning process; risk assessment and hazard identification; mitigation strategy; coordination of local mitigation planning, maintenance and implementation; and adoption. In addition, the Commonwealth's Plan meets the requirements related to dam (HHPD) and wildfire (FMAG) risk per FEMA Policy 302-094-2, FEMA State Mitigation Planning Policy Guide (released April 19, 2022).

A FEMA approved state mitigation plan is a condition of receiving certain non-emergency Stafford Act assistance and FEMA mitigation grants from the following programs:

Public Assistance-Categories C through G
Fire Management Assistance Grants (FMAG)
Hazard Mitigation Grant Program (HMGP)
Pre-Disaster Mitigation (PDM) / Building Resilient Infrastructure and Communities (BRIC)
Flood Mitigation Assistance (FMA)
Rehabilitation of High Hazard Potential Dam (HHPD)

The Commonwealth of Virginia must revise its plan and obtain approval within 5 years to continue to be eligible for non-emergency Stafford Act assistance and FEMA mitigation grants. This plan should be reviewed at least annually to keep it relevant to the mitigation goals throughout the commonwealth.

FEMA recognizes Virginia's dedication demonstrated in your timely preparation and adoption of a strategy to reduce future disaster losses. If you have any questions, please contact Mari Radford, Hazard Mitigation Planning Section Supervisor, at (267) 319-6310.

Sincerely,

MARYANN E TIERNEY Digitally signed by MARYANN E TIERNEY Date: 2023.03.10 13:58:51 -05'00'

MaryAnn Tierney
Regional Administrator

cc: Stacy McKinley, Hazard Mitigation Planner, VDEM
Thomas Berry, Planning Division Director, VDEM
Debbie Messmer, State Hazard Mitigation Officer, VDEM
April Cummings, Division Director, Mitigation
Dustin Brosius, Acting Deputy Director, Mitigation
Sarah Wolfe, Chief, Floodplain Management and Insurance Branch