Middle Peninsula
All Hazards Mitigation Plan

2016

Participating Middle Peninsula localities include Essex, Middlesex, Mathews, Gloucester, King & Queen, and King William Counties, and the Towns of West Point, Urbanna, and Tappahannock.

MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

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Abbreviations

AHMP	All Hazard Mitigation Plan
AQI	Air Quality Index
BFE	Base Flood Elevation
CDT	Central Daylight Time
COA	Chief Administrative Officer
CO	Carbon monoxide
CO2	Carbon Dioxide
CRS	Community Rating System
DCR	Department of Conservation and Recreation
DEQ	Department of Environmental Quality
EM	Emergency Manager
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESC	Emergency Services Coordinator
DMA 2K	Disaster Mitigation Act of 2000
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Maps
GIS	Geographic Information System
HIRA	Hazard Identification Risk Assessment
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HOI	Health Opportunity Index
HRSD	Hampton Roads Sanitary District
LPT	Local Planning Team
LiMWA	Limit and Moderate Wave Action
MCS	Mesoscale Convective System
MOU	Memorandum of Understanding
MPNHMP	Middle Peninsula Natural Hazards Mitigation Plan
MPPDC	Middle Peninsula Planning District Commission
MPRWSP	Middle Peninsula Regional Water Supply Plan
NCDC	National Climatic Data Center
NESIS	Northeast Snowfall Impact Scale
NFIP	National Flood Insurance Plan
NO_2	Nitrogen Dioxide
NOAA	National Oceanic and Atmospheric Administration
NWS	Nation Weather Service
O_3	Ozone
OSDS	Onsite Sewage Disposal Systems
PA	Peak acceleration
PM	Particulate Matter
PDM	Pre-Disaster Mitigation
RL	Repetitive Loss
RP	Regional Planner
RSL	Relative Sea Level
SLOSH	Sea, Lake, and Overland Surges from Hurricane
SO_2	Sulfur Dioxide
USGS	United States Geological Survey
VAC	Virginia Administrative Code
VDEM	Virginia Department of Emergency Management
VDGIF	Virginia Department of Game and Inland Fisheries
VDH	Virginia Department of Health
VDOF	Virginia Department of Forestry
VDOT	Virginia Department of Transportation
VFD	Volunteer Fire Departments
VRS	Volunteer Rescue Squads
VWP	Virginia Water Protection
WMO	World Meteorological Organization

Section 1: Introduction

The Disaster Mitigation Act of 2000 (DMA 2K) is a key component of the Federal government's commitment to reduce damages to private and public property through mitigation actions. This legislation established the Pre-Disaster Mitigation (PDM) Program and created requirements for the Post-Disaster Hazard Mitigation Grant Program (HMGP). This key piece of federal legislation is known as Public Law 106-390.

DMA 2K requires local governments to develop and submit mitigation plans to qualify for Hazard Mitigation Assistance (HMA) funds. The Act requires the plan to demonstrate "a jurisdiction's commitment to reduce risk from natural hazards, serving as a guide for decision makers as they commit resources to reducing the effects of natural hazards." Upon completion, the final plan must be approved by the Virginia Department of Emergency Management (VDEM) as well as the Federal Emergency Management Agency (FEMA), and then adopted by each participating jurisdiction.

Therefore to meet such requirements Middle Peninsula Planning District Commission (MPPDC) staff guided the development of Regional Natural Hazard Mitigation Plans and Plan updates according to the requirements of DMA 2K. All nine (9) Middle Peninsula localities, including Essex, Gloucester, King and Queen, King William, Mathews, and Middlesex Counties and the Towns of Tappahannock, Urbanna, and West Point, participated in the plan's development and amendments. The region's plan will be adopted by local jurisdictions upon plan approval by FEMA.

This plan follows DMA 2K planning requirements and associated guidance documents for developing Natural Hazards Mitigation Plans. The guidance sets forth a four-step mitigation planning process that includes the following (FEMA, 2015):

The plan also utilizes the elements outlined in FEMA's Local Mitigation Plan review Crosswalk and Local Mitigation Plan Review tool, published in July 2008 and October 2011 respectively.

Since the adoption of the Middle Peninsula Natural Hazards Mitigation Plan (MPNHMP) in 2006, the nine (9) Middle Peninsula jurisdictions jointly participated in Revision #1 of the plan by developing detailed flood mitigation strategies to address the region's most critical natural hazards (i.e. flooding from severe storms). Then during the second revision, the plan's non-flood related natural hazards were reviewed and updated. Therefore, as FEMA requires hazard mitigation plan to be reviewed an updated every five years in order to remaining eligible for FEMA funding, MPPDC submitted a grant proposal to the VDEM to update the 2010 All Hazards Mitigation Plan (AHMP). Upon receipt of funding, Middle Peninsula localities signed a memorandum of understanding committing local funds and personnel to this endeavor.

Section 2: The Planning Process – Public Involvement and Community Partners

While the Middle Peninsula Planning District Commission hired a Regional Preparedness Planner to facilitate the 2016 update of the All Hazards Mitigation Plan, all nine localities participated and contributed substantial staff time to the development of this plan. In addition to time spent on this plan, each locality financially contributed in order to meet FEMA funding match requirements. Therefore to begin this project and to realize local commit, MPPDC staff drafted a Memorandum of Understanding (MOU) for each locality to sign. The MOU outlined the terms of agreement between the MPPDC and the County/Town concerning financial obligations of the local adoption of the 2016 Middle Peninsula PDC All Hazards Mitigation Plan Update. In response, each locality reviewed and signed the MOU (Appendix A).

Key stakeholders from the Middle Peninsula planning area, including 6-county and 3-town, were invited to participate and actively engage in the 2016 AHMP update. Their participation helped to determine the plan's outcomes and substantive content. Those invited included the Chief Administrative Officers – County Administrators and Town Managers, Planning Directors, Emergency Service Coordinators (ESC), Virginia Department of Conservation and Recreation (DCR) – Floodplain Division Staff, VDEM Staff, Virginia Department of Transportation (VDOT) – Saluda Residency Administrator and our federal partners at the National Weather Service, U.S. Corps of Engineers and U.S. Coast Guard. Local, state and federal staff/officials on the Steering Committee were targeted for their direct experience and knowledge in natural hazard mitigation efforts and/or actively involved in one or more of the 4 phases of emergency management – preparedness, response, prevention/mitigation or recovery. Due to the rural nature of the Middle Peninsula area, there are no private not-for profit environmental organizations based in the region that were identified by the Steering Committee members at the onset of the planning phase of this project that could provide meaningful input. In conjunction with the Steering Committee, Middle Peninsula Planning District Commissioners, consisting of elected officials and citizen representatives were kept abreast of the progress made throughout the plan updating process through written staff report at monthly committee meetings.

In order to provide consistency and continuity to this regional planning process, MPPDC Regional Planners, Harrison Bresee and Jackie Rickards, served as the facilitators and leaders of the Steering Committee during the revisions of the update. A list of the Steering Committee members can be found in Appendix B. For meeting minutes please see Appendix C.

2.1. Project Timeline for Update

Financial support for the update was provided by FEMA and VDEM, as well as funds contributed by the nine member jurisdictions of the MPPDC. Table 1 provides a timeline of the project and associated tasks of this three year project.

Table 1: Project timeline and associated tasks				
Task	**Starting Point**	**Unit of Time**	**Duration**	**Work Completed By**
Grant Implementation and kickoff	1-60	Days	60 days	Regional Planner (RP)
Organize Resources: 1. Form a Mitigation Advisory and Planning Committee 2. Award HAZUS Contract 3. Inventory available resources/collect data 4. Begin Public Outreach Efforts	60-185	Days	124 days	RP and Team Members
Revise Hazard Identification and Risk Assessment 1. Compile and analyze data for HIRA analysis 2. Vulnerability assessment/ loss identification 3. Provide HIRA, vulnerability & loss estimation analysis to public 4. VDEM review of HIRA, vulnerability & loss estimation analysis	186-445	Days	259 days	RP and Team Members VDEM and FEMA
Community Assessment/Profile 1. Review current community profiles with each locality	446-565	Days	119 days	RP and Team Members
Revise Mitigation Plan 1. Update mitigation goals, strategies and actions 2. Solicit/incorporate public comments 3. Prepare implementation strategy 4. Compile/ review draft plan 5. Solicit / incorporate public comment on final draft 6. VDEM/FEMA review and final plan	566-825	Days	259 days	RP and Team Members VDEM and FEMA
Adoption and Implementation 1. Final VDEM/FEMA review and plan approval 2. Publish VDEM/FEMA approved HMP for public distribution 3. Each Locality adopts the plan	826-1005	Days	179 days	RP/VDEM/FEMA
Project Closeout with VDEM	1006-1095	Days	89 days	RP/VDEM

Beginning in January 2014, MPPDC staff hosted regular meeting of the AHMP Steering Committee. A lead Steering Committee Member from each of the nine jurisdictions in the Middle Peninsula was designated to coordinate the hazard identification, capability assessment, completed mitigation strategy reporting, strategy development, and plan adoption. The lead member was the jurisdiction's Emergency Services Coordinator/Emergency Manager. They undertook tasks within the guidelines and time-frames noted below:

Task 1 - Hazard Identification/Capability Assessment

AHMP Steering Committee completed a series of 5 tasks using the hazard worksheets provided by VDEM staff to:

1. Identify all natural hazards;
2. Compile a history detailing the nature of each identified hazard;
3. Develop an inventory of assets that are at risk from each identified natural hazard;
4. Write a narrative describing the vulnerability of the community's assets to these natural hazards; and
5. Assess their locality's capability to use the local regulatory tools and the jurisdiction's technical staff to implement hazard mitigation activities.

To gather the appropriate information, Steering Committee members were asked to complete hazard worksheets by June 30, 2014 in order to provide the Regional Emergency Preparedness Planner time to compile community assessments by the August 2014 Steering Committee meeting. However since several localities were late or did not complete the worksheets until December 2014, there was a delay in completing community assessments. Also as King William County had vacancies in its Emergency Coordinator and County Administrator positions for a large part of 2014, a completed worksheet was finally received in April 2015.

Next a Hazards Identification and Risk Assessment (HIRA) was conducted using the HAZUS version 2.2 software from FEMA. MPPDC staff contracted with Dewberry to have this assessment completed. Results anticipated damages from hurricanes and serve wind storms. Additionally a sea level rise assessment was added to the HAZUS analysis for this 2016 plan update.

In conjunction with HAZUS, the Natural Hazards ranking, developed by the Kaiser Permanente Model, from the 2010 MPAHMP was made available to the Steering Committee for reference and to update the 2016 plan. Upon review four new hazards were added to the list and regional hazards were re-ranked.

Task 2 - Review of the Strategies from the 2010 MPNHMP

At the August 13, 2015 meeting of Steering Committee, the Regional Emergency Preparedness Planner reviewed each strategy within the 2010 with members. They were able to see the strategies that they committed to in 2010 and had an opportunity to make changes as a reflection of their local priority changes. Additionally jurisdictions were given a spreadsheet to report the status - completed, deleted, not started, cancelled or in progress - of the mitigation strategies since 2010.

Steering Committee Members were asked to update this information on April 14, 2015 and return the updated spreads sheets by June 1, 2015 for inclusion into the plan.

Task 3 - Inform the Public – Hazard Identification/Assessment Phase

Once the natural hazards were identified and assessed, Steering Committee members solicited comments from residents. Two sets of public meetings were scheduled in the region. The first two meetings were scheduled for July 29, 2015 in King & Queen County and July 30, 2015 in Saluda, Virginia, while the second two meetings were scheduled for January 5, 2016 in Saluda, Virginia and January 6, 2016 in King & Queen County. Only one citizen attended the public meetings. The sign-in sheet can be found in Appendix D

To advertise for the public meetings, the MPPDC Regional Emergency Preparedness Planner wrote and sent a press release to the area newspapers that serve Middle Peninsula residents to solicit public input on the All Hazards Mitigation Plan and the hazards that affect them and/or their communities. The same press release was posted on the Middle Peninsula Planning District Commission's website (Appendix E) from June 29th to July 28, 2015 as well as December 16, 2015 to January 14, 2016 to solicit additional input from residents. A copy of this press release in the Gazette Journal can be found in Appendix F.

Resident's comments were collected and considered by the All Hazards Mitigation Plan Local Planning Team for incorporation into the AHMP update.

Task 4 - Develop Goals and Objectives

At the June 25, 2015 Steering Committee meeting, the group reviewed existing mitigation goals and decided no changes would be needed to the regional goals and objectives for the MPAHMP update. Also at their June meeting, the Committee members reviewed the criteria used to develop their mitigation strategies and again decided to make no changes..

The evaluation criteria used to develop the mitigation strategies included the following:

Social Considerations

1. Will the proposed strategy be considered acceptable to the residents?
2. Will the proposed strategy treat all residents of the locality equally?
3. Will the proposed strategy cause any social disruption in the community?

Technical Considerations

1. Will the proposed strategy work?
2. Will the proposed strategy create more problems than it solves?
3. Will the proposed strategy solve the problem or just mask a symptom?
4. Is the proposed action in line with other locality goals?

Administrative Factors

1. Does the locality have the capacity to implement the proposed strategy?
2. Who in the locality will spearhead the strategy?
3. Is there sufficient funding, staff and technical support to undertake this effort?

Political Considerations

1. Will members of the governing body accept and support the proposed strategy?
2. Is there support to implement and maintain the proposed strategy by members of the governing body?

Legal Issues

1. Is the locality legally authorized to undertake this proposed strategy?
2. Will the proposed strategy constitute a legal taking?
3. Is the proposed activity in compliance with the jurisdiction's comprehensive plan?
4. Will the locality face legal liability if the proposed strategy is not implemented or conversely, legally challenged if the strategy is implemented?

Economic Concerns

1. What are the costs and the benefits of implementing the proposed strategy?
2. Do the benefits outweigh the costs? Construction projects seeking FEMA financial assistance to mitigate the adverse affects of natural hazards will utilize FEMA's Benefit/Cost Formula to insure that the proposed project benefits exceed the anticipated project costs.
3. Are the capital, maintenance and administrative costs accounted for with the proposed strategy?
4. Has the funding been secured for this project?
5. What burden will this strategy place on the locality's tax base or local economy?
6. Does the proposed strategy contribute to other jurisdictional goals?

Environmental Factors

1. What affect will the action have on the environment?
2. Will this action need environmental regulatory approvals?
3. Approvals from whom and does this create any concerns about the feasibility of the proposed action?

Task 5 - Strategy Development

At the August 13, 2015 Steering Committee meeting, the members developed and updated mitigation strategies to address the hazards that they determined adversely affected their communities.

Task 6 - Inform the Public – Strategy Development Phase

The Steering updated and developed mitigation strategies. This task was completed at the August 13, 2015 Steering Committee Meeting. These mitigation strategies were included in the Plan and were available to the public comment during the second comment period during December 16, 2015 to January 14, 2016.

Task 7 - Draft Plan

The draft plan was completed by December 16, 2016 and submitted to VDEM/FEMA for their review and comments. The Steering Committee Members also received a copy of the draft plan to review and circulate amongst their communities for further input by their co-workers – who will be involved in the implementation phase of the plan - and residents affected by the proposed action items.

The draft plan was reviewed, revised and approved by the Steering Committee members on December 15, 2015.

Task 8 - Adoption

Once VDEM/FEMA staff gave conditional approval of the draft plan, jurisdictional staff presented the updated plan to their governing body and requested its adoption.

Once adopted, jurisdictional staff and others identified in the plan will begin with the implementation phase of the strategies based on the schedule outlined in Section 9 of the update.

Task 9 - Public Input during Plan Development

Most of the Steering Committee members that are listed in Appendix B are staff from the Middle Peninsula localities that either create or implement ordinances and policies that affect development in areas that are susceptible to damage from natural hazards. The Steering Committee members were able to provide community based information about specific flood hazards as well as determining what mitigation tools their communities could adopt and implement to decrease flood hazards. The local Building Officials and Planning Directors on the Committee have brought their experience working with local residents, businesses and non-government organizations by providing guidance on proposed development projects in flood prone areas during the development of the plan update. Overall all these steering committee members have the ability to incorporate mitigation strategies and goals into the locality's building regulations, zoning ordinance, environmental regulations and/or comprehensive plan and enforced by the county code compliance employees in their respective departments.

During this 2016 update the Gazette Journal published news releases about the plan on June 24, 2015, December 16, 2015 and December 30, 2015. A copy of the press releases is included in Appendix F.

A similar version of this news release was posted on the MPPDC website from June 29, 2015 to July 29, 2015 as well as December 16, 2015 to January 14, 2016 soliciting public comments. A copy of the MPPDC's website homepage is shown in Appendix E. As a result of the news releases the Regional Preparedness Planner collected a total of 10 public comments from Middle Peninsula citizens during the entire project period (Appendix G).

Steering Committee Members from the jurisdictions – more specifically the local Emergency Services Coordinators/Emergency Managers - solicited comments from residents within their network of community contacts.

The local newspapers were also utilized to announce public informational sessions surrounding the adoption of the updated plan. Public informational opportunities to view/comment on the draft of the update included the following:

1. Middlesex County and the Town of Urbanna posted a short description of the AHMP and a link to the draft plan for public comment on December 16, 2015. While Gloucester County and King William County reposted the news release on their county websites encouraging citizens to comment on the plan.
2. At the January 2016 Board of Supervisors Meeting, Middlesex County presented the plan and reviewed the remaining project timeline.

Summary of Steering Committee Actions

During the update process, the Steering Committee members were instrumental in reviewing and significantly improving the original natural mitigation plan. A brief summation of their contributions include:

1. Meetings: Throughout the course of this project the Steering Committee meet on 12 separate occasions to discuss the plan update. Meeting dates were:

March 13, 2014	November 13, 2014
April 10, 2014	April 16, 2015
May 8, 2014	June 25, 2015
August 14, 2014	August 13, 2015
September 18, 2014	January 26, 2016

   For meeting minutes visit Appendix C.

2. March 2014
    - Reviewed project timeline
    - Reviewed hazard ranking from the 2010 Plan and the Kaiser Permanente Hazard Vulnerability Tool.
    - Expressed interest in adding air quality to the 2010 hazards list.
3. April 2014
    - Discussed and added HAZMAT, ditch flooding, air quality, and summer storms to the list of hazards. Also agreed to not remove hazards from the hazards list presented in the 2010 AHMP.
4. May 2014
    - Finalized the public outreach process for this plan
5. August 2014
    - Gloucester County and the Towns of Urbanna and West Point completed the Kaiser Permanente Hazard Vulnerability Tool worksheet.
6. September 2014
    - Essex, King & Queen, and Middlesex Counties and the Town of Tappahannock completed the Kaiser Permanente Hazard Vulnerability Tool worksheet.
7. April 2015
    - Contracted with Dewberry to complete a regional HAZUS analysis (ie. flooding, hurricane winds, and sea level rise).
    - Reviewed 2010 Mitigation Strategies.
8. June 2015
    - Public comment period scheduled and advertised for.
    - Draft plans were sent to local libraries
    - Public meetings were scheduled.
9. July 2015
    - Public meetings were held on July 29, 2015 (King & Queen County Regional Library) and June 30, 2015 (Saluda, Va).

10. August 2015
    - Local Planning Team reviewed public comments received during the public comment period.
    - The Local Planning Team completed a National Flood Insurance Program Survey and a capability assessment survey.
11. December 2015
    - The Local Planning Team reviewed and approved the updated All Hazards Mitigation Plan on December 15, 2015.
    - Scheduled and advertised for the 2nd public comment period.
    - Final plans were sent to local region libraries for the public to review.
    - Sent the final plan to VDEM for review.
12. January 2016
    - Hosted two public meetings on January 5, 2016 (Saluda, VA) and January 6, 2016 (King & Queen Library Branch).
    - Reviewed public comments at the January 26, 2016 meeting.
    - Reviewed VDEM comments.

Summary of Primary Revisions of the 2010 MPNHMP

The below will list the sections of the plan and updates that the All Hazards Mitigation Plan Local Planning Team made to keep this plan current.

Section 1 – Introduction

- Added a visual of the four-step mitigation planning process (FEMA, 2015).

Section 2 – Planning Process

- Updated the planning process to reflect the activities that took place during the plan update.
- Included public comments received during the public comment periods of this plan (Appendix G).

Section 3 – Community Profiles

- Updated community profiles to include the 2010 Census data.
- Added information about Economic Resiliency within the Middle Peninsula as well as the Health Opportunity Index from Virginia Department of Health (VDH).

Section 4 – Hazard Assessment

- Added air quality, HAZMAT, Ditch Flooding and Summer Storms to the list of hazards impacting the Middle Peninsula region. The Local Planning Team also changed the plan from a natural hazards mitigation plan to an all hazards mitigation plan in order to include air quality, HAZMAT, and ditch flooding.
- Updated the prioritization worksheet for hazards impacting to include the new hazards listed above and the LPT reassessed and re-prioritized hazards. In 2010 the critical hazards included hurricanes, winter ice storms, tornadoes and coastal flooding where as in 2016 plan the most critical hazards included: Winter Storms (Ice), Coastal Flooding, Lightning, Hurricanes, and Summer Storms.
- Updated the Repetitive Loss and Severe Repetitive Loss data.

- Updated the flood plain maps with new Flood Insurance Rate Map GIS data.
- Added a description of the derecho to further the description of windstorms
- Updated wildfire data for 2010-2015 events
- Added Point Source Emissions Inventory and air quality index to describe air quality in the region

Section 5 – Hazus Assessment

- The flood, hurricane wind, and sea level rise analysis for the HIRA was completed using the FEMA Hazus – MH V2.2 software. In part it included updated data including:
    - new 2010 Census Data
    - new Hazus Dasymetric Census Geographies inventory (general building stock)
    - utilized stock Hazus inventory values (Version 2.2 – Census 2010)
    - All modeling utilized stock Hazus facilities
    - Utilized 1 square mile drainage runs instead of 10 square mile drainage runs used in the 2010 analysis
- Integrated and utilized new coastal elevation studies from FEMA
- Integrated and utilized coastal studies from the US Army Corps of Engineers. This included 1% depth grids.
- Developed hot spot maps that identified the location where the loss would be the highest
- Methodology of Hazus analysis has been added to the Appendices (Appendix J)

Section 6 – Capability Assessment

- Added capability assessment tables to this updated plan that focus on the planning and regulatory, administrative and technical, education and outreach, and financial capabilities of each Middle Peninsula localities.
- Included National Flood Insurance Program compliance tables to the report (Appendix K)
- Updated the Stormwater Management Ordinance paragraph to reflect Virginia's stormwater management regulations.

Section 7 – Review of Strategies from the 2010 Middle Peninsula Natural Hazards Mitigation Plan (MPNHMP)

- Updated the status of mitigation strategies.
- Color coated the tables of strategies to show those strategies that have been completed.
- Added multiple updated to goal 1: Prevent Future Hazard Related Losses, including:
    - Added dates of when localities adopted ordnances to implement the Drought Response and Contingency Plan which was a strategy from the 2010 plan.
    - Included dates of when localities adopted new Flood Insurance Rate Maps.

Section 8 - New Mitigation Goals, Objectives and Strategies

- Color coated the "Goals", "Objectives" and "Strategies"
- Updated repetitive loss properties and sever repetitive loss properties in the Middle Peninsula.
- Updated flood prone roads in Strategy 1.1.6
- Merged Strategy 1.1.6 and 1.1.16. The Local Planning Team believed that these strategies duplicated each other and could be merged into one.
- Added Strategies 1.1.19 and 1.3.1 and added Objective 1.3.

  - Strategy 1.1.19 focuses on integrating mitigation strategies into locality plans, policies, codes and programs across disciplines and departments.
  - Objective 1.3 focuses on localities supporting implementation of structural and nonstructural mitigation activities to reduce exposure to natural and man-made hazards
  - Strategy 1.3.1 focuses on specific mitigation projects to protect public and private property from natural hazards.
- Updated strategies with localities interested in participating:

Strategy	**Locality(ies added to the Strategy**
1.1.1	King William County
1.1.2	Town of Urbanna
1.1.4	Middlesex and King William Counties
1.1.5	Gloucester, Mathews, and Middlesex Counties and the Town of West Point
1.1.7	Gloucester and Mathews Counties and the Town of West Point
1.1.10	Middlesex County
1.1.11	King William County
1.1.18	Middlesex and Gloucester County
1.1.19	All nine Middle Peninsula Localities were added
1.3.1	Gloucester County
3.1.5	King William County
3.17	Middlesex and King William Counties

Section 9 – Implementation Plan

- Included how this plan will be integrated into locality plans, policies, codes and programs across disciplines and departments.
- Included information about how the Chesapeake Bay Nation Estuarine Research Reserve intents to educate students and teacher about climate science, which will assist in developing more resilient communities.

Section 10 – Plan Adoption

- The dates that Board of Supervisors and Town Councils adopt the 2016 All Hazards Mitigation Plan will be updated.

Section 11 – Plan Maintenance

- Developed a worksheet that will be used as an annual survey for localities to track progress and updates towards meeting mitigation strategies.

Section 3: Community Profile of Middle Peninsula Localities

The Middle Peninsula region encompasses six (6) counties and three (3) towns including Essex, Gloucester, King and Queen, King William, Mathews, and Middlesex Counties as well as the Towns of Tappahannock, Urbanna, and West Point (Figure 1). According to the 2010 Census, the total population of the Middle Peninsula is 90,826.

The Middle Peninsula is located on the western shore of the Chesapeake Bay, bound to the north by the Rappahannock River and to the south by the York River. As the region is located in the Virginia coastal plain, it has a relatively flat topography. The southeastern-most portions of the region are at sea level, while elevation rises to approximately 200 feet above sea level moving in a northwesterly direction.

Based on the regions low topography, 1200+ miles of coastline, and its proximity to waterways-broad rivers, meandering creeks, wide bays and tidal marshes, the Middle Peninsula is highly susceptible to floods and coastal storms. Additionally with a high water table in lower elevations of the Middle Peninsula, water cannot easily drain from land and thus exacerbates flooding from summer thunderstorms, hurricanes, nor'easters, as well as rising seas. Tidal surges associated with these severe storms often compound the flooding within this region.

While the Middle Peninsula region remains largely rural, it lies in close proximity to the metropolitan areas of Hampton Roads, Richmond and the Fredericksburg-Northern Virginia Metropolitan Areas. Suburban growth from these urban areas is spreading into the Middle Peninsula, affecting the region's natural resource-based industries and traditional rural lifestyle. For instance the region's traditional land use patterns can best be described as having:

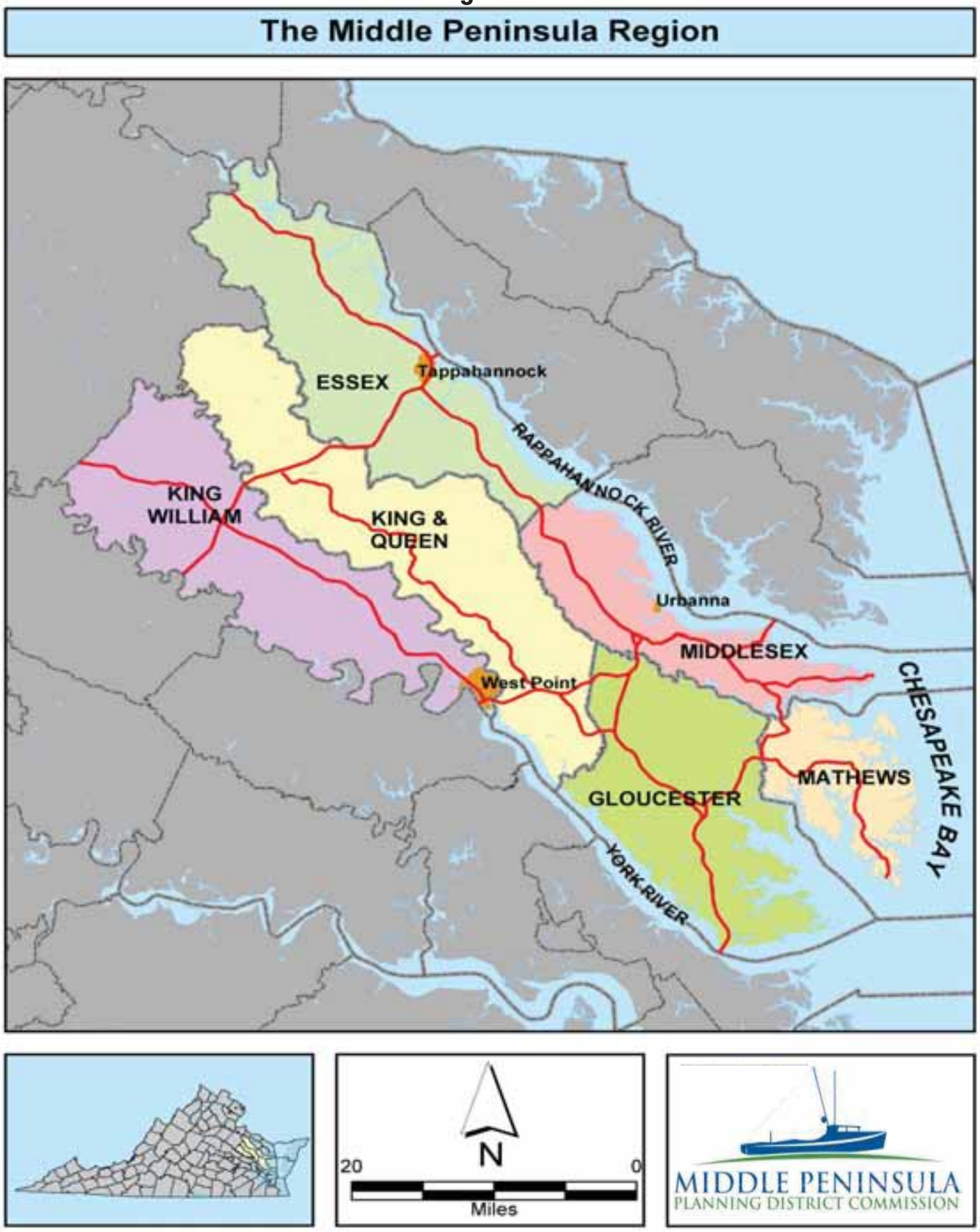
- A predominantly rural character with large, scattered farms and forested tracts;
- A number of closely-knit, small communities surrounded by working farms and forests;
- Small scale commercial fishing communities along the lower reaches of the watersheds;
- Three small towns that provide a focal point for commercial, industrial, and residential development at a modest scale; and
- Government operation centers that provide another focal point of local activity in the region.

However the last 20 to 30 years, the region has seen a slight shift to:

- Growing sectors in tourism, retiree housing and related retiree services;
- Large forested tracts are converting from woodlands to residential development;
- Waterfront communities transitioning from commercial fisheries with a reduced level of fisheries to an increasing number of marinas and residential developments; and
- Commercial development being located along Route 33 in Middlesex, Route 360 in King William, and Route 17 in southern Gloucester County between the Court House and the Coleman Bridge.

In summary, changes in land uses that concentrate development along the region's waterfront poses the greatest risk for hazard prevention and mitigation activities – particularly in the low-lying southeastern areas of Gloucester, Mathews, and Middlesex Counties.

Figure 1:



Essex County

Essex County is predominantly a rural county located at the northern end of the Middle Peninsula. It is bound on the north and east by the Rappahannock River, on the south by Middlesex County and on the west by Caroline and King and Queen Counties. The County comprises of approximately 261 square miles (Essex County Comprehensive Plan, 2015). Residential developments exist as small rural communities along the Rappahannock River or along the primary and many secondary roads. With a history of slow/gradual growth and strong land use control regulations, the County has remained mostly rural.

According to the 2010 Census figures, the population in Essex consists of 11,151 people, an increase of 1,162 (11.63%) from the 2000 Census. The population has 5,274 men and 5,877 women and is comprised of 6,370 whites, 4,247 African Americans, and 534 people of other races. The population aged somewhat during the period from 2000 to 2010 with a modest reduction in school age population. These trends suggest that County programs may require redirection to meet the specific needs (i.e. health care, transportation, etc.) of an older population. A low to moderate trend in growth in the County's population is expected to continue into the future.

Town of Tappahannock

Tappahannock is an incorporated town located along the shores of the Rappahannock River in the east-central portion of Essex County. The Town of Tappahannock is both the employment and population center of the County. Occupying less than three square miles of land, Tappahannock features an active waterfront, a historic downtown, residential subdivisions, schools, public buildings, an old airport and industrial center, a business corridor, and extensive wetland areas. Tappahannock serves as the county seat for Essex County.

According to the 2010 Census, the population in Tappahannock consists of 2,375 people, an increase of 307 (14.8%) from the 2000 Census. The population has 975 men and 1,400 women and is comprised of 1,076 whites, 1,128 African Americans, and 171 people of other races.

Gloucester County

Gloucester County's proximity to urban centers to the south, and the northwestward migration of suburban development from the greater Hampton Roads/Newport News area has transformed portions of the County into a suburban landscape. This is most pronounced at the southern reaches of the County from the Historic Court House Village and Gloucester Point. Residents from the Hampton Roads area and other areas of the urban crescent are lured to the County by the promise of lower taxes, lower housing costs, rural character, and relative freedom from the congestion evident in metropolitan areas. This has created increased traffic volumes on the limited collector roads not designed for such heavy use within the county. Commuters, travelers and trucks from the Middle Peninsula and points north use Route 17 as an alternative to interstate 64 to get to the Peninsula, Southside and the Outer Banks. Route 17 is the primary route through Gloucester and is also the heart of Gloucester's Development District where public water and sewer are available and where the county has expressed a desire to see continued economic development along this corridor. The need for alternative routes and connection to take local traffic off of Route 17 to reduce congestion is one of the goals expressed in the adopted Comprehensive Plan and the proposed update to the plan.

Despite the urban/suburban character of the County's Development District, the majority of the County remains relatively rural with low density development and active farm and timberlands. Much of the eastern portion of the County, east of Route 17 and South of Route 3/14 is characterized by low lying lands, low to moderate density housing and waterfront homes and communities. North of the Court House is very similar to other localities on the Middle Peninsula with a mixture of low and moderate density residential development and large tracts of farms and forests. Route 33, which runs along the northern portion of the County, provides convenient access from the interstate to upper Gloucester and Mathews County.

According to the 2010 Census, the population in Gloucester County consists of 36,858 people, an increase of 2,078 (5.97%) from the 2000 Census. The population has 18,239 men and 18,619 women, comprised of 32,149 whites, 3,197 African Americans, and 1,512 people of other races. A moderate trend in growth is expected to continue in the future (Virginia Employment Commission, 2013).

King and Queen County

King and Queen County is located in the north-central portion of the Middle Peninsula and is bounded on the west by the York and Mattaponi Rivers which separate King and Queen from King William and New Kent Counties. The Dragon Swamp separates King and Queen County from Essex, Middlesex and Gloucester Counties on the east. Often called the "shoestring county", King and Queen County is about 65 miles long and less than 10 miles wide. Farming and logging continue to be the mainstays to the local economy.

King and Queen County is the least populous county of the Middle Peninsula and one of the most rural counties in Virginia today. In 1990, the population density was only 20 people per square mile. Nearly three-fourths of the County's 318.1 square miles of land area is timberland. Over the past four decades, King and Queen County has experienced slow, but steady population growth. In 2010 the population density was 22 people per square mile.

According to 2010 Census figures, the population in King and Queen County consist of 6,945 people, an increase of 315 (4.8%) from the 2000 Census. The population has 3,454 men and 3,491 women and is comprised of 4,663 whites, 1,975 African Americans, and 307 people of other races. A moderate trend in population growth is expected to continue in the future and the overall population distribution appears to be experiencing a gradual shift to the upper and lower ends of the County where transportation routes to jobs and retail markets are most favorable.

King William County

Located approximately 20 miles northeast of the City of Richmond, King William County is rapidly growing into a bedroom community of the metro-Richmond area. Much of the county's 286 square miles are made up of gently rolling farmland and scenic timberland located between the Pamunkey and Mattaponi Rivers. Farming and logging continue to be the mainstays of the local economy. King William is home to the only Native American Indian Reservations in the Commonwealth and to the oldest courthouse in continuous use in the United States. The Mattaponi and Pamunkey Tribes operate fish hatcheries on the rivers. Residents and visitors enjoy the numerous recreational opportunities that the rivers provide.

According to 2010 Census figures, the population in King William County consists of 15,935 people, an increase of 2,789 (21.2%) from the 2000 Census. The population has 7,759 men and 8,176 women and is comprised of 12,297 whites, 2,819 African Americans, and 819 people of other races. Projections indicate that King William County will continue to experience moderate to accelerated population growth. By the year 2020, it is estimated that the County's population will grow at a rate of 8.62%, increasing the population by 1,373 persons. Growth management will become more important as competing uses vie for space and facilities.

Town of West Point

The Town of West Point lies at the extreme southern end of King William County where the Mattaponi and Pamunkey Rivers join to form the York River. The town is relatively flat, with large sections comprised of tidal marshes, particularly along the Mattaponi River. The highest elevations occur at the northern end of town at a height of 30+ feet above sea level. Most of the Pamunkey River waterfront is on a bluff averaging 20 feet in height. Union forces destroyed the town and the railroad, completed in 1859, during the Civil War. Only four houses survived the torching and remain intact today. West Point became an incorporated town in 1870. During the late 19th and early 20th centuries, West Point was a popular tourist destination. After the decline of tourism, a shipyard, built in 1917, and a pulp mill, built in 1918, revitalized the town.

The river areas surrounding the town are primarily used for recreation and barge access to the WestRock, a Meadwestvaco and Rock Tenn Corporation, where pulping operations convert wood chips, sawdust and recyclable paper products into pulp for use in producing various types of paperboard. The Old Dominion Grain Corporation also benefits from barge access.

According to 2010 Census figures, the population in King William County consists of 3,306 people, an increase of 400 (15.4%) from the 2000 Census. The population has 1543 men and 1763 women and is comprised of 2618 whites, 509 African Americans, and 179 people of other races.

Mathews County

Mathews County is located at the eastern tip of the Middle Peninsula. The County is bordered mostly by water, with the Chesapeake Bay to the east, the Mobjack Bay to the south, the North River to the west, and the Piankatank River to the north. Except for approximately five miles that border Gloucester County, the County's perimeter is formed by its 217 mile shoreline. Mathews is predominantly a rural community that has attracted an increasing number of retirees and vacationers. More than half of the working residents earn their living outside the County. The mainstays of the local economy are agriculture, trade, seafood, and tourism.

Much of the housing in Mathews is traditional single family dwellings, but the County also has a growing number of manufactured homes and vacant seasonal housing (built typically for summer occupancy). Seasonal housing, in the form of cottages, recreational vehicles, rental mobile homes, and a few condominium units increased in number from 448 in 1970, to 583 in 1980, to 783 in 1990. Residents of seasonal housing are often not accounted for in the census counts because the units were not occupied during the census survey. It is estimated that only about 75% of the housing units in Mathews County are occupied year-round, adding significantly to the summer population of Mathews County.

According to 2010 Census figures, the population in Mathews County consists of 8,978 people, a decrease of 229 (-2.5%) from the 2000 census. The population has 4,363 men and 4,615 women and is comprised of 7,898 whites, 823 African Americans, and 257 people of other races. Projections indicate that Mathews County will continue to experience low population growth. By the year 2020, it is estimated that the County's population will grow at a rate of 3.41%, increasing the population by 9,284 persons. Mathews County's population changed little between 1840 and 1900. The population peaked in 1910 with 8,922 residents, but gradually declined over the next five decades to a low point of 7,121 in 1960. This was in keeping with a national trend of population shifts from rural to urban areas because of the increased job opportunities in the cities. The population began to grow in the 1970's and it took until the mid 1990's before the population reached the peak reported in 1910.

Middlesex County

Middlesex County, located at the eastern end of the Middle Peninsula, is comprised of 131 square miles of land and 135 linear miles of shoreline. The County is surrounded by three significant waterways; the Rappahannock River to the northeast, the Piankatank River to the southwest, the Chesapeake Bay to the east. The County is also bordered by Gloucester County to the southeast, King and Queen County to the West, and Essex County to the north. The geographic location of Middlesex County, particularly with the close proximity to two significant rivers, the Chesapeake Bay and the Atlantic Ocean, make Middlesex County communities much more vulnerable to tropical weather events, affecting the eastern seaboard of the United States. The county government operations are managed by a County Administrator, who is appointed by a five-person elected Board of Supervisors. The Government Seat, Board of Supervisors Meeting Room, and Courts Complex, are located in the area known as Saluda, Virginia. The Middlesex County School System is comprised of an elementary, middle and high school, with the School Board Administration Offices located in the Cooks Corner Office Building, just east of Saluda.

Middlesex has remained largely rural over the years, with farming, forestry, and fin and shell fishing providing the principal elements of the economic base. The County's relatively remote geographical location adds to the community's rural character. The 2013 Census reports the county population to be 10,762 full-time residents, a decrease of 197 (2%), from the 2010 census of 10,959. The population is made up by 5,413 females, and 5,349 males, comprised of 8,545 Whites, 1,937 African-Americans, and 280 people of other races. A total of 3,056 residents, or 28.4% of the population of Middlesex, are over 65 years-of-age. With the population dropping 2% in the past three years, it is estimated that the county's population will not see any drastic fluctuations, up or down, throughout the next decade.

The county population lives in 7,184 dwellings, with only 3.5% of the occupancies being comprised of multi-family dwelling units, a figure significantly lower than the Commonwealth's average of 21.7%. County officials estimate that 30% of the housing units in the community are seasonal, increasing the population between May and October with an additional 20,000 residents. Middlesex, Virginia, is home to one of the top boating populations in the Commonwealth of Virginia, another factor which adds to the seasonal population of the county.

Public Safety Services in Middlesex County are provided by the Office of the Sheriff, four individual volunteer fire companies, Deltaville, Hartfield, Urbanna, and Waterview; two volunteer rescue squads, Deltaville and Urbanna. The collective departments work hand-in-hand responding to law enforcement situations, fires, medical emergencies, and all-hazards incidents throughout the community. All Emergency Management activities, including operations of the Emergency Operations Center as well as maintenance and oversight of the Emergency Operations Plan, are managed by a county appointed Emergency Services Coordinator. This individual works in conjunction with the Middlesex Emergency Management Director, who is an appointed member, from the Board of Supervisors. The Emergency Services Coordinator also works in conjunction with the leadership and members of the volunteer fire departments and volunteer rescue squads.

Town of Urbanna

The Town of Urbanna is located in Middlesex County on the Rappahannock River on a finger of land bounded by Perkins Creek and Urbanna Creek. The Town is one of America's original harbor towns and is located approximately five miles from Saluda, VA. Incorporated in 1902, the present town boundary comprises an area of about one-half square mile. The town operates an active boat harbor which is a major gateway for the fishing and recreational boating industries serving the area.

According to 2010 Census figures, the population in the Town of Urbanna consists of 476 people, a decrease of 67 (-12.3%) from the 2000 Census. The population has 204 men and 272 women and is comprised of 431 whites, 35 African Americans, and 10 people of other races. The Town of Urbanna experiences a seasonal swelling of the population to well above 2,000 people within the town and at the nearby Bethpage Campground due to seasonal use of vacation homes and campsites. This influx of tourists brings in much needed revenue and helps support the service industry and the tax base for the county. Also, the Town is the location of an annual Urbanna Oyster Festal. Since 1958, this event features oyster specialties and other Chesapeake Bay seafood, a parade, a fine arts exhibit and visiting tall ships. Crowds for the two-day event reach approximately 75,000 people.

Regional – Health Opportunity Index

The Health Opportunity Index (HOI) is a measure of social determinants of health at the census tract level. It is a composite measure comprising of 13 indices that may impact social conditions thought to influence an individual's ability to live a long and health life. It does not, however, include data on disease incidence. Indices taken into account include:

Affordability: Measures how affordable an area is

- The affordability index is developed to measure the proportion of income spent on housing and transportation. The index of affordability is calculated by combining housing and transportation costs in a neighborhood and dividing that number by income

Towsend Material Deprivation Index ("Towsend Index"):

- Townsend deprivation index is a measure of material deprivation. According to Townsend, "Material deprivation entails the lack of goods, services, resources, amenities and physical environment which are customary, or at least widely approved in the society under consideration
- 4 indicators make up Towsend:
    - overcrowding (>2 persons per room),
    - unemployment,
    - % of persons no vehicle or car,
    - % of person who rent

Job Participation Index: Information about the workforce

- Job Participation Rate is the percentage of individuals 16-64 years of age in the active labor force. The job participation rate is often used by economics as an indicator for economic development and growth

Employment accessibility index: you may have a workforce but how accessible are

- Poor job access leads to difficulties in job search or job retention and, consequently, to poverty and socioeconomic disadvantages
- Employment accessibility index: you may have a workforce but how accessible are they to the potential jobs --- how far are you (distance) from a potential job. In other words, the index is based on jobs and distance decay function
- Ownership of a vehicle plays a function

EPA (Air quality Index):

- Measures air pollution from road, off-road, non point (fertilizer, farming, erosion)
- Areas of high concentration are more vulnerable to environmental pollution

***Population Weighted Density (Dasymetric)**

- Weighted density is to capture the density at which the average person lives

- Example Craig County has 1 census tract which is large, however there is a concentration of people live in a small area; we weighted the density of the population by subtracting the census tracts that had no population to better predict where the concentration of people reside

Population Churning: how mobile the people are what is the turnover of the people

- Population churning rates relate the combined inflow and outflow for an area to the resident population.
- The rates can provide a useful measure of the potential disruption to local services caused by migration into and out of the Census tract.

Food Accessibility Index

- Low access was measured as living far from a supermarket, where 1 mile was used in urban areas and 10 miles was used in rural areas to demarcate those who are far from a supermarket.

Access to Care

- HRSA definition based on distance. Look at the population at the center of the census tract and look at the number of FTEs within a 30 mile radius
- Combined with the proportion of insured.

Walkability is accessed using 4 concepts:

- ***Density – Residential and employment***
  - Indicator: Total acidity units per acre of land
  - Measures the concentration of activity types within a walkable area
- ***Diversity – Land use and destinations***
  - Indicator: Range of land uses by census tract
  - Measures the mix of activities available within a walkable area
- ***Design – Built environment and safety features***
  - Indicator: Number of street crossings by census tract
  - Measures the degree of connectivity to support safe pedestrian travel
- ***Distance – Transit accessibility***
  - Indicator: Aggregate frequency of transit service per square mile
  - Measures level of accessibility for pedestrian to reach a transit stop

Education Index

- Average years of schooling
- Preschool through doctorate (this index is weighted based upon how far you have advanced in education
- Higher the number the higher average number of schooling

Income Inequality Index (GINI coefficient): Measures inequality of income

- The GINI coefficient (also known as the index of income concentration).
- Measures inequality of income.
- Measures how homogeneous or diversity of actual earned income by neighborhood

Spatial Segregation Index

- Measures how (whether the racial composition of the population of the census tract has the same composition as the state).
- It also measures the influence of those census tracts that are adjacent

The following images provide visuals of the entire region's HOI (Figure 2) and the results from the walkability index, average years in schooling, local multi-Group Spacial Dissimilarty Indx and the GINI Index of Income Inequality (Firgure 3).

Figure 2: Middle Peninsula Region's Health opportunity index (Virginia Department of Health, 2015)

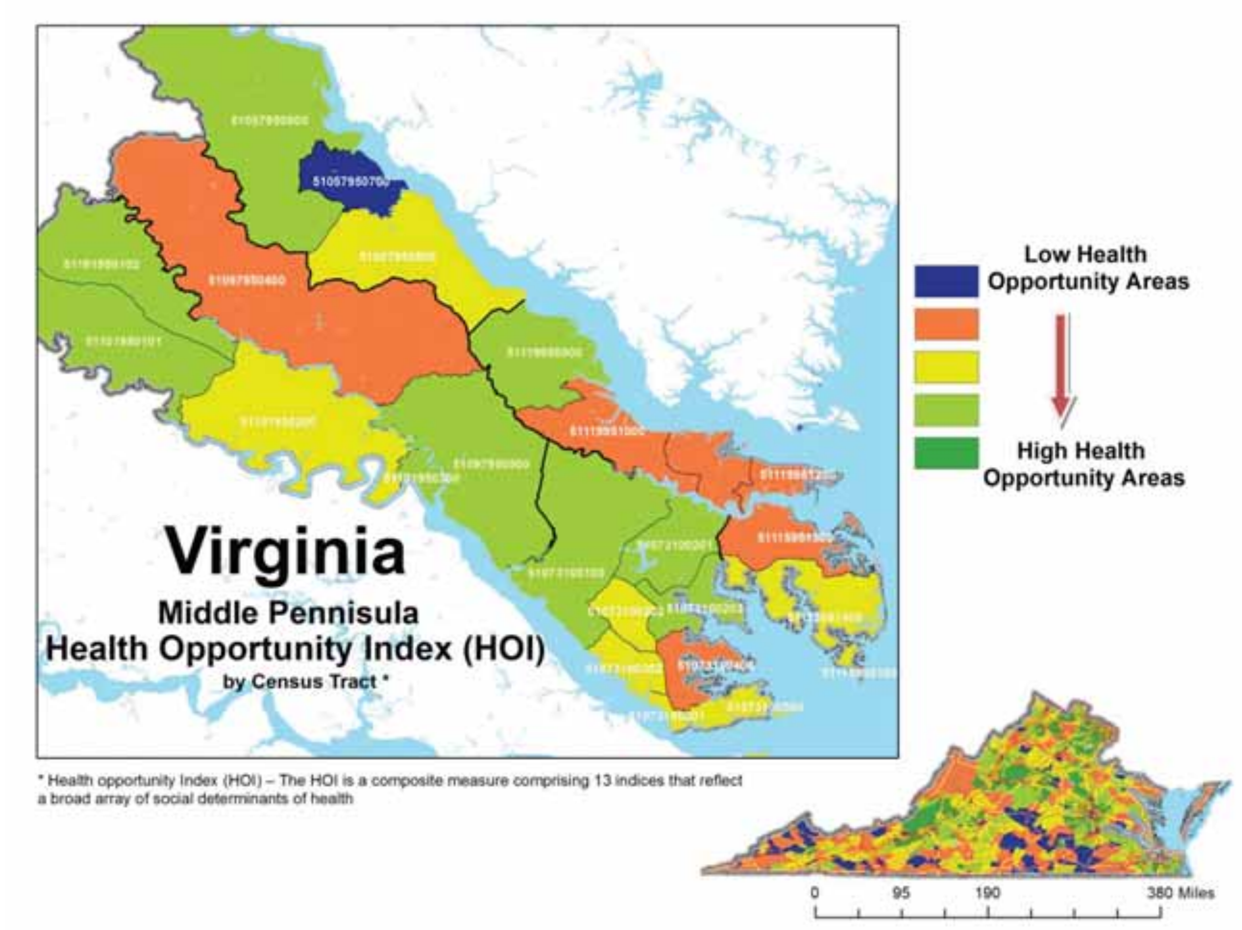
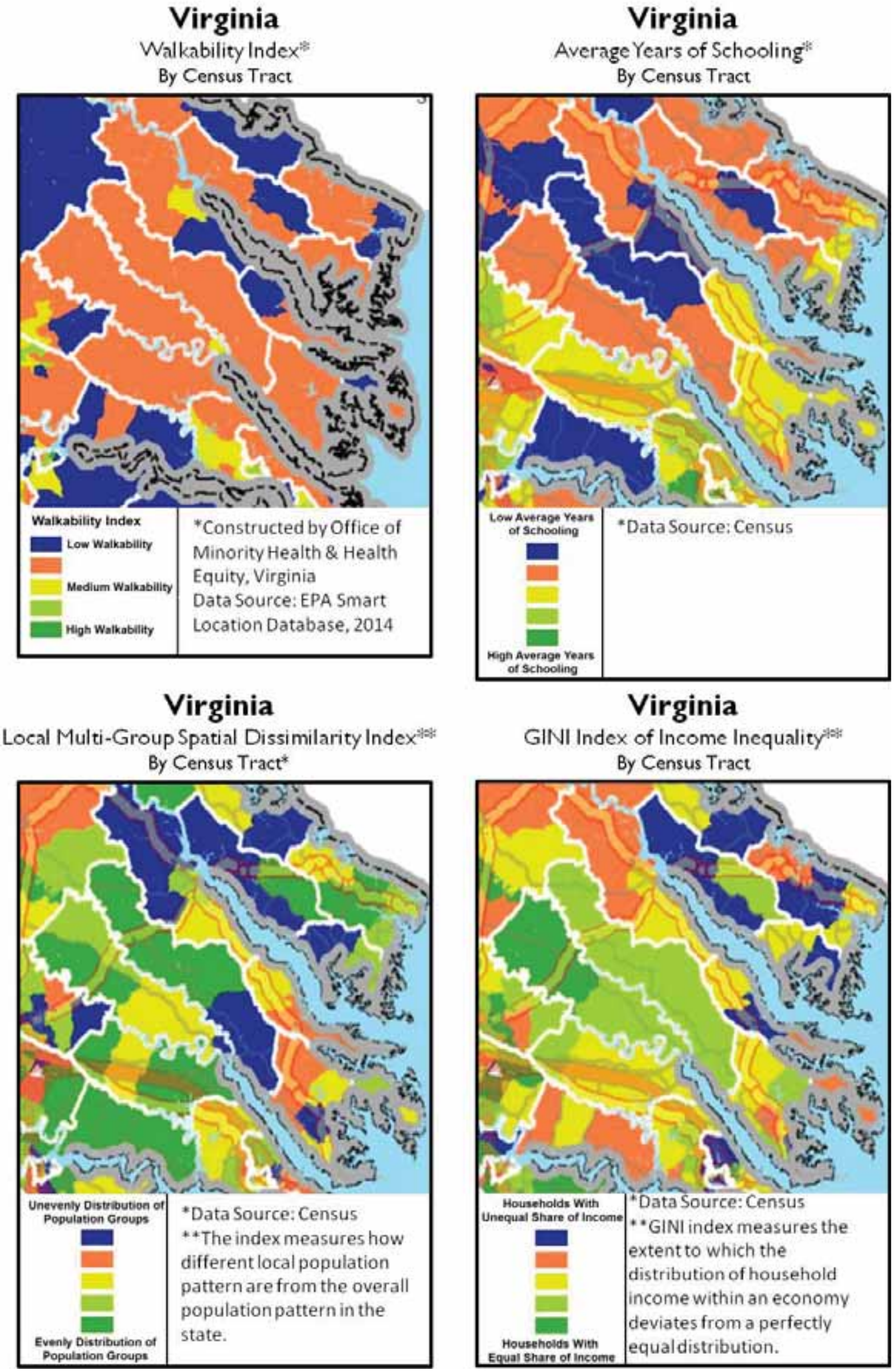


Figure 3: Middle Peninsula Region's walkability index, average years in schooling, local multi-Group Spacial Dissimilarty Indx and the GINI Index of Income Inequality (VDH, 2015).



Economic Resiliency

In 2013, the MPPDC adopted a Regional Comprehensive Economic Development Strategy (CEDS) that sets forth goals and objects necessary to improve the regional economy. As hazards pose threats to the local and regional economy, economic resiliency of the region is critical to the regions long term success. The three primary attributes of economic resiliency include: the ability to recover quickly from a shock, the ability to withstand a shock, and the ability to avoid the shock altogether.

Based on mapping efforts by the Bureau of Labor Statistics (BLS) in 2012, maps of Employment in Hurricane Storm Surge Flood Zones were developed that provide an example of impacts to employment in hurricane storm surge flood zones in Gloucester, Mathews, and Middlesex Counties (Figures 4-6). These maps show that in Mathew County 61% of all business establishments would be impacted by hurricane storm surge that would reduce quarterly revenues by at least 54%. In Middlesex County 7.8% of all business establishments would be impacted by hurricane storm surge that would reduce quarterly revenues by at least 6%. In Gloucester County 17% of all business establishments would impacted by hurricane storm surge that would reduce quarterly revenues by at least 8%. Needless to say this will have economic consequences to the overall region.

Figure 4: Employment in Hurricane Storm Surge Flood Zones in Mathews County (BLS, 2012).

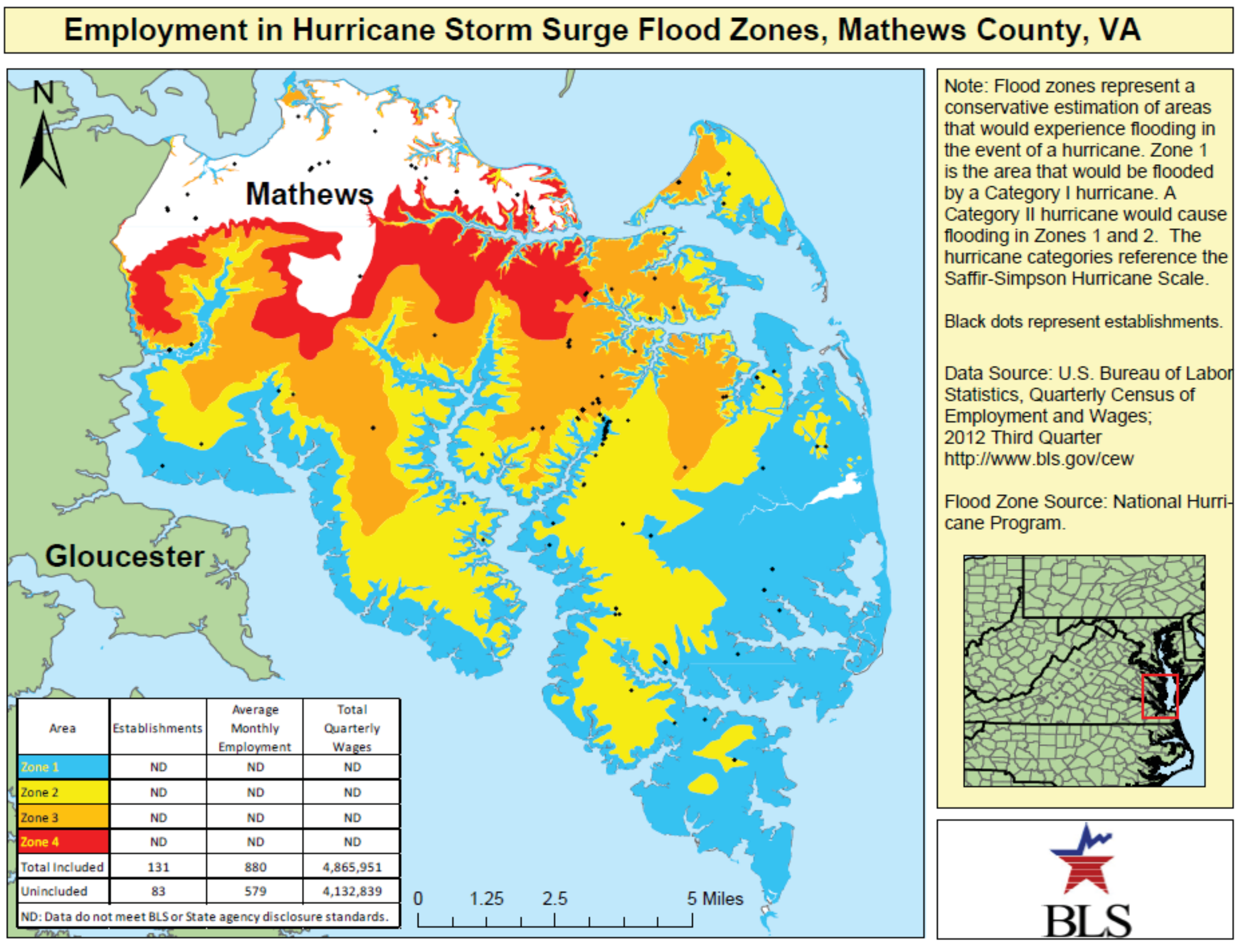
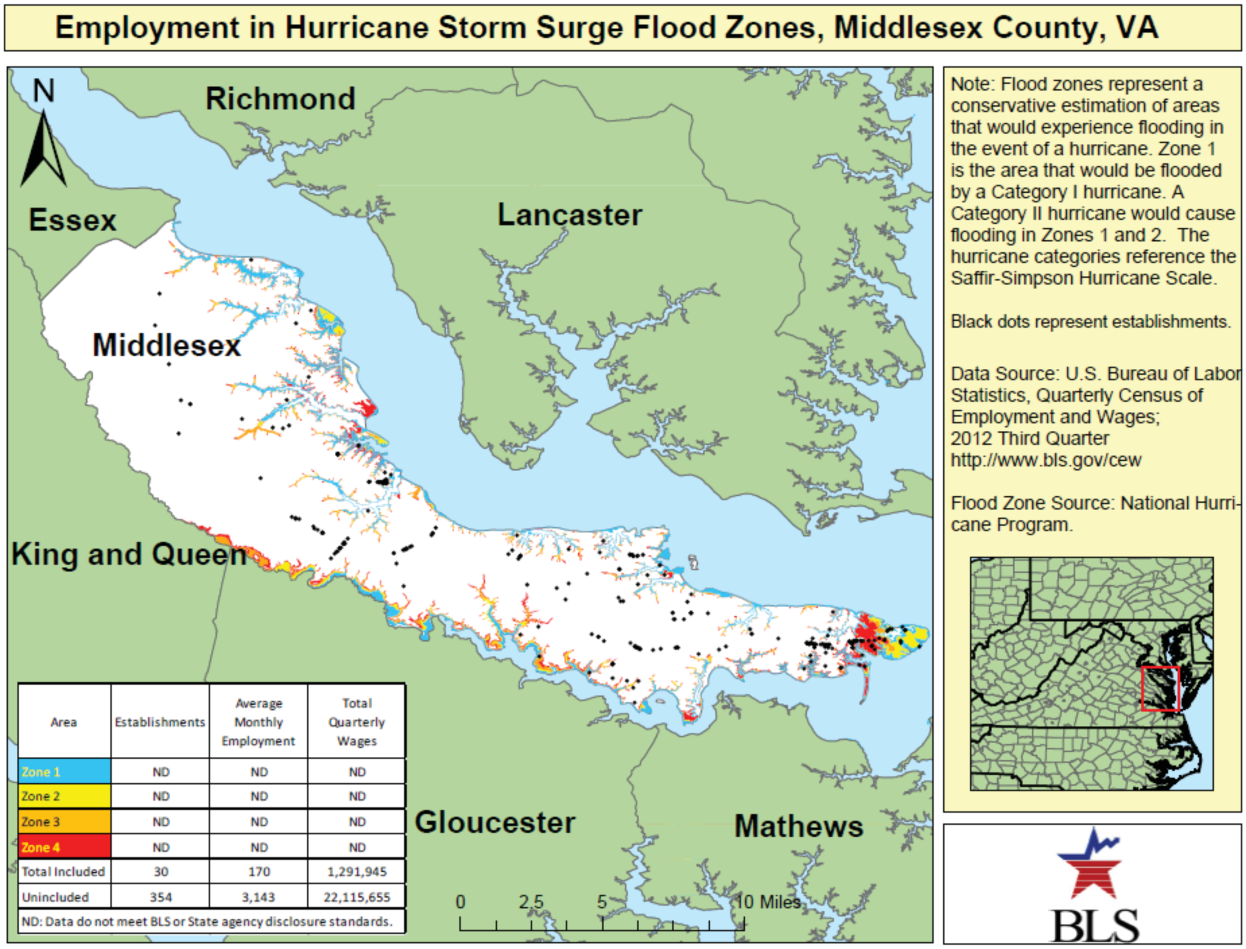


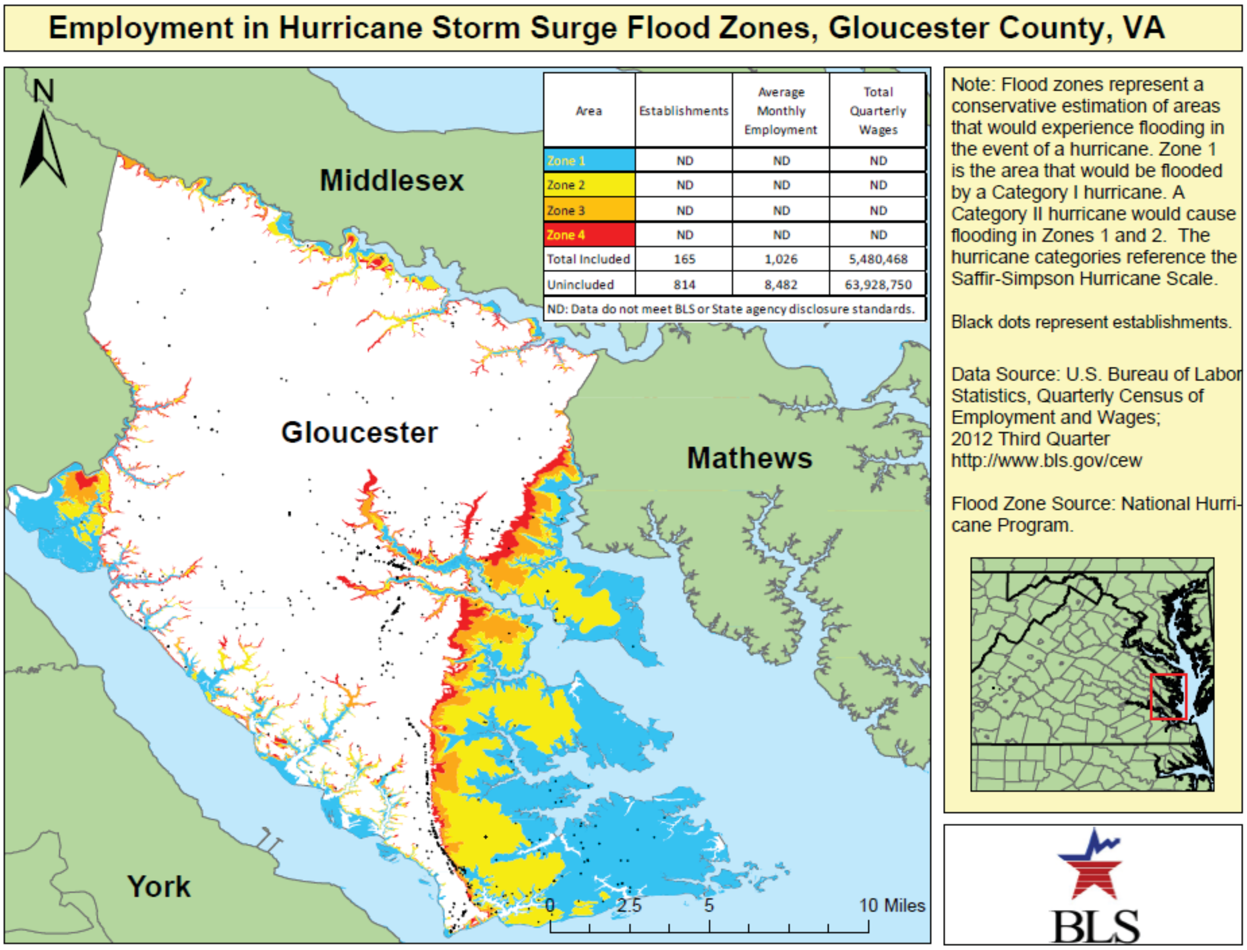
Figure 5: Employment in Hurricane Storm Surge Flood Zones in Middlesex County (BLS, 2012).



Area	Establishments	Average Monthly Employment	Total Quarterly Wages
Zone 1	ND	ND	ND
Zone 2	ND	ND	ND
Zone 3	ND	ND	ND
Zone 4	ND	ND	ND
Total Included	30	170	1,291,945
Unincluded	354	3,143	22,115,655

ND: Data do not meet BLS or State agency disclosure standards.

Figure 6: Employment in Hurricane Storm Surge Flood Zones in Gloucester County (BLS, 2012).



Area	Establishments	Average Monthly Employment	Total Quarterly Wages
Zone 1	ND	ND	ND
Zone 2	ND	ND	ND
Zone 3	ND	ND	ND
Zone 4	ND	ND	ND
Total Included	165	1,026	5,480,468
Unincluded	814	8,482	63,928,750

ND: Data do not meet BLS or State agency disclosure standards.

Therefore to minimize impacts, not only from hurricane storm surge, but from all other hazards indentified in this plan, local business leaders should anticipate, prepare, and plan for impacts and consider how to recover if such events occur.

Section 4 – Hazard Identification and Risk Assessment

To update this hazard identification section MPPDC staff engaged community partners as well as the general public concerning the nature of hazards that may potentially threaten the Middle Peninsula localities. A Local Planning Team (LPT) was created to provide local insight and expertise. The LPT identified hazards of the Middle Peninsula, how they should be prioritized as critical, moderately-critical and non-critical hazards, and they also decided that an in depth analysis was needed for critical hazards. Non- Critical and moderately hazards were not re-analyzed with the exception of recent occurrences due to their minimal impact.

Based on the Federal Guidelines [Disaster Mitigation Act of 2000, *§201.1(b)]*, the Hazards Identification and Risk Assessment (HIRA) is only focused on natural hazards and their impacts. It measures potential loss of life, personal injury, economic impairment, and property damage resulting from natural hazards that threaten the Middle Peninsula. The Middle Peninsula HIRA involved:

1. Hazard Identification,
2. Risk Assessment Analysis, and
3. Financial Loss Estimations.

4.1 Hazard Identification

The LPT first reviewed and evaluated the 2010 list of hazards that could potentially affect the Middle Peninsula and added four new hazards that they deemed to be of concern to the region (Table 2). However instead of just focusing on natural hazards the LPT decided to be inclusive of all hazards that may threaten Middle Peninsula localities.

Table 2: List of Hazards. *The LPT identified the following as hazards that may impact the region.*	
• Hurricanes	• Earthquakes
• Ice Storms	• Shrink-swell Soils
• Tornadoes	• Extreme Cold
• Coastal Flooding/Nor-easters	• Extreme Heat
• Coastal/Shoreline Erosion	• Land Subsidence/Karst
• Sea Level Rise (added in 2010)	• Landslides
• Snow Storms	• Tsunamis
• Riverine Flooding	• Volcanoes
• Wildfires	• **Air Quality (added in 2016)**
• High Winds/Windstorms	• **HAZMAT (added in 2016)**
• Dam Failure	• **Ditch Flooding (added in 2016)**
• Droughts	• **Summer Storms (added in 2016)**
• Lightning	

Based on discussions had by the LPT, four new hazards were added to the list they have caused new concern to the region. More specifically the LPT agreed to add the following new hazards:

HAZMAT is carried by a number of vehicles throughout the region, and while the Commonwealth has a HAZMAT plan, local jurisdictions would be the first responders on scene if an accident/spill where to occur.

Ditch Flooding is a specific hazard that results in flooded roads during localized and widespread events in the whole region. This hazard specifically causes issues for first responders attempting to reach people in distress.

Summer Storms include straight line wind events and are a clearly defined natural hazard that can unexpectedly cause downed trees, power outages, etc. These storms are specific to the warmer months and are clearly different and separate from other storm events.

Air Quality is a hazard that affects many citizens, specifically those suffering from asthma. Developing an Air Quality alert system for our area would be beneficial.

In conjunction with the list of hazards, the LPT reviewed the 2010 prioritization (Table 3) of natural hazards as a result of utilizing the Hazards Vulnerability Tool worksheet provided by VDEM staff (originally designed to estimate medical center hazard and vulnerability by Kaiser Permanente).

Table 3: Prioritization Worksheet for Hazards on the Middle Peninsula *(2010 worksheet)*

MIDDLE PENINSULA HAZARD AND VULNERABILITY ASSESSMENT TOOL
NATURAL HAZARDS -- SUMMARY SHEET

EVENT	PROBABILITY	HUMAN IMPACT	PROPERTY AND FACILITY IMPACT	BUSINESS IMPACT	Mitigation Options	UNMITIGATED RISK	UNMITIGATED RANKING
	Likelihood this will occur	*Possibility of death or injury to public and responders*	*Physical losses and damages*	*COOP and Interruption of services*	*Pre-Planning*	*Relative Threat*	*Based only on probability and threat*
SCORE	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 - 100%	
Hurricanes	3	3	3	3	2	92%	
Winter Storms (Ice)	2	2	2	3	2	50%	
Tornados	2	2	2	2	2	44%	
Coastal Flooding	3	2	3	2	2	75%	
Coastal/Shoreline Erosion	3	1	2	1	2	50%	
Sea Level Rise	3	0	2	2	2	50%	
Winter Storm (Snow)	2	2	2	2	2	44%	
Wildfire	2	1	1	1	2	28%	
Riverine Flooding	2	2	1	1	2	33%	
High Wind/Windstorms	2	2	2	1	1	33%	
Dam Failure	2	1	1	1	2	28%	
Drought	2	0	1	2	2	28%	
Lightning	3	1	2	2	1	50%	
Earthquake	1	0	0	0	0	0%	
Shrink-Swell Soils	2	0	1	0	1	11%	
Extreme Cold	1	2	0	0	1	8%	
Extreme Heat	2	2	0	0	1	17%	
Landslides	1	0	0	0	0	0%	
Land Subsidence/Karst	1	0	0	0	0	0%	
Tsunami	1	0	0	0	0	0%	
Volcano	0	0	0	0	0	0%	
AVERAGE	2.27	1.27	1.67	1.53	1.67	25%	

**Threat increases with percentage.*

UNMITIGATED RISK=		PROBABILITY * IMPACT	
	0.25	0.63	0.39

KAISER PERMANENTE.

Modifications by:
Revised: 2/25/2010

Similar to the 2006 and 2010 updates, the LPT agreed to continue using the Kaiser Permanente Hazard Vulnerability Assessment Tool for this AHMP update. In doing so, this would provide a measure of continuity and consistency between the MPAHMPs. Therefore the emergency services coordinator/manager from each of the nine jurisdictions were asked to complete the vulnerably worksheet for their locality and turn it into the MPPDC Regional Emergency Preparedness Planner. Emergency services coordinators/managers evaluated each hazard based on five criteria to rank the hazards from highest to lowest priorities. The five categories included the probability based on past events, the potential impacts to structures, primary impacts (percentage of damage to a typical structure or industry in the community), secondary impacts (based on impacts to the community at large), and potential mitigation options. The definitions given in Table 4 were used as a standard for evaluation of all the hazards.

Table 4: Prioritization Criteria for Hazards on the Middle Peninsula
Probability - *Frequency of occurrence based on historical data of all potential hazards*
Level 0 Not Applicable 1 Unlikely (less than 1% occurrence: no events in the last 100 years) 2 Likely (between 1% and 10% occurrence: 1-10 events in last 100 years) 3 Highly Likely (over 10% occurrence: 11 events or more in last 100 years)
Affected Structures - *Number of Structures affected*
Level 0 Not Applicable 1 Small (limited to 1 building) 2 Medium (limited to 2-10 buildings) 3 Large (over 10 buildings)
Primary Impacts - *Based on percentage of damage to a typical structure or industry in the community*
Level 0 Not Applicable 1 Negligible (less than 3% damage) 2 Limited (between 3% and 49% damage) 3 Critical (more than 49% damage)
Secondary Impacts - *Based on impacts to the community at large*
Level 0 Not Applicable 1 Negligible (no loss of function, no displacement time, no evacuations) 2 Limited (some loss of function, displacement time, some evacuations) 3 Critical (major loss of loss of function, displacement time, major evacuations)
Mitigation Options - *Number of cost effective mitigation options*
Level 0 Not Applicable 1 Many (over 3 cost effective mitigation options) 2 Several (2-3 cost effective mitigation options) 3 Few (1 cost effective mitigation option)

After much consideration of the criteria, as well as consider of readily available data, local knowledge and observations the LPT re-ranked the hazards for this update. Table 5 provides the new ranking of the hazards.

Table 5: Prioritization worksheet for Hazards in the Middle Peninsula for the 2016 update.

MIDDLE PENINSULA HAZARD AND VULNERABILITY ASSESSMENT TOOL
NATURAL HAZARDS -- SUMMARY SHEET
Priority Worksheet for Hazards

						UNMITIGATED	
EVENT	PROBABILITY	HUMAN IMPACT	PROPERTY AND FACILITY IMPACT	BUSINESS IMPACT	Mitigation Options	RISK	RANKING
	Likelihood this will occur	*Possibility of death or injury to public and responders*	*Physical losses and damages*	*COOP and interruption of services*	*Pre-Planning*	*Relative Threat*	*Based only on probability and threat*
SCORE	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 - 100%	
Winter Storms (Ice)	3	3	2	2	2	75%	1
Coastal Flooding	3	2	3	2	2	75%	1
Lightning	3	2	2	2	1	58%	2
Hurricanes	2	2	3	2	2	50%	3
Summer Storms	3	2	2	1	1	50%	3
Tornados	2	2	2	2	2	44%	4
Winter Storm (Snow)	2	2	2	2	2	44%	4
Coastal/Shoreline Erosion	2	2	2	1	2	39%	5
Wildfire	2	2	2	1	2	39%	5
Riverine Flooding	2	2	2	1	2	39%	5
Sea Level Rise	2	1	2	1	2	33%	6
High Wind/Windstorms	2	2	2	1	1	33%	6
HAZMAT	2	2	2	1	1	33%	6
Ditch Flooding	2	1	2	1	2	33%	6
Drought	2	1	2	1	1	28%	7
Extreme Cold	2	2	1	1	1	28%	7
Extreme Heat	2	2	1	1	1	28%	7
Dam Failure	1	1	1	1	1	11%	8
Earthquake	1	1	1	1	1	11%	8
Air Quality	1	1	1	1	1	11%	8
Shrink-Swell Soils	1	0	1	0	1	6%	9
Landslides	1	1	1	0	0	6%	9
Land Subsidence/Karst	1	0	0	0	0	0%	10
Tsunami	0	0	0	0	0	0%	10
Volcano	0	0	0	0	0	0%	10
AVERAGE	1.64	1.32	1.48	0.96	1.16	28%	

**Threat increases with percentage.*

UNMITIGATED RISK*		PROBABILITY * IMPACT	
	0.28	0.65	0.43

Spreadsheet developed by:
KAISER PERMANENTE.

As an outcome of the reassessment and re-ranking of hazards, there were five hazards ranked as having the highest relative risk and thus considered **"Critical Hazards".** These five hazards include:

1. Winter Storms (Ice),
1. Coastal Flooding,
2. Lightning,
3. Hurricanes, and
3. Summer Storms.

The hazards considered **"Moderately Critical"** have historically occurred in the Middle Peninsula, yet ranked lower than the Critical Hazards in terms of risk during the hazard prioritization exercise. These Moderately-Critical hazards include:

4. Tornadoes,
4. Winter Storms (snow),
5. Coastal/shoreline Erosion,

5. Wildfires,
5. Riverine Flooding,
6. Sea Level Rise,
6. High Wind/Windstorms,
6. HAZMAT, and
6. Ditch Flooding.

Hazards considered **"Non-Critical"** have occurred very infrequently, or have not occurred at all – based on the available historical records. These hazards are not considered a widespread threat that would result in significant losses of property and life in the Middle Peninsula. These Non-Critical hazards included:

7. Drought,
7. Extreme Cold,
7. Extreme Heat,
8. Dam Failure,
8. Earthquake,
8. Air Quality,
9. Shrink-swell Soils,
9. Landside,
10. Land Subsidence / Karst,
10. Tsunami, and
10. Volcano.

4.2. Hazards Considered "Non-Critical" Hazards to the Middle Peninsula

The following section describes hazards that are uncommon throughout the Middle Peninsula region and deemed "Non-Critical" Hazards to the Middle Peninsula by the LPT.

4.2.1. Drought

Empirical studies conducted over the past century have shown that drought is never the result of a single cause. It is the result of many causes, often synergistic in nature, and therefore often difficult to predict more than a month or more in advance. In fact, an area may already be in a drought before drought is even recognized. The immediate cause of drought is the predominant sinking motion of air (subsidence) that results in compressional warming or high pressure, which inhibits cloud formation and results in lower relative humidity and less precipitation. Most climatic regions experience varying degrees of dominance by high pressure, often depending on the season. Prolonged droughts occur when large-scale anomalies in atmospheric circulation patterns persist for months or seasons (or longer). The extreme drought that affected the United States and Canada during 1988 resulted from the persistence of a large-scale atmospheric circulation anomaly (National Drought Mitigation Center, 2004).

There have been four major statewide droughts since the early 1900's (USGS, 2002). The drought of 1930-32 was one of the most severe recorded in the Commonwealth while the droughts of 1938-42 and 1962-71 were less severe; however, the cumulative stream flow deficit for the 1962-71 drought was the greatest of the droughts because of its duration. The drought of 1980-82 was the least severe and had the shortest duration. Tidewater Virginia experienced "Severe Drought" conditions during the drought of 2001-2002 when stream flow into Chesapeake Bay was only half the average annual flow into the Bay (Virginia State Climatology Office, 2002).

In 2007, seventeen counties fell into severe drought status as over $10 million in crop damages occurred in Southwest Virginia.

Virginia is one of 44 states that have implemented a Drought Plan. The goals of these plans are to reduce water shortage impacts, personal hardships, and conflicts between water and other natural resource users. These plans promote self-reliance by systematically addressing issues of principal concern. The National Drought Policy Commission's report to Congress and the president, "Preparing for Drought in the 21st Century" (available on-line at: http://www.fsa.usda.gov/drought/finalreport/fullreport/pdf/reportfull.pdf), emphasizes the need for drought planning at the state, local, federal, and tribal levels of government. While some state plans focus on mitigation strategies, Virginia's Plan emphasizes response strategies.

In a parallel effort, Middle Peninsula localities with the exception of Gloucester County, participated in the development of the Middle Peninsula Regional Water Supply Plan (MPRWSP) in 2009. Gloucester County participated in the development of the Hampton Roads Regional Water Supply Plan. Overall the water supply plans contain proposed strategies and polices that the localities can undertake to mitigate adverse affects of periodic droughts

As both the Regional Water Supply Plan and Drought Response plans focus on responding to drought, both plans should identify the role the jurisdiction's Emergency Services Coordinator/Manager will have with the locality's County Administrator/Town Manager during the implementation of both plans.

Drought Vulnerability

Drought is a phenomenon that, affects the Commonwealth on nearly an annual basis. Drought has several definitions, depending upon the impact. **Agricultural drought** is the most common form of drought, and is characterized by unusually dry conditions during the growing season. **Meteorological drought** is defined as an extended period (generally 6 months or more) when precipitation is less than 75 percent of normal during that period. If coincident with the growing season, agricultural and meteorological drought can occur simultaneously. In general, hydrologic drought is the most serious, and has the most wide reaching consequences. **Hydrologic drought** occurs due to a protracted period of meteorological drought, which reduces stream flows to extremely low levels ("Dry years" in Figure 7), and creates major problems for public (reservoir/river) and private (well) water supplies.

Extended periods of drought can impact crop and hay yields, and significant crop losses can result. The impact of meteorological drought can vary significantly depending upon dry years indicated by red bars the length of the dry period, the time of year the dry period occurs, the antecedent moisture conditions prior to the onset of the dry period, and the relative dryness (in percent of normal precipitation) of the period in question. Drought duration is highly variable by region. The duration also depends on when the precipitation is needed for such activities as planting and irrigation.

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.

Specific impacts of drought to Middle Peninsula localities may be experienced differently. In particular economic losses may due to crop loss and water shortages.

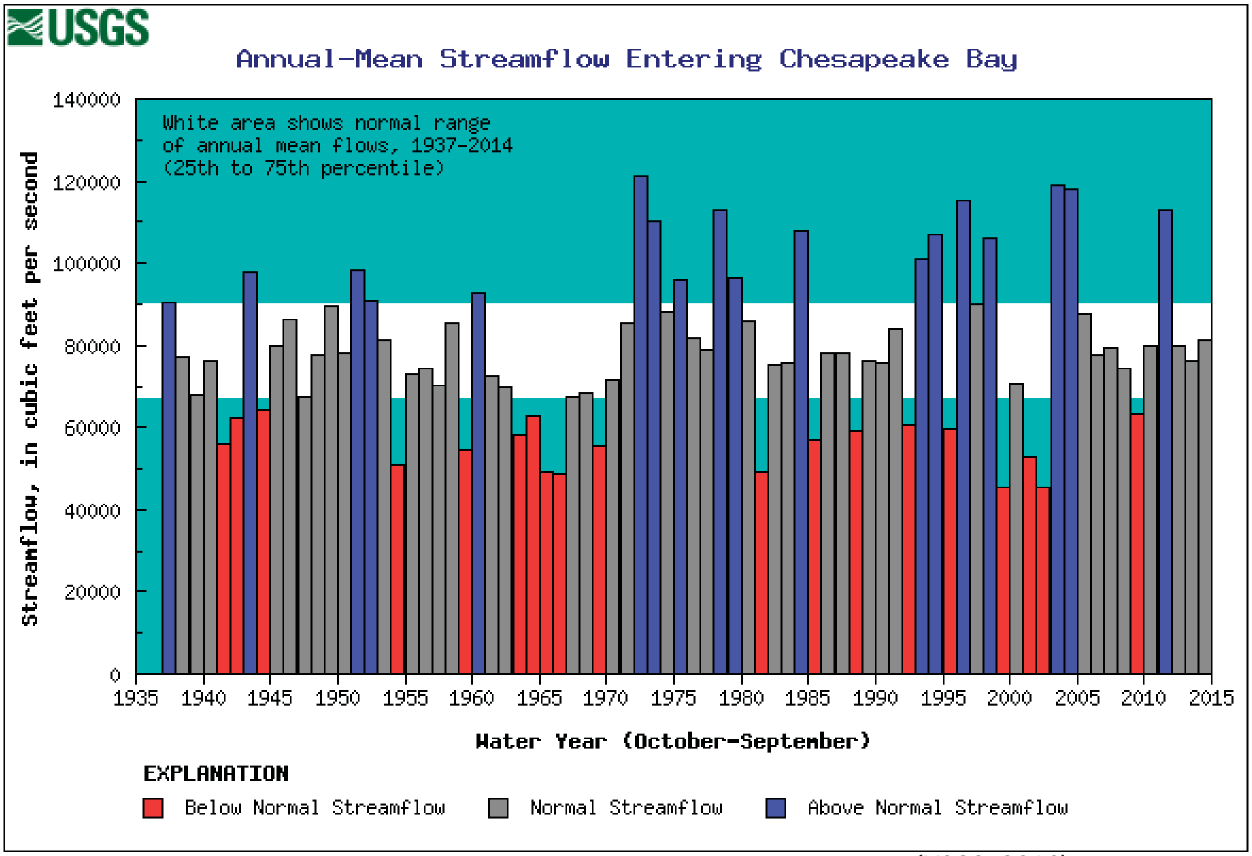


Figure 7: Annual mean stream inflow into Chesapeake Bay 1937 – 2015. *(USGS, 2016).*

Drought Extent (Impact)

To assist in identifying the severity of a drought event a classification system is utilized and will dictate public water restriction (Table 6). Notice that water restrictions start as voluntary and then become required as the severity of the drought increases.

Table 6: Drought Severity Classification		
Category	**Description**	**Possible Impacts**
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.
D1	Moderate Drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions

4.2.2. Extreme Cold and Extreme Heat

Extreme cold temperatures are not an annual event in Virginia. Although wind chill advisories are issued nearly every year, especially in Western and Northern portions of the state, life-threatening extreme cold, requiring wind chill warnings, is a rare occurrence in the Middle Peninsula. The frequency of occurrence is dependent entirely upon the extreme cold criteria used - wind chill vs. air temperature. The primary impact of extreme cold is increased potential for frostbite, hypothermia, and potentially death because of over-exposure to extreme cold. Some secondary impacts of extreme/excessive cold may present a danger to livestock and pets, and frozen water pipes in homes and businesses.

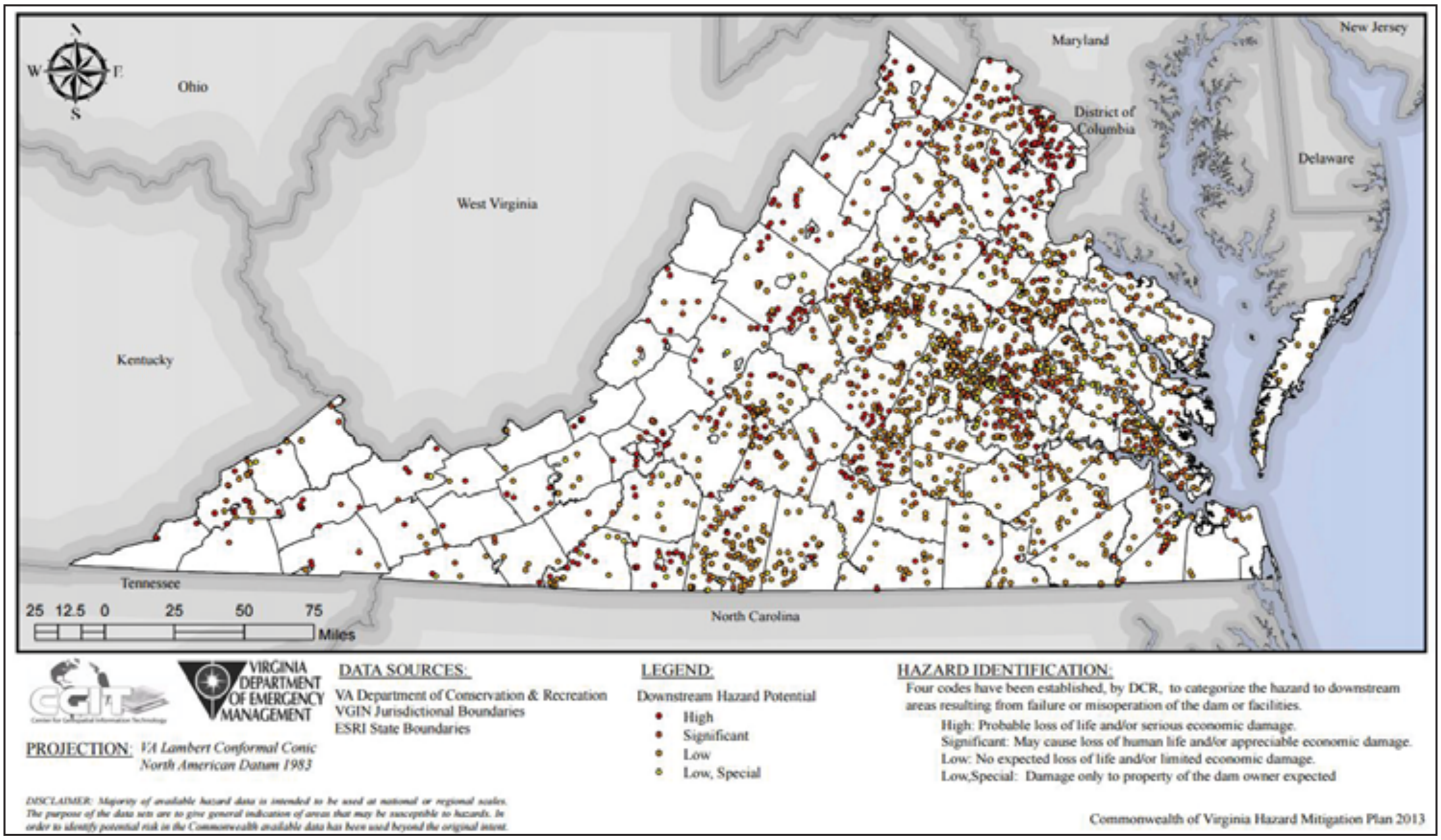
Extreme heat, generally associated with drought conditions, is a phenomenon that is generally confined to the months of July and August, although brief periods of excessive heat have occurred in June and September. Extreme heat can be defined either by actual air temperature, or by the heat index, which relates the combined effects of humidity and air temperature on the body. Extreme heat is not an annual event in the Middle Peninsula. Although heat advisories are issued near every year, especially in the urban areas of Northern Virginia, life-threatening extreme heat is a rare occurrence in the Middle Peninsula region. The frequency of occurrence is dependent entirely upon the extreme heat criteria used (i.e. heat index vs. air temperature). The primary impact of extreme heat is increased potential for hyperthermia, which can be fatal to the elderly and infirmed. In addition, there is an increased risk of dehydration, if proper steps are not taken to ingest adequate amounts of non-alcoholic fluids. The impact of extreme heat is most prevalent in urban areas, which are not found in the Middle Peninsula. Secondary impacts of excessive heat are severe strain on the electrical power system, and potential brownouts or blackouts.

Specific impacts to Middle Peninsula localities will vary due to extreme cold and extreme heat.

4.2.3. Dam Failure

Since the last plan, the Virginia Department of Conservation and Recreation (DCR) created an inventory of dams throughout the Commonwealth. According to DCR data there are approximately 2,406 dams within the Commonwealth and approximately 101 in the Middle Peninsula (Table 7). Figure 8 provides a map of dam locations and their associated hazard potentials.

Figure 8: Dam locations and associated hazard potential *(Source: Commonwealth of Virginia Hazard Mitigation Plan, 2013).*



Dam Failure Extent (Impacts)

As failure of dams may result in a localized major impact, including loss of human life, economic loss, lifeline disruption, and environmental impact such as destruction of habitat, there are also secondary impacts including flooding to the surrounding areas. Thus a scale has been developed to classify the hazard potentials of dams due to their overall impact to a given area:

- **High** – dams that upon failure would cause probable loss of life or serious economic damage.
- **Significant** – dams that upon failure might cause loss of life or appreciable economic damage.
- **Low** – dams that upon failure would lead to no expected loss of life or significant economic damage. This classification includes dams that upon failure would cause damage only to property of the dam owner. **Special criteria** – includes dams that upon failure would cause damage only to property of the dam owner.

Table 7: Inventory of dams within the Middle Peninsula and their risk classification.						
County	**High**	**Significant**	**Low**	**Low, Special**	**Unknown**	**Total # of Dams**
Essex	0	1	15	1	0	17
Gloucester	1	3	6	1	0	11
King and Queen	0	6	8	7	1	22
King William	1	8	23	4	0	36
Mathews	0	0	0	0	0	0
Middlesex	0	2	11	2	0	15
TOTAL	2	20	63	15	1	101

Dam Failure Vulnerability

Dams are classified with a hazard potential depending on the downstream losses estimated in event of failure. The recent regulatory revisions bring Virginia's classification system into alignment with the system already used in the National Inventory of Dams maintained by the U.S. Army Corps of Engineers. Hazard potential is not related to the structural integrity of a dam but strictly 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 the extent of emergency operations plans, are dependent upon the dam classification. The owner of each regulated Class I, II, and III dam is required to apply to the Soil and Water Conservation Board for an operation and maintenance certificate.

The Virginia DCR Division of Dam Safety's mission is to conserve, protect, enhance, and advocate the wise use of the Commonwealth's unique natural, historical, recreational, scenic and cultural resources. The program's purpose is to provide for safe design, construction, operation, and maintenance of dams to protect public safety. Disaster recovery programs 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 compliant with the National Flood Insurance Program (NFIP) regulations.

For those dam failures that pose a risk when there are large potential areas with large populations surrounding dams. On-going dam inspections and Virginia's participation in the National Dam Safety Program maintained by FEMA and the U.S. Army Corps of Engineers serve as preventative measures against dam failures.

Most dam failures occur due to lack of maintenance of dam facilities in combination with excess precipitation events, such as hurricanes and thunderstorms. During Hurricane Floyd in 1999, floods broke open at least 12 unregulated dams in eastern Virginia. One of those failures, at the Cow Creek Dam near Gloucester Courthouse, temporarily closed state Route 14; No one was hurt. Rebuilding the dam cost about $160,000 (U.S. Water News Online, 2002). During Tropical Storm Gaston in late summer of 2004, a dam was overtopped in King William County and caused a washout of Route 610 between Rt. 608 and Rt. 609. The road was closed to traffic for several weeks (VDOT, 2004).

Each Middle Peninsula locality, with the exception of Mathews County, has dams and therefore vulnerable to dam failure. However the degree of vulnerability and impact will vary between the localities if a dam failure occurs. For instance Gloucester County may experience the most impact from a failure at Beaver Dam as it is the largest in the region. The 39' high dam structure, covers approximately 635 acres of land, and is in close proximity to the Gloucester County Courthouse area which is a main residential and business corridor for the County. This increases the potential of economic loss.

Dam Impoundments

In 2001, Virginia's legislature broadened the definitions of "impounding structure" to bring more dams under regulatory oversight. On February 1, 2008, the Virginia Soil and Water Conservation Board approved major revisions to the Impounding Structure Regulations in the Virginia Administrative Code, changing the dam hazard potential classification system, modifying spillway requirements, requiring dam break inundation zone modeling, expanding emergency action plan requirements, and making a variety of other regulatory changes.

All dams in Virginia are subject to the Virginia Dam Safety Act and Dam Safety Regulations unless specifically excluded. A dam is excluded from these regulations if it meets one or more of the following criteria:

1. is less than 6 feet high,
2. has a maximum capacity of less than 50 acre-feet and is less than 25 feet in height,
3. has a maximum capacity of less than 15 acre-feet and is more than 25 feet in height,
4. is used primarily for agricultural purposes and has a maximum capacity of less than 100 acre-feet or is less than 25 feet in height (if the use or ownership changes, the dam may be subject to the Dam Safety Regulations),
5. is owned or licensed by the federal government,
6. is operated for mining purposes under 45.1-222 or 45.1-225.1 of the Code of Virginia, or
7. is an obstruction in a canal used to raise or lower water levels.

The height of the dam is defined as the vertical distance from the streambed at the downstream toe to the top of the dam. The maximum capacity of a dam is defined as the maximum volume capable of being impounded at the top of the dam.

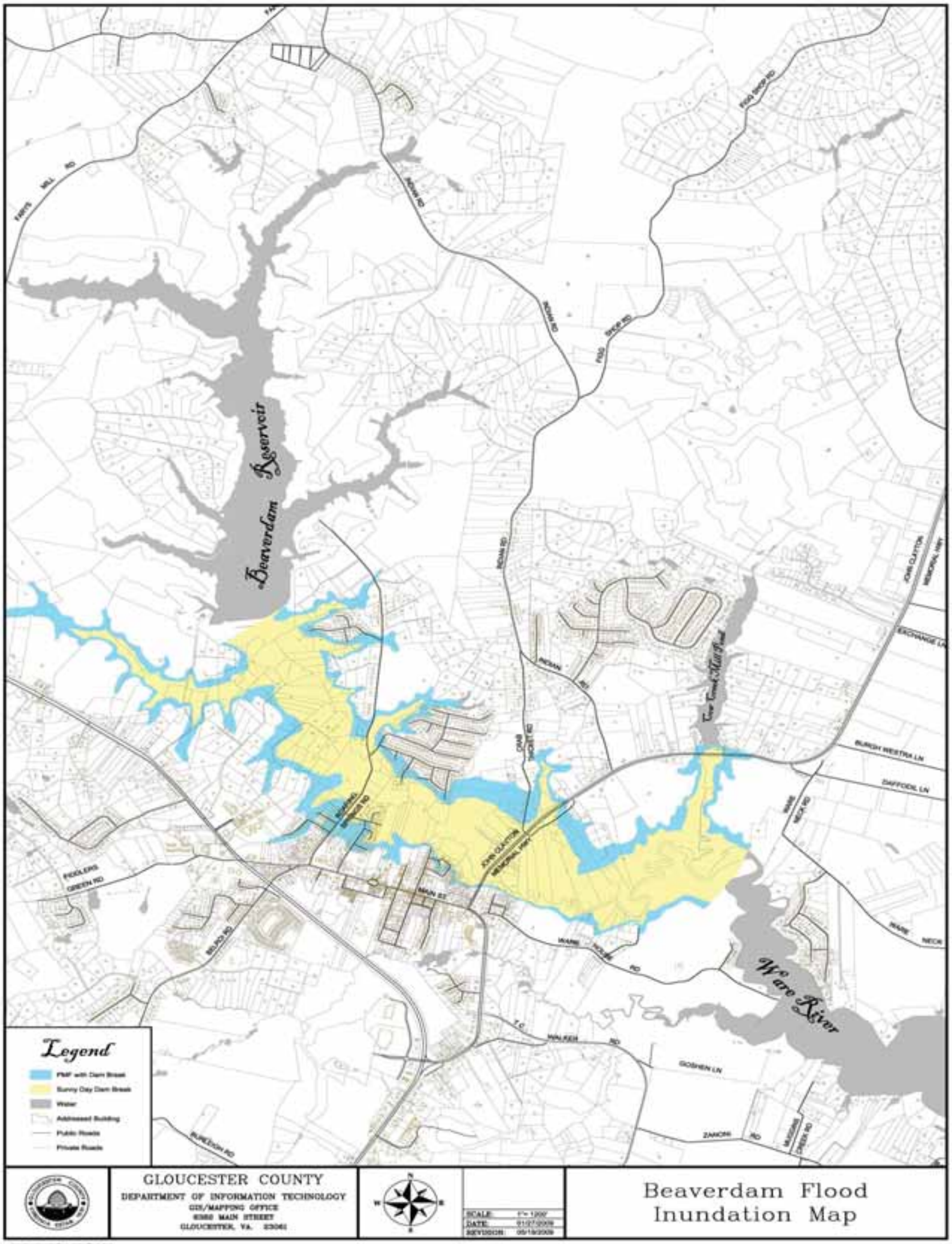
The DCR – Division of Dam Safety is the state agency responsible for enforcing the Virginia Dam Safety Act and overseeing the issuance of Operation and Maintenance Certificates for regulated dams.

Beaverdam Reservoir Dam – Gloucester, County

The Beaverdam Reservoir, located to the north of the Gloucester Courthouse area, is contained by a 39' high dam structure and covers approximately 635 acres of land. The reservoir is primarily surrounded by land zoned for low density development and there is a 300' by 600' buffer area surrounding this water impoundment. The property is owned by Gloucester County and it is an actively used local recreational site known as Beaverdam Park as well as a drinking water source for Gloucester County residents.

Figure 9 shows areas shaded in yellow and blue that would be inundated if the reservoir dam were to fail. According to Gloucester County officials, these shaded areas represent 405 homes just north of the Gloucester Courthouse Complex and the downtown business district that would be inundated if the dam were to fail.

Figure 9: Beaverdam. *Flood Inundation Map (Source: Gloucester County)*



Lake Anna Dam

The Lake Anna Dam, located near Mineral in Louisa County, Virginia, creates an impoundment with a surface area of approximately 13,000 acres. Periodic major water releases from Lake Anna flow into the Pamunkey River which can have adverse affects on river levels during major releases.

Depending on the amount of water released by the dam owner, Dominion/Virginia Power Company, a potential flooding hazard exists for King William County residents, which would include flooding of low-lying agricultural land, some roads, threes (3) bridges along these roads, a scattering of residences and some agricultural structures.

4.2.4. Earthquakes

An earthquake is a sudden movement or trembling of the Earth, caused by the abrupt release of strain that has accumulated over a long time. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface slowly move over, under, and past each other. Sometimes the movement is gradual; at other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free and result in an earthquake (Shedlock and Pakister, 1997). If the earthquake occurs in a populated area, it may cause deaths, injuries, and extensive property damage.

Earthquake Vulnerability

During an earthquake when the ground is shaking, it experiences acceleration. The peak acceleration (PA) is the largest acceleration recorded by a particular station during an earthquake (expressed as %g). When acceleration acts on a physical body, the body experiences the acceleration as a force. The force we are most experienced with is the force of gravity, which causes us to have weight. Units of acceleration are measured in terms of g, the acceleration due to gravity. For example, an acceleration of 11 feet per second per second is 11*12*2.54 = 335 cm/sec/sec. The acceleration due to gravity is 980 cm/sec/sec, so an acceleration of 11 feet/sec/sec is about 335/980= 0.34 g. Expressed as a percent; 0.34 g is 34 %g.

The United States Geological Survey (USGS) rates the susceptibility of areas of the United States to earthquakes and has published risk maps, which give the probability of various levels of ground motion being exceeded in 5 years. An approximate threshold for shaking that causes building damage (for pre-1965 dwellings or dwellings not designed to resist earthquakes) is 10 %g. According to USGS predictions, the Middle Peninsula is located within the 1-2%g, 2-3%g and 3-4%g contour lines (Figure 10).

Historical data is supportive of this low risk assessment. Virginia has had over 160 earthquakes since 1977 of which 16% were felt (Stover and Coffman, 1993). This equates to an average of one earthquake occurring every month with two felt each year. Figure 11 depicts the historical earthquake epicenters in and near Virginia from 1568 through 2011. The largest earthquake in Virginia was a magnitude 5.8 earthquake in Giles County in 1897. This earthquake was the third largest in the eastern US in the last 200 years was felt in twelve states. Based on the map there were no earthquake epicenters recorded within the area of the Middle Peninsula. However in 2011 a 5.8 earthquake in Mineral, Virginia was felt in the Middle Peninsula region and causes damages according to VDEM (Figure 12).

Depending on the epicenter of the earthquake Middle Peninsula localities may experience varying impacts. According to the USGS (2015) the eastern most portions of Mathews and Gloucester County have a lower chance of being impacted by earthquakes.

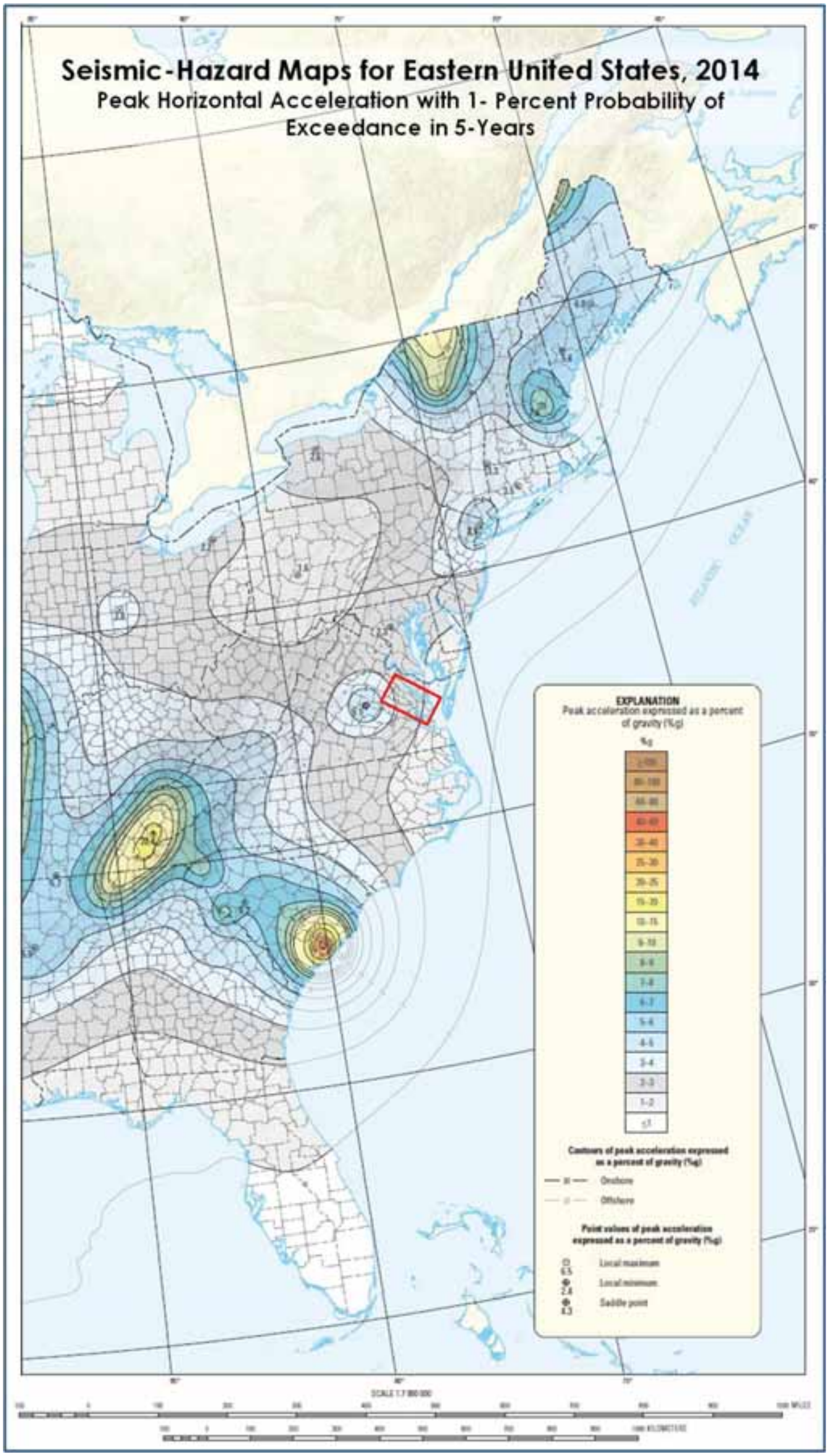


Figure 10: Seismic- Hazard Map of the Eastern United States. *Predicted earthquake hazards are depicted by contour values of earthquake ground motions that have a 1% probability if being exceeded in 5 years. The Middle Peninsula of Virginia (hi-lighted by the red square on the map) falls within the 1-2%g, 2-3%g and 3-4%g contour. Image courtesy of Petersen, et. al. with USGS (2015)*

Figure 11: Significant Earthquakes 1568 – 2011 - *Historical earthquake epicenters in and near Virginia from 1568 through 2011. The Middle Peninsula of Virginia (highlighted by the red square on the map) is void of any historic earthquake epicenters (Source: Commonwealth of Virginia Hazard Mitigation Plan 2013).*

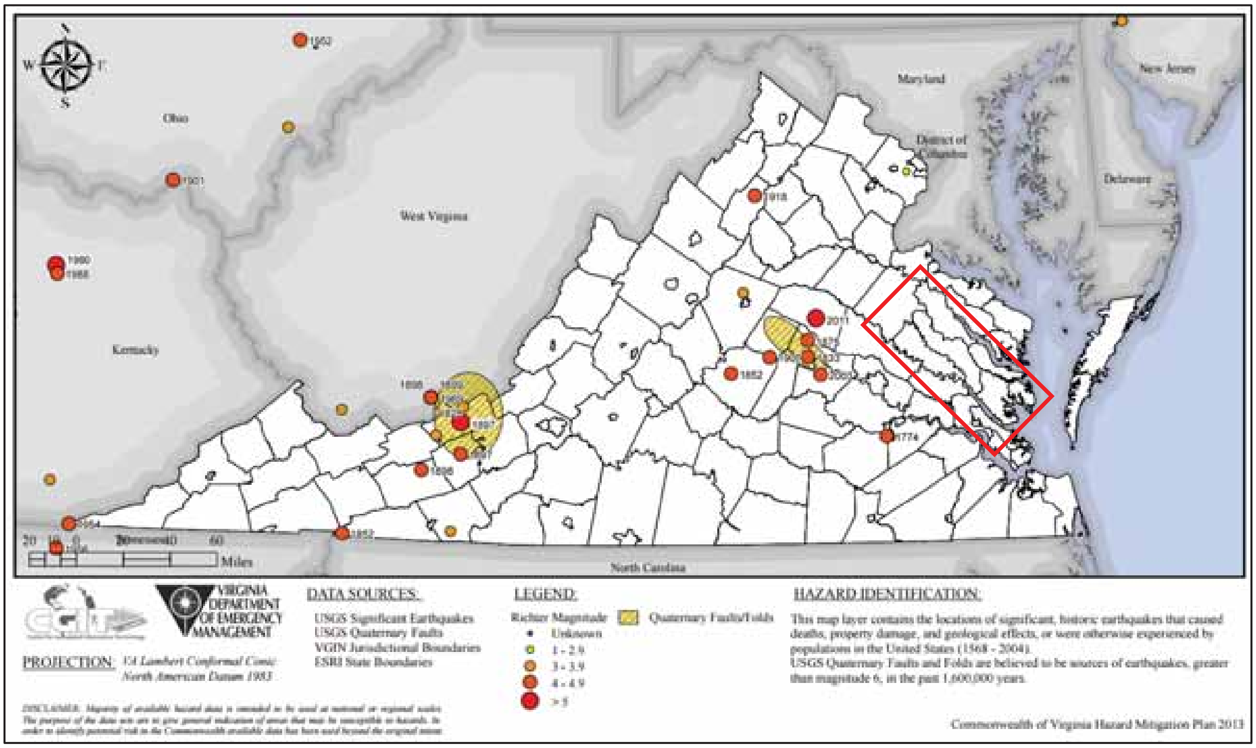
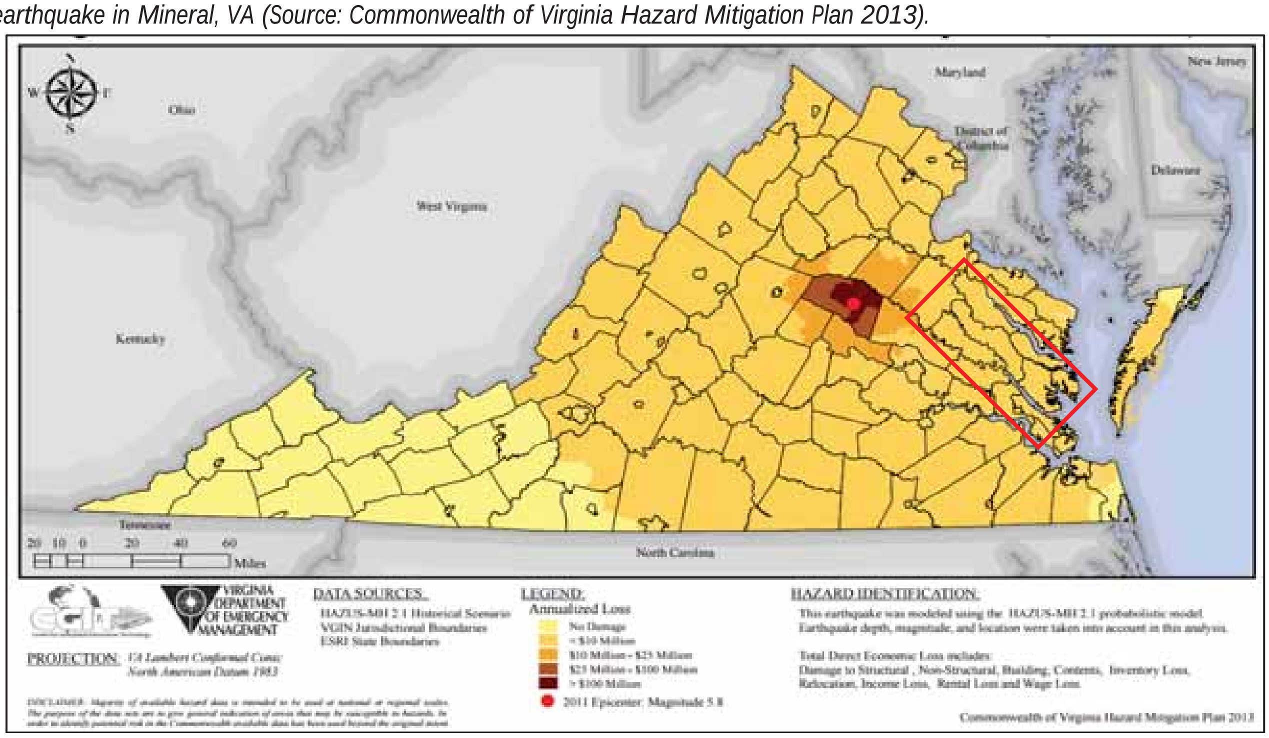


Figure 12: Total loss from 2011 Mineral, VA Earthquake (HAZUS). *The Middle Peninsula of Virginia (highlighted by the red square) is void of any historic earthquake epicenters, however endured losses as a result of impact from the 2011 earthquake in Mineral, VA (Source: Commonwealth of Virginia Hazard Mitigation Plan 2013).*



Earthquake Extent (Impact)

The severity of an earthquake can be expressed in terms of both intensity and magnitude. However, the two terms are quite different, and they are often confused. Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter. Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments which have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.

Earthquake severity is commonly measured on two different scales: the Modified Mercalli Intensity scale and the Richter Magnitude scale. The following provides ranking and classification definitions for the two scales (Table 8).

Table 8: Ranking and classification definitions for two scales that measure earthquake severity.

Richter Magnitude Scale	Modified Mercalli Intensity Scale
1.0 to 3.0	I
3.0 to 3.9	II to III
4.0 to 4.9	IV to V
5.0 to 5.9	VI to VII
6.0 to 6.9	VII to IX
7.0 and Higher	VIII or Higher
Defined Modified Mercalli Intensity Scale Rating	
I	Not Felt except by a very few under especially favorable conditions
II	Felt only by a few persons at rest, especially on upper floors of buildings
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors, disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

4.2.3. Air Quality

Good air quality is taken for granted by most of the citizens of the Middle Peninsula of Virginia. However there are natural and human-caused factors that may influence the air quality within the region.

First emissions from human activity can influence overall air quality within the region. From vehicle emissions to local businesses (ie. industry), Virginia Department of Environmental Quality (DEQ) Air Division's monitors and regulates emissions as they responsible for carrying out the mandates of the Virginia Air Pollution Control Law as well as the Federal obligations under the Clean Air Act on behalf of the State Air Pollution Control Board. For local industry, DEQ issues air quality permits to regulate emitted pollutants to ensure that these emissions do not cause harm to the public or the environment. Each year DEQ will compile an inventory of criteria pollutants air emissions from point, area, mobile and biogenic sources (ie. natural sources, from vegetation and soils as well as other relevant sources include volcanic emissions, lightning, and sea salt). Table 9 displays the most recent 2013 Point Source Criteria Pollutant Emissions Report for Middle Peninsula localities.

Table 9: 2013 Point Source Emissions Inventory. *DEQ periodically compiles an inventory of criteria pollutant air emissions from point, area, mobile, and biogenic sources in the state. Point source emissions are inventoried annually (DEQ, 2014).*

County	Plant Name	Emissions (tons)							
		NH_3	NO_2	Pb	PM 10	PM 2.5	SO_2	VOC	Plant Total
Essex	Tidewater Lumber				35.55	35.55			71.11
Essex	June Parker Oil Co Inc							2.31	2.31
Essex	FDP Brakes of Virginia		1.80		2.64	2.64	0.00	14.83	22.14
Essex	Perdue Foods LLC - Tappahannock/Essex		0.75		16.06	15.51	0.00	0.03	32.45
Essex	Essex Concrete Corporation - Tappahannock				0.46	0.46			0.93
Essex	O'Malley Timber Products, Inc.	0.00	9.96		16.24	7.70	1.13	26.82	89.02
Gloucester	Rappahannock Concrete White Marsh		0.02		0.36	0.36	0.04	0.00	0.79
Gloucester	Philips Energy Inc							5.91	5.91
Gloucester	Riverside Walter Reed Hospital	0.04	0.74	0.00	0.09	0.08	0.24	0.01	1.39
Gloucester	Rappahannock Concrete Saluda				0.27	0.27			0.54
Gloucester	Canon Environmental Technologies Incorporated				27.80	27.80			55.59
Gloucester	Middle Peninsula Landfill		109.27		17.73	17.08	4.69	15.25	368.33
Gloucester	C. W. Davis Asphalt Division				0.14	0.14			0.29
Gloucester	Hogg Funeral Home				0.01	0.01			0.04
Gloucester	Contract Crushing/Construction Inc		0.00		0.06	0.06		0.00	0.13
Gloucester	Branscome Incorporated - Gloucester				0.36				0.36
Gloucester	Mid Atlantic Materials Incorporated - Gloucester				2.28	0.41			2.69
Gloucester	Shadow Farms Animal Cremation Services Inc		0.00		0.00				0.00
King and Queen	Ball Lumber Company Incorporated		9.42	0.00	24.77	11.25	1.07	45.72	117.92
King and Queen	Bennett Mineral Company Inc		2.87	0.00	1.07	0.99	1.13	1.36	57.30
King and Queen	Essex Concrete Corporation - Aylett				6.28	6.28			12.56
King and Queen	BFI King and Queen Landfill		24.21		10.45	7.42	6.19	18.05	146.98
King and Queen	INGENCO - King and Queen		96.87		57.45	57.45	0.17	76.12	407.41
King and Queen	Helena Chemical Company - Portable 52353				0.12	0.11		0.00	0.22
King William	West Point Veneer LLC	0.00	5.28	0.00	10.13	10.13	0.27	36.24	71.76

County	Plant Name	Emissions (tons)							
		NH_3	NO_s	Pb	PM10	PM 2.5	SO_2	VOC	Plant Total
King William	Trible-Perry Oil Co/PAPCO Oil Co.							3.85	3.85
King William	RockTenn CP LLC - West Point	64.45	1717.38	0.14	489.52	455.36	814.68	599.83	5524.43
King William	Old Dominion Grain		2.18	0.00	18.04	3.13	0.00	0.06	23.77
King William	Augusta Wood Products LC - Sawmill		1.28	0.00	11.62	11.62	0.25	14.51	48.55
King William	NPPC King William		45.16		38.25	38.25	0.23	1.02	138.97
King William	West Point Chips Incorporated				40.43	40.43			80.85
King William	Aggregate Industries MAR - Mattaponi Plant				0.12	0.12			0.24
King William	Powerhouse Equipment and Engineering Co Inc		0.00		0.00		0.00	0.00	0.00
King William	Cross Land Harbour LLC				0.43	0.43			0.86
King William	Powerhouse Equipment and Enginrng - Portable 52322		11.20		0.56		3.98		18.54
King William	Gillies Creek Recycling Center - Portable 52420		4.90		1.19		0.32	0.08	7.40
King William	Vincent Funeral Home - West Point		0.00		0.00		0.00	0.00	0.00
Mathews	Wroten Oil Company							2.67	2.67
Middlesex	J T and C A Thrift Incorporated							2.01	2.01
Total Regional Admissions		**64.49**	**2043.29**	**0.15**	**830.5**	**751.05**	**834.4**	**866.65**	**866.65**

**Note: Blank squares within the table indicate that there are no emissions to be measured.

NH_3 – Ammonia; **NO_2**- Nitrogen dioxide; **Pb** – Lead; **PM 10** –particulate matter 10 micrometers or less in diameter; **PM 2.5** – particulate matter 2.5 micrometers or less in diameter, generally described as fine particles; **SO_2**- Sulfur dioxide; **VOC**- Volatile organic compound

With the passing of the Clean Air Act in 1970 and then amendments in 1990, the US Congress required DEQ to enhance the vehicle emissions inspection program in order to keep improving air quality and to reduce emission further. In response Virginia now requires the inspection of vehicles operating in the counties of Arlington, Fairfax, Loudoun, Prince William, Stafford and the Cities of Alexandria, Fairfax, Falls Church, Manassas and Manassas Park. Vehicle emission contain pullulates that contribute to the formation of ozone, the main component of smog that builds up at ground level in hot sunny weather and may impact water quality in the Chesapeake Bay and its tributaries (ie. through atmospheric deposition).

In conjunction with emissions caused by humans there are natural, such as forest fires and controlled burns, may cause the air quality to deteriorate and become unsafe, especially for those who suffer medical conditions that make them sensitive to poor air quality. As a rural region of Virginia, the Middle Peninsula landscape is dominated by fields and forests. To properly manage these resources, property owners may carry out prescribed burning, a deliberate use of fire under specified and controlled conditions to achieve a resource management goal. Benefits including:

- site preparation for reforesting,
- hardwood control in pine stands,
- wildfire hazard reduction,
- improved wildlife habitat, and
- threatened and endangered species management.

According to the VDOF: *Products from the combustion of forest fuels are mainly carbon-containing compounds. The most important pollutants being particulate matter and carbon monoxide (CO).*

Two products of complete combustion are carbon dioxide (CO2) and water, these make up over 90% of the total emissions. Under ideal conditions it takes 3.5 tons of air to completely burn 1 ton of fuel. The combustion of 1 ton *of fuel will produce the following:*

Carbon dioxide (CO2)	*2,000 to 3,500 lbs*
Water Vapor	*500 to 1,500 lbs*
Particulate Matter	*10 to 2000 lbs*
Carbon Monoxide (CO)	*20 to 500 lbs*
Hydrocarbons	*4 to 40 lbs*
Nitrogen Oxides	*1 to 9 lbs*
Sulfur Oxide	*Negligible amounts*

To assist with the management of the smoke generated from prescribed burning, the VDOF has developed voluntary smoke management guidelines to lessen the public health and welfare impacts (www.dof.virginia.gov/resources/fire/prescribed-fire-smoke-mgmt.pdf). In additional to prescribed burns there are also unplanned forest fires that would impact the region's air quality. For instance, on August 4, 2011, a lightning strike caused a fire in the Great Dismal Swamp that kept smoldering for 111 days. This impacted air quality impacted Southern Virginia, Middle Peninsula Localities as well as northward across Virginia and as far as Annapolis, Maryland. Wind currents over the Chesapeake Bay provided a channel for the ash-heavy smoke to travel north and caused a CODE ORANGE (See Table 10 below) for most of coastal Virginia.

Each locality within the Middle Peninsula will have varying vulnerability to air quality impacts. Localize events (i.e. wildfires, emissions for business, etc.) as well as wind currents may influence air quality within a given area.

Air Quality Extent

To monitor and assess daily air quality, the Environmental Protection Agency (EPA) has established the Air Quality Index (AQI). This scale determines how clean or polluted the air is and its impacts on human health. Based on a 0-500 scale, the higher the AQI value the greater the level of air pollutions and the greater the health concern. Table 10 identifies the AQI levels of health concern, the associated numerical value and the meaning:

Table 10: AQI Scale. *AQI levels and associated numerical values and meaning of the index (AirNow, 2015).*

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air Quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensible groups may experience more serious health effects
Very Unhealthy	201 to 300	Health warning of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects

Based on this scale the EPA will calculate daily AQI number for each of the five major air pollutants regulated by the Clean Air Act, including ground ozone, particle pollution, carbon dioxide, sulfur dioxide, and nitrogen dioxide (Table 11).

Table 11: Description of regulated pollutants *(AirNow, 2015))***.**

Pollutant	Description
Ozone (O_3)	Ozone is a form of oxygen with three atoms instead of the usual two atoms. It is a photochemical oxidant and, at ground level, is the main component of smog. Unlike other gaseous pollutants, ozone is not emitted directly into the atmosphere. Instead, it is created in the atmosphere by the action of sunlight on volatile organic compounds and nitrogen oxides. Higher levels of ozone usually occur on sunny days with light winds, primarily from March through October. An ozone exceedance day is counted if the measured eight-hour average ozone concentration exceeds the standards.
Carbon Monoxide (CO)	Carbon Monoxide (CO) is a colorless, odorless, very toxic gas produced by the incomplete combustion of carbon-containing fuels, most notably by gasoline powered engines, power plants, and wood fires. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death.
Sulfur Dioxide (SO_2)	Sulfur dioxide (SO_2) is one of a group of highly reactive gasses known as "oxides of sulfur." The largest sources of SO_2 emissions are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%). Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment. SO_2 is linked with a number of adverse effects on the respiratory system.
Nitrogen Dioxide (NO_2)	Nitrogen dioxide (NO_2) is one of a group of highly reactive gasses known as "oxides of nitrogen", or "nitrogen oxides (NO_x)". Other nitrogen oxides include nitrous acid and nitric acid. While EPA's National Ambient Air Quality Standard covers this entire group of NO_x, NO_2 is the component of greatest interest and the indicator for the larger group of nitrogen oxides. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. In addition to contributing to the formation of ground-level ozone and fine particle pollution, NO_2 is linked with a number of adverse effects on the respiratory system.
Particulate Matter (PM-2.5 PM-10)	Particle pollution (also called particulate matter or PM) is the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small, they can only be detected using an electron microscope. Particle pollution includes *inhalable coarse particles*, with diameters larger than 2.5 micrometers and smaller than 10 micrometers and *fine particles*, with diameters that are 2.5 micrometers and smaller. How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter -- making it 30 times larger than the largest fine particle. These particles come in many sizes and shapes and can be made up of hundreds of different chemicals. Some particles, known as *primary particles*, are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires. Others form in complicated reactions in the atmosphere of chemicals such as sulfur dioxides and nitrogen oxides that are emitted from power plants, industries and automobiles. These particles, known as *secondary particles*, make up most of the fine particle pollution in the country. Coarse particulates (PM-10) come from sources such as windblown dust from the desert or agricultural fields (sand storms) and dust kicked up on unpaved roads by vehicle traffic. PM-10 data is the near real-time measurement of particulate matter 10 microns or less in size from the surrounding air. This measurement is made at standard conditions, meaning it is corrected for local temperature and pressure. Fine particulates (PM-2.5) are generally emitted from activities such as industrial and residential combustion and from vehicle exhaust. Fine particles are also formed in the atmosphere when gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds, emitted by combustion activities, are transformed by chemical reactions in the air. Large-scale agricultural burning or sand storms can produce huge volumes of fine particulates. PM-2.5 data is the near real-time measurement of particulate matter 2.5 microns or less in size from the surrounding air. This measurement is made at local conditions, and is not corrected for temperature or pressure.

AirNow.com provides a daily air quality forecast for select regions of Virginia including Hampton Roads, Northern Virginia, Richmond, Roanoke, Shenandoah National Park and Winchester. This site also provides calendars of air quality nationally as well as at the state level (Figure 13 & 14).

Figure 13: Calendar of air quality *throughout across the nation (AirNow, 2015).*

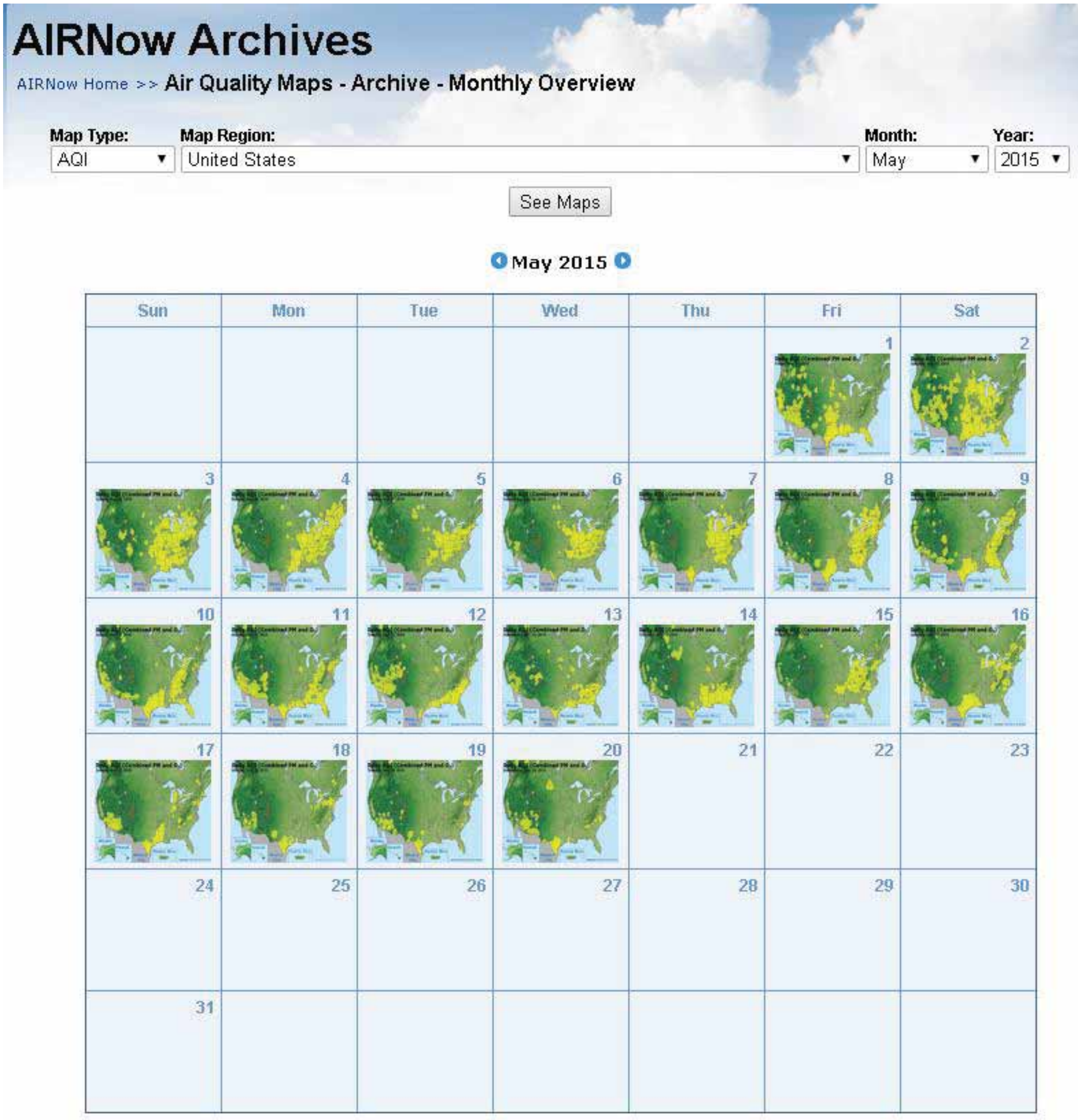
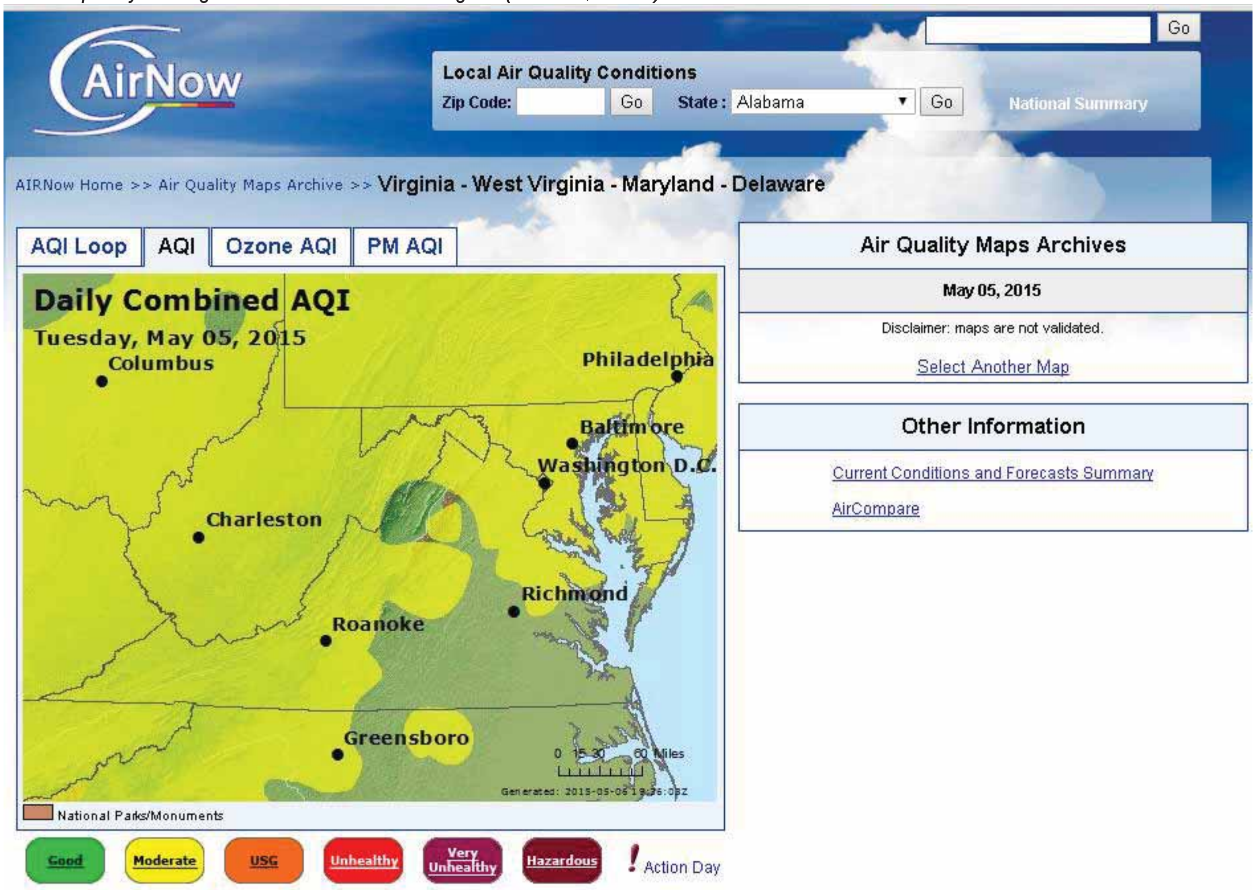


Figure 14: Regional map *of Virginia, West Virginia, Maryland, and Delaware on May 5, 2015. This provides an example of air quality throughout the Mid Atlantic Region (AirNow, 2015).*



Air Quality Vulnerability

Poor air quality can impact a variety of factors including human health, the local economy as well as the environment.

Human health impacts of air pollution can range from minor breathing problems to premature death. The more common effects include changes in breathing and lung function, lung inflammation, and irritation and aggravation of existing heart and lung conditions (e.g., asthma, emphysema and heart disease). For instance, $PM_{2.5}$ and ground-level O_3 can affect human respiratory and cardiovascular systems. $PM_{2.5}$ and ground-level O_3 has also been associated with eye, nose and throat irritation, shortness of breath, exacerbation of respiratory conditions, chronic obstructive pulmonary disease and asthma, exacerbation of allergies, increased risk of cardiovascular diseases and premature death. Another example is as CO enters the lungs it forms a compound known as carboxyhemoglobin that inhibits the blood capacity to carry oxygen to organs and issues. Therefore, heart disease patients may be sensitive to CO pollution. Additionally infants, elderly and individuals with respiratory diseases are also sensitive to air pollution. Such negative health effects increase with concentrations of pollutants in the air increases.

Economic impacts of air pollution can result from the health effects air pollution. Air pollution may not only reduce work attendance and overall participation in the labor force, it can increase health care costs, missed days of work, and reduced work productivity. Ultimately this would impact a local and regional economy and profit. While the impacts to human health can be detrimental to the economy, increased O_3 levels may reduce the growth of crops, plants and trees, leading to economic losses in agriculture and forestry. Finally, smog can lower tourism since it reduces and impair visibility of surroundings and scenic views.

Environmental impacts of air pollution consist of:

- Ground-level O_3 can significantly impact vegetation and reduce the productivity of some crops. It can also injure flowers and shrubs and may contribute to forest decline. Ecosystem changes can also occur, as plant species that are more resistant to O_3 can become more dominant than those that are less resistant.
- Plant response to PM is largely due to the resultant changes in soil chemistry rather than direct deposition on the plant. Various PM constituents taken up by the plant from the soil can reduce plant growth and productivity. PM can also cause physical damage to plant surfaces via abrasion.
- NO_x and SO_2 can become acidic gases or particulates, and cause or accelerate the corrosion and soiling of materials. Together with NH_3, they are also the main precursors of acid rain. Acid rain affects soils and water bodies, and stresses both vegetation and animals.

4.2.4. Shrink-swell Soils

Various areas of the Middle Peninsula have expandable soils that may have the potential to shrink and /or swell with changes in moisture content. The sensitivity of a soil to shrink or swell is related to the amount of clay minerals in the soil. These soils are very affected by changes in moisture content. They have a high tendency to expand (swell) when receiving a lot of moisture and contract (shrink) during times of little or no precipitation. Soils that have a high shrink-swell rating may cause damage to buildings, roads, or other structures if not compensated for by engineering. Special design is often needed for construction in such soils.

House Joint Resolution No. 243 (passed by the Virginia House of Delegates and Senate in March 1996) requires mandatory education for Virginia building code officials on the issue of expansive soils. Where expansive or other problem soils are identified, various methods for responding to them are permitted, including removal and replacement of soils, stabilization by dewatering or other means, or the construction of special footings, foundations, or slabs on how to deal with such soil conditions. This mandatory education is intended to provide guidance on the type of construction techniques to be employed where problem soils are present. While not preventing a site from being used, a high shrink-swell capability places a potential restriction on the size and weight of the building that may be built upon it.

Shrink-swell soils are not specifically addressed in the Essex County Comprehensive Plan (1998 & 2015), however soils associations are generally described. The Rappahannock-Molena-Pamunkey soil association is located on tidal marshes along the Rappahannock River and along floodplain of major creeks that feed into the River. The soil association is predominately Rappahannock soils, which are not suitable for any type of development because of flooding, high water table, and high organic content. These soils are very poorly drained with a surface layer of loam and subsurface of loam, fine sandy loam, and clay loam. About half of the land within this soil association is farmed; the rest is tidal and freshwater marshes. Some areas are used for waterfront development, but seasonal wetness, flooding, and unsuitability for septic systems limits the uses of this land. The suitability of the soil for septic systems and for agriculture is a prime consideration in making general land use policy decisions in Essex County.

Some of the area of the Town of Tappahannock is also on soils of the Rappahannock-Molena-Pamunkey soil association, primarily along Hoskin's Creek and Tickner's Creek (Town of Tappahannock Comprehensive Plan, 2014). These areas are not suitable for development, therefore eliminating potential problems associated with structures built on shrink-swell soils.

Shrink-swell soils are not specifically addressed in the Gloucester County Comprehensive Plan (amended 2001). However, in an analysis of soil suitability for development, clayey soils account for roughly 6,600 acres, or approximately 5% of the area of the county. Because these conditions are often coincident with shrink-swell soils, this is an approximate estimation of shrink-swell soil conditions within the county. These clayey soils are also listed as being unsuited for housing septic systems. The Gloucester County Land Use Plan generally coordinates the Bayside Conservation District and Resource Conservation District with large areas of soils unsuitable for septic tank use or otherwise unsuitable for high density or commercial development due to physical constraints. Shrink-swell soils are also not addressed in the King and Queen County Comprehensive Plan (2006).

Only one area in King William County (Bohicket) is rated high for shrink-swell soils (King William Comprehensive Plan, 2003). According to the Comprehensive Plan, the County uses the Soil Survey results in formulating future land use policies. Goals and implementation strategies within the County's Comprehensive Plan include increasing public awareness of potential problems resulting from building on soils with moderate to high shrink-swell characteristics, discouraging development in areas that are unsuited for development because of soil conditions, continue policies that require soil feasibility studies prior to approval of residential rezonings, include in the plan review process a requirement for evaluating shrink-swell soil qualities, and provide builders and developers with advice and information on shrink-swell qualities of soils and the need to evaluate these conditions before committing to construction. Shrink-Swell soils are not addressed in the Town of West Point's Comprehensive Plan (2000).

High shrink-swell soils are present in the northeastern tip of Mathews County and along the waterfront of the rivers and streams. Most of the wetlands in the County and most of the areas within the Chesapeake Bay Resource Protection Areas (protected from development by the Chesapeake Bay Preservation Act, adopted by the Virginia General Assembly in 1988) are shrink-swell soils. These soils account for just a little more than 7,000 acres of Mathews County.

According to the Middlesex County Comprehensive Plan (2009), shrink-swell soils within Middlesex County limit community development in the Ackwater, Craven, and Slagle soil series. Together, the lands comprised of these soils make up approximately 12,350 acres, or roughly 15% of the area of the county. Community development in these areas is restricted because the limitations caused by these soils cannot normally be overcome without exceptional, complex, or costly measures.

Only low to moderate shrink-swell soil potential exists in the Town of Urbanna, leaving the soils of the Town generally moderately suited for development (Town of Urbanna Comprehensive Plan, 2012). The Town's Comprehensive Plan states that individual sites should be examined in detail prior to any development.

Therefore it's important to note that there are varying degrees of vulnerability amongst Middle Peninsula localities.

Shrink-swell Soil Vulnerability

As shrink-swell soil expands and shrinks this may cause pressure and stress on house foundations. If foundations are not properly designed to handle this, then the foundation may crack, ultimately causing harm to residents.

Shrink-swell Soil Extent (Impact)

A soil survey is a scientific inventory of soils. This inventory can include maps that show soil's location and type, detailed descriptions of each soil and laboratory data on many physical and chemical properties of the soil. The data can be used to make decisions on how to use the land.

These surveys show the extent and hazards of flood-prone areas, give the amount of sand, silt and clay in soil, and rate the shrinking and swelling potential of soils high in clay content. They also detail erodibility, slope, permeability, wetness, depth to bedrock and water tables to determine, for example, whether a septic tank absorption field can be safely installed.

The amount of clay present in the soil determines its shrink-swell potential. Soils containing 60% or more of clay are considered to have a high shrink-swell potential.

4.2.5. Landslides

Similar to karst, Figure 15 shows that most landslide hazards are located in western and southwestern Virginia. The term "landslide" is used to describe the downward and outward movement of slope-forming materials reacting under the force of gravity. The term covers a broad category of events, including mudflows, mudslides, debris flows, rock falls, rock slides, debris avalanches, debris slides, and earth flows. These terms vary by the amount of water in the materials that are moving.

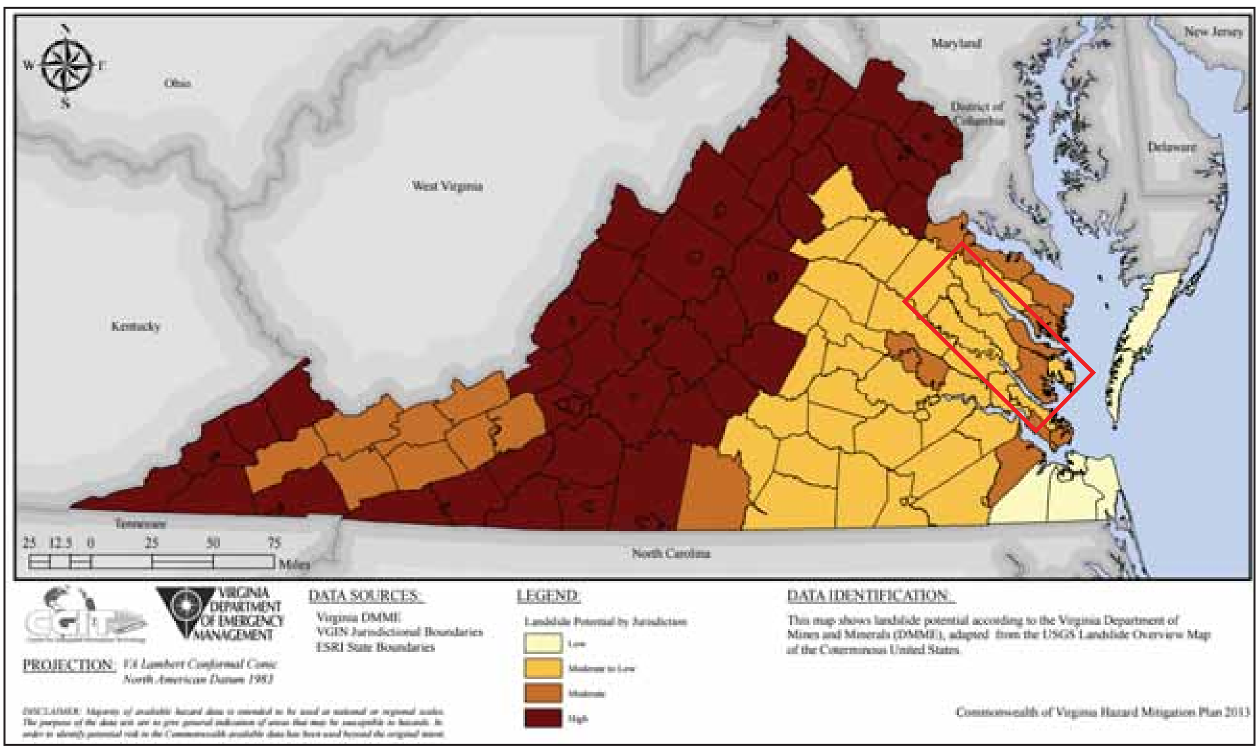


Figure 15: Landslide Potential *as assessed by VDEM. Middle Peninsula localities have a potential of landslides ranging from Moderate or Low to Moderate. The area encompassing the Middle Peninsula is highlighted on the map with a red square. (Source: Commonwealth of Virginia Hazard Mitigation Plan, 2013)*

Landslide Vulnerability

Several natural and human factors may contribute to or influence landslides. How these factors interrelate is important in understanding the hazard. The three principal natural factors are topography, geology, and precipitation. The principle human activities are cut-and-fill construction for highways, construction of buildings and railroads, and mining operations. 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.

As depicted in Figure 15, there are varying degrees of vulnerability throughout the region. While Essex, King William, King & Queen and Mathews County have a moderate to low potential of landslides, Gloucester and Middlesex County have a higher potential for landslides. Additionally, Figure 16 identified that that a small portion of King William County is highly susceptibility to landslides.

Landslide Impact (Extent)

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 off of these groupings. The categories include:

<u>High Risk</u>

1. High susceptibility to landsliding and moderate incidence.
2. High susceptibility to landsliding and low incidence.
3. High landslide incidence (more than 15% of the area is involved in landsliding).

<u>Moderate Risk</u>

4. Moderate susceptibility to landsliding and low incidence.
5. Moderate landslide incidence (1.5 - 15% of the area is involved in landsliding).

<u>Low Risk</u>

6. Low landslide incidence (less than 1.5 % of the area is involved in landsliding).

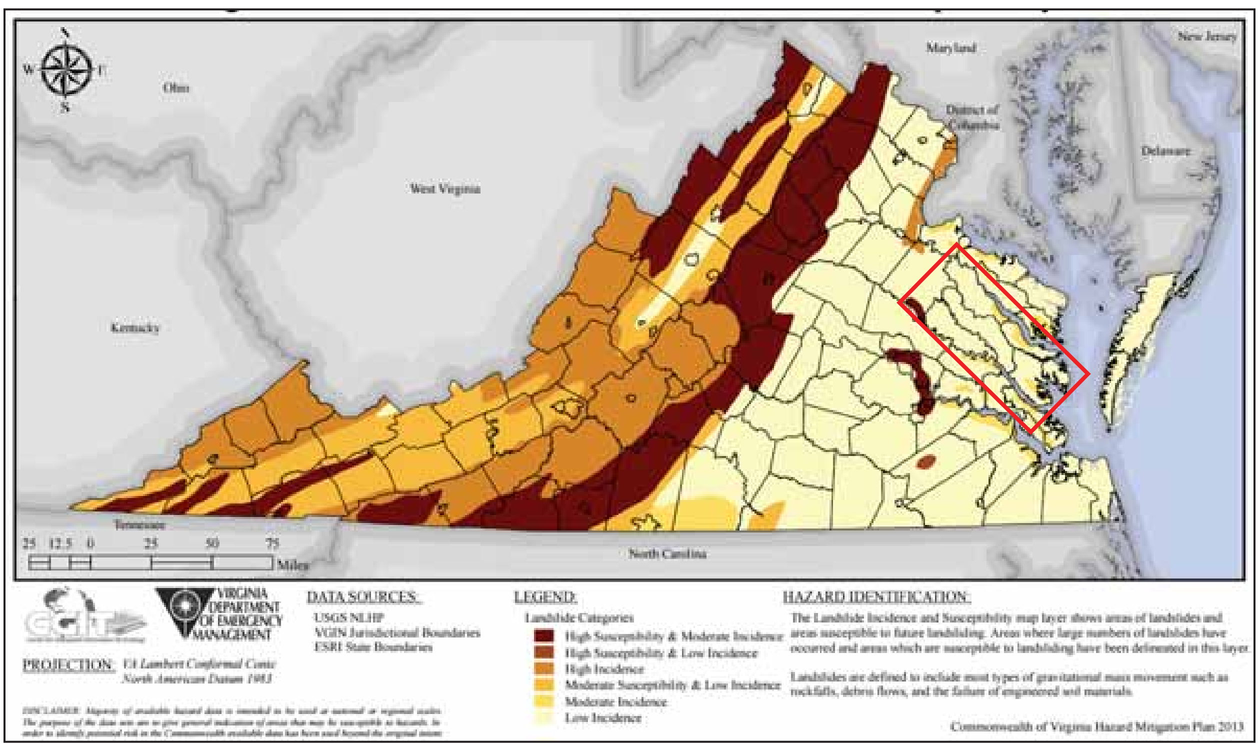


Figure 16: Landslide Incidence and Susceptibility. *The area encompassing the Middle Peninsula is highlighted on the map with a red square. (Source: Commonwealth of Virginia Hazard Mitigation Plan, 2013)*

4.2.5. Land Subsidence due to Karst

According to the Unite State Geological Survey, land subsidence is the gradual settling or sudden sinking of the Earth's surfaces. Principal causes of land subsidence may include aquifer system compaction, drainage of organic soils, underground mining, hydro-compaction, natural compaction, sinkholes and thawing permafrost. In particular, human activity such as withdrawing water, oil, or gas from underground reservoirs may cause land subsidence.

Land subsidence often occurs in regions with mildly acidic groundwater and where the geology is dominated by limestone, dolostone, marble or gypsum. In western parts of the Commonwealth the geology consists of karst which is limestone and similar soluble rocks. Therefore as karst is easily dissolved by acidic groundwater sinkholes are created. Sinkholes are classified as natural depressions of the land surface. Areas with large amounts of karst are characterized by the presence of sinkholes, sinking streams, springs, caves and solution valleys. As karst is not part of the Middle Peninsula geology, land subsidence due to karst does not occur within the region (Figure 17).

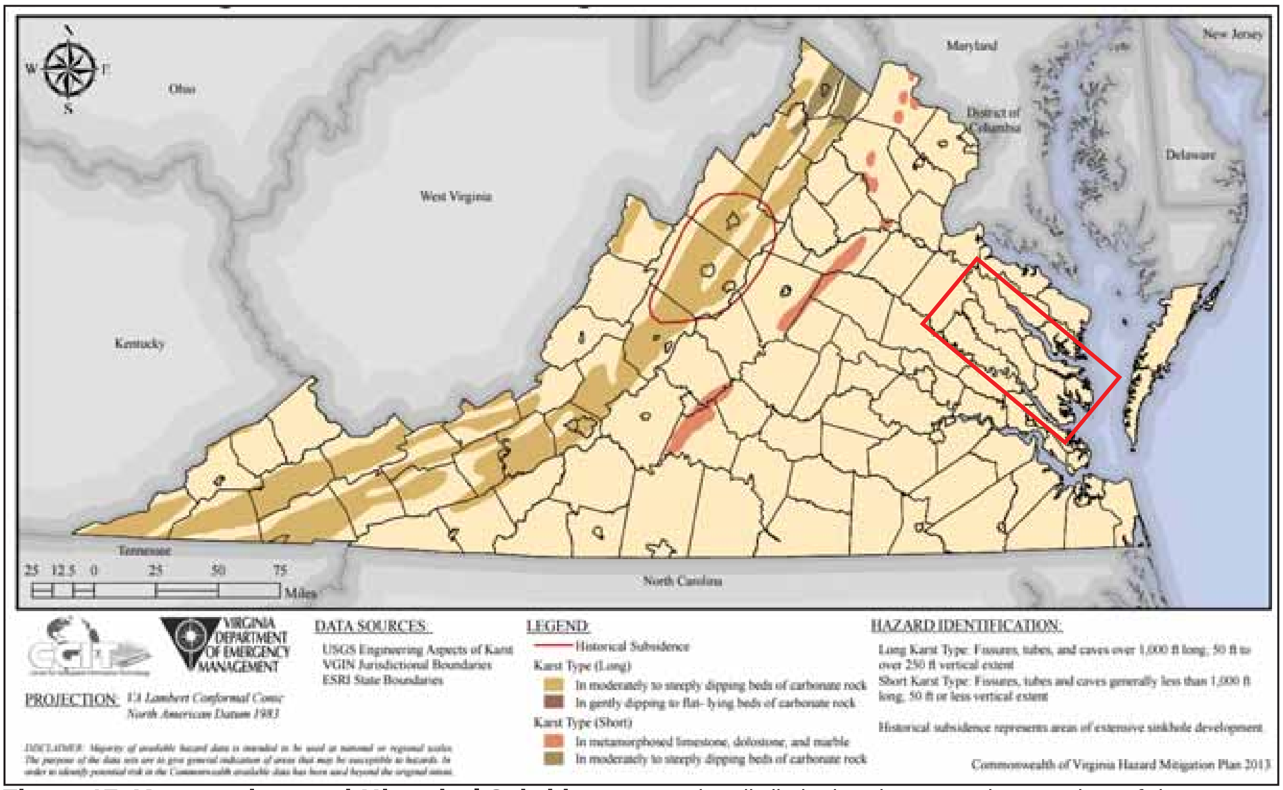


Figure 17: Karst regions and Historical Subsidence *are primarily limited to the mountainous regions of the state. The area encompassing the Middle Peninsula is highlighted on the map with a red square. (Source: Commonwealth of Virginia Hazard Mitigation Plan, 2013)*

While the Middle Peninsula may not be impacted by land subsidence due to karst it's important to note that the region is impacted by land subsidence due to water withdraws as well as rebounding land from the last glacial period. Land subsidence rates on the order of 0.05-0.06 in/yr (1.2-1.4 mm/yr) are attributed to the postglacial forebulge collapse within the Bay region (Douglas 1991). It can take many thousands of years for impacted regions to reach isostatic equilibrium.

Land Subsidence due to Karst Extent

The USGS recognizes four major impacts caused by land subsidence: (1) Changes in elevation and slope of streams, canals, and drains; (2) Damage to bridges, roads, railroads, storm drains, sanitary sewers, canals and levees; (3) Damage to private and public buildings; and (4) Failure of well casings from forces generated by compaction of fine-grained materials in aquifer systems.

Land Subsidence due to Karst Extent

Since the Middle Peninsula region does not have karst the region is not susceptible to land subsidence due to karst.

4.2.7. Tsunami

A tsunami is a wave, or series of waves, generated in a body of water by a disturbance that vertically displaces (moves up or down) the water column. Earthquakes, landslides, explosions, volcanic eruptions, and meteorites can generate tsunamis (Musick, 2005). Earthquakes can cause tsunamis when large areas of the sea floor move and vertically displace the overlying water. If the sea floor movement is horizontal, a tsunami is not generated. After a large-scale vertical sea-floor movement, waves are formed when the displaced water mass travels across the surface of the ocean.

Tsunami Vulnerability

Tsunamis along the east coast of the United States are extremely unlikely. However, geologists Steven N. Ward and Simon Day (2001) describe a landslide that could cause a collapse of a massive piece of the west flank of Cumbre Vieja Volcano on La Palma Island in the Canary Islands (off the western coast of Africa) into the Atlantic Ocean. This could generate tsunami waves that arrive on the coasts of the Americas as much as 70 ft in height. The scientists used modeling techniques to produce their conclusion of this “worst case scenario”. The Cumbre Vieja Volcano last erupted in 1949 and shows no signs of activity.

Tsunamis have great erosion potential, stripping beaches of sand that may have taken years to accumulate and undermining trees and other coastal vegetation. Tsunamis are capable of inundating, or flooding, hundreds of miles inland past the typical high-water level, the fast-moving water associated with the inundating tsunami can crush homes and other coastal structures.

There are varying degrees of vulnerability amongst Middle Peninsula localities. While the majority of the region would be impacted, the lowest lying localities, including Gloucester and Mathews County would get the brunt of the water damage. As one moves up the region to King William, King & Queen and Essex Counties, the impacts would be less; however ultimately this would be depended on the direction and strength of the tsunami.

Tsunami Extent (Impact)

Tsunamis can be measured in a variety of manner including tide gauges, satellites, and the DART System. Through tide gauges the height of the sea-surface is measured. While they may not be able to predict a tsunami the tide gauges can measure the tsunami. Satellite altimeters measure the height of the ocean surface directly by the use of electro-magnetic pulses. These are sent down to the ocean surface from the satellite and the height of the ocean surface can be determined by knowing the speed of the pulse, the location of the satellite and measuring the time that the pulse takes to return to the satellite. One problem with this kind of satellite data is that it can be very sparse - some satellites only pass over a particular location about once a month. The Deep-ocean Assessment and Reporting of Tsunamis (DART system) created by the National Ocean and Atmospheric Administration (NOAA) was developed in 1995. This system is currently deployed in the Pacific Ocean to measure the pressure of the pressure of the water column which relates to the height of the sea surface.

4.2.8. Volcanoes

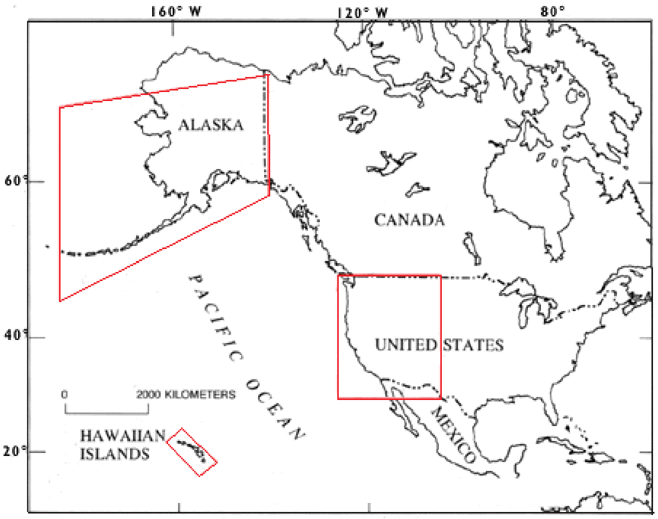


Figure 18: Map of United States showing areas where active volcanoes are located *(USGS, 1997).*

The United States ranks third, behind Indonesia and Japan, in the number of historically active volcanoes. In addition, about 10 percent of the more than 1,500 volcanoes that have erupted in the past 10,000 years are located in the United States (Brantley, 1997). Most of these volcanoes are found in the Aleutian Islands, the Alaska Peninsula, the Hawaiian Islands, and the Cascade Range of the Pacific Northwest; the remainders are widely distributed in the western part of the Nation (Figure 18).

Volcano Vulnerability

Volcanoes are considered hazardous because of the dangers associated with pyroclastic flows emitted from them during an eruption (USGS, 1999). Pyroclastic flows are high-density mixtures of hot, dry rock fragments and hot gases that move away from the vent that erupted them at high speeds. They may result from the explosive eruption of molten or solid rock fragments, or both. They may also result from the non-explosive eruption of lava when parts of dome or a thick lava flow collapses down a steep slope. A pyroclastic flow will destroy nearly everything in its path. With rock fragments ranging in size from ash to boulders traveling across the ground at speeds typically greater than 80 km per hour, pyroclastic flows knock down, shatter, bury or carry away nearly all objects and structures in their way. The extreme temperatures of rocks and gas inside pyroclastic flows, generally between 200°C and 700°C, can cause combustible material to burn, especially petroleum products, wood, vegetation, and houses.

Volcano Extent (Impact)

The Eastern United States does not have any active volcanoes; therefore, pyroclastic flows are not considered a critical hazard to the Middle Peninsula.

4.3. Hazards considered "Moderately-Critical" Hazards to the Middle Peninsula

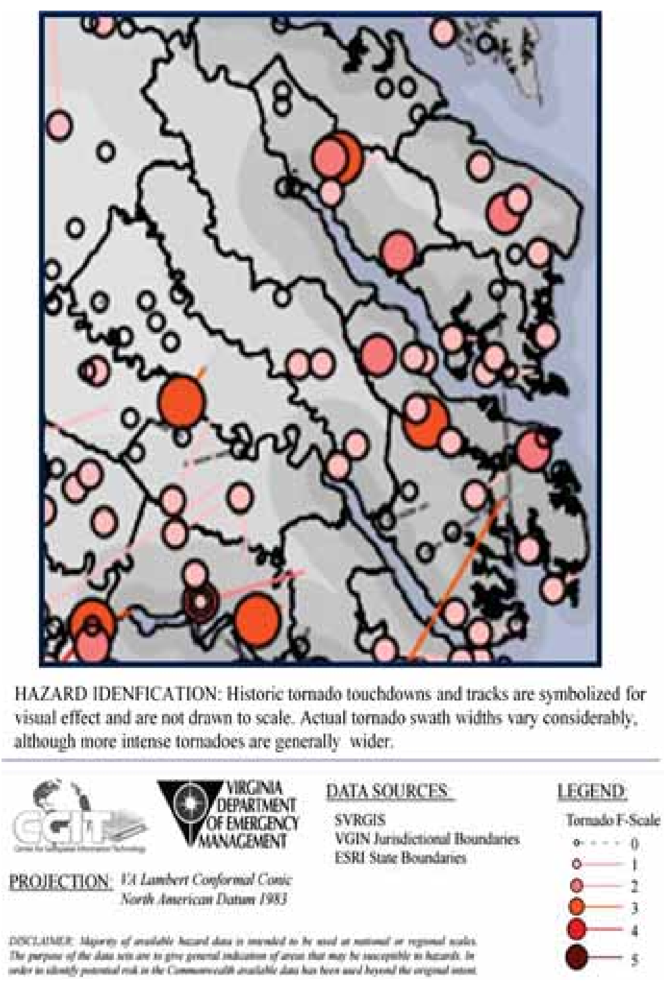
The following sections describe hazards that have historically occurred in the Middle Peninsula, yet ranked lower than the Critical Hazards in terms of risk during hazard prioritization. These hazards were deemed "Moderately-Critical Hazards" to the Middle Peninsula region by the LPT.

4.3.1 Tornadoes

The National Weather Service (NWS) defines a tornado as a violently rotating column of air in contact with the ground and extending from the base of a thunderstorm. A condensation funnel does not need to reach to the ground for a tornado to be present; however a debris cloud beneath a thunderstorm is all that is needed to confirm the presence of a tornado, even without a condensation funnel. Tornadoes are distinguishable from waterspouts, which are small, relatively weak rotating columns of air over water beneath a cumulonimbus or towering cumulus cloud. Waterspouts are most common over tropical or subtropical waters. The exact definition of waterspout is debatable. In most cases the term is reserved for small vortices over water that are not associated with storm-scale rotation (i.e., they are the water-based equivalent of landspouts). Yet there is sufficient justification for calling virtually any rotating column of air a waterspout if it is in contact with a water surface.

Tornadoes often appear as a funnel shaped cloud or a spiraling column of debris extending from storm clouds to the ground. They are created during severe weather events like thunderstorms and hurricanes when cold air overrides a layer of warm air, causing the warm air to rise rapidly. Tornadoes may be only several yards across, or in rare cases, over a mile wide. Winds within a tornado can reach speeds over 250 mph, but most tornado winds are 100 mph or less. Weak tornadoes (categorized as F0 and F1 on the Fujita scale, Table 12 & 13) are most common on the Middle Peninsula and often last only a minute before dissipating. From 1950 through the year 2014, 673 tornadoes were documented in Virginia (Tornado History Project, 2015). Within Middle Peninsula localities 38 tornadoes that touched down between1950 to 2014 (See Appendix H). While the most tornadoes touched down in the Middle Peninsula during April, July is considered the most active month for tornadoes in Virginia. The hot, humid days common to July are often accompanied by a late afternoon or evening thunderstorm.

Figure 19: Historic Tornado Touchdowns and Tacks 1950-2011.



The hot temperatures and humidity of the late afternoon fuel the thunderstorm's growth. If certain conditions are right, a tornado may develop. Hurricane-induced tornadic activity can also occur close to the coastline as a hurricane makes landfall (Watson, 2002). Virginia's tidewater counties see a fair number of tornadoes for two reasons, both of which are related to the region's proximity to Chesapeake Bay and the coast. For instance, as waterspouts are common they will occasionally come onshore and do some damage. Once the waterspout comes onshore, it is considered a tornado and is generally classified as a F0. The second instance this area sees an increase in tornadoes is that often during the warm months there is a bay breeze or sea breeze front (bay or sea cooled air on one side of the front and land heated air on the other). When a large rotating thunderstorm moves over a boundary/front such as this, there is an increased chance that conditions will be right for the development of a tornado (Watson, 2002). Between 1950 and 2014, twelve tornadoes were reported in Gloucester County, seven in Middlesex, seven in Mathews, six in King and Queen County, two in Essex County, and seven in King William County (NCDC Storm Event Database, 2015). The Virginia State Hazard Plan illustration above shows historic tornado touchdowns within the Middle Peninsula (Figure 19). While the historic data appears to show that the Middle Peninsula has a low annual probability of being struck by a tornado, it is important to note that because tornadoes can result from severe thunderstorms and hurricanes, the susceptibility of this region to these storms carries the threat of tornadoes along with it. However it's important to mention that the vulnerability will vary from locality to locality. This is clear when looking at Figure 19. Those localities within the closest proximity to the water seem to be more vulnerable where as the upper localities (i.e. King William, King & Queen and Essex) are less vulnerable.

On April 16, 2011, three separate tornadoes touched down in the Middle Peninsula. The first tornado came from the southwest. The tornado took a 46 mile path that hit Surry, James City, York, Gloucester and Mathews County. This tornado registered as a F3 tornado on the Fujita Scale which means that winds were 158-206 miles per hour (mph) that can severely damage roofs and wall and can throw cars. In Gloucester County alone this tornado tore the roof off Page Middle School and crumpled fences and buses on the property (Figure 20). Overall this tornado caused approximately $8,020,000 in damages, caused 2 fatalities and 60 injuries. The second and third tornadoes touched down in Middlesex County. The second tornado registered as a FI tornado on the Fujita Scale. This path was 1.06 miles and caused approximately $100,000 in damages. The third tornado registered as a F2 tornado on the Fujita Scale. This path was 2.8 miles and caused approximately $6,000,000 in damages.

Figure 20: Photo of the damage at Page Middle School in Gloucester County *(Gloucester-Mathews Gazette Journal, 2011).*

Tornado Vulnerability

Weak tornadoes may break branches or damage signs. Damage to buildings (ie. mobile homes or weak structures) primarily affects roofs and windows, and may include loss of the entire roof or just part of the roof covering and sheathing. Windows are usually broken from windborne debris.

In a strong tornado, some buildings may be destroyed but most suffer damage like loss of exterior walls or roof or both; interior walls usually survive.

Violent tornadoes cause severe to incredible damage, including heavy cars lifted off the ground and thrown and strong frame houses leveled off foundations and swept away; trees are uprooted, debarked and splintered.

Weak tornadoes make up 74% of all tornadoes, while 67% of all tornado deaths come from violent tornadoes.

Tornado Extent (Impact)

In Virginia, tornadoes primarily occur from April through September, although tornadoes have been observed in every month. Low-intensity tornadoes occur most frequently; tornadoes rated F2 or higher are very rare in Virginia, although F2, F3, and a few F4 storms have been observed. In comparison to other states, Virginia ranks 28th in terms of the number of tornado touchdowns reported between 1950 and 2006; Midwestern and Southern states ranked significantly higher.

Table 12: Fujita Scale to measure tornados.

F #	Est. Wind (mph)	Typical Damage
F0	< 73	Light: chimneys damaged, shallow-rooted trees pushed over
F1	73-112	Moderate: mobile homes pushed off foundations, cars blown
F2	113-157	Considerable: mobile homes demolished, trees uprooted, roofs torn off frame houses
F3	158-206	Severe: roof and walls torn down, trains overturned, cars thrown
F4	207-260	Devastating: well-constructed walls leveled, large objects thrown
F5	261-318	Incredible: homes lifted and carried, cars thrown 300 ft, trees de-barked

Table 13: Fijita Scale, Derived Enhanced Fujita (EF) Scale and Operated EF Scale.

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

4.3.2. Snow Storm

The winter months can bring a wide variety of hazards to the Middle Peninsula, including blizzards, snowstorms, ice, sleet, freezing rain, and extremely cold temperatures. All of these weather events can be experienced throughout the state, depending on the depth of cold air that is in place over the region when the storm event comes. The Middle Peninsula's biggest winter weather threats come from Northeasters or Nor'easters. These large storms form along the southern Atlantic coast and move northeast into Virginia along the Mid-Atlantic coast. These events are explained in detail in the following section describing Critical Hazards to the Middle Peninsula, under the sub-heading "Winter Ice Storms". Winter storm events can bring strong winds and anything from rain to ice to snow to even blizzard conditions over a very large area. This combination of heavy frozen precipitation and winds can be quite destructive and lead to widespread utility failures and high cleanup costs. Nor'easters may occur from November through April, but are usually at their worst in January, February, and March.

Snow Storm Vulnerability

The impacts of winter storms are minimal in terms of property damage and long-term effects. The most notable impact from winter storms is the damage to power distribution networks and utilities. Severe winter storms with significant snow accumulation have the potential to inhibit normal functions of the Middle Peninsula. Governmental costs for this type of event are a result of the needed personnel and equipment for clearing streets. Private sector losses are attributed to lost work when employees are unable to travel. Homes and businesses suffer damage when electric service is interrupted for long periods. Health threats can become severe when frozen precipitation makes roadways and walkways very slippery and due to prolonged power outages and if fuel supplies are jeopardized. Occasionally, buildings may be damaged when snow loads exceed the design capacity of their roofs or when trees fall due to excessive ice accumulation on branches. The primary impact of excessive cold is increased potential for frostbite, and potentially death as a result of over-exposure to extreme cold. Some secondary hazards extreme/excessive cold present is a danger to livestock and pets, and frozen water pipes in homes and businesses.

Snowstorms do not occur every year in the Middle Peninsula. The West Virginia University Extension Service developed estimates the likelihood for snowfall frequency and accumulation for 152 monitoring stations across the Commonwealth based on historic snowfall accumulation and frequency data (Rayburn and Lozier 2001, these data are available on-line at: http://www.wvu.edu/~agexten/forglvst/VAsnow/index.htm). Three of these stations are located on the Middle Peninsula: Urbanna in Middlesex County, Walkerton in King and Queen County, and West Point in King William County. While the other counties of the Middle Peninsula were not included in the West Virginia University Extension Office data, these stations may be considered representative to predict annual snow cover likelihood for the rest of the Middle Peninsula.

At the Urbanna Station in Middlesex County, snow cover data was collected for 24 years between 1949 and 1973. Based on snowfall frequency and accumulation during this period, a general risk of snow cover and snow depth in a given year was calculated. Rayburn and Lozier determined that there is a 50% risk of having between 1 and 8 inches of snow on the ground for 8 days or more. This means that, in one (1) year out of two (2), Urbanna will probably have snow of up to 8 inches on the ground for 8 days. In one (1) year out of four (4), Urbanna may have snow cover up to 8 inches deep for 12 days (in other words, there is a 25% chance of having snow for 12 days). In one year out of ten, Urbanna may have up to 8 inches of snow for 17 days (there is a 10% chance of having snow for 17 days). For deeper accumulations (greater than 8 inches), there is a 10% risk of having snow cover for 2 days or more. This means that, in 1 year out of 10, this location probably will have snow cover of at least 8 inches for 2 days.

At the Walkerton Station in King and Queen County, snow cover data was collected for 66 years between 1931 and 1997. Based on snowfall frequency and accumulation during this period, a general risk of snow cover and snow depth in a given year was calculated. Rayburn and Lozier determined that there is a 50% risk of having between 1 and 8 inches of snow on the ground for 6 days or more. This means that, in one year out of two, Walkerton will probably have snow of up to 8 inches on the ground for 6 days. In one year out of 4, Walkerton may have snow cover up to 8 inches deep for 13 days (in other words, there is a 25% chance of having snow for 13 days). In one year out of ten, Walkerton may have up to 8 inches of snow for 22 days (there is a 10% chance of having snow for 22 days). For deeper accumulations (greater than 8 inches), the risk is the same as reported for Urbanna and there is a 10% risk of having snow cover for 2 days or more. This means that, in 1 year out of 10, this location probably will have snow cover of at least 8 inches for 2 days. The average annual snowfall for 2014 at the Walkerton Station was 10.0 inches.

At the West Point station in King William County, snow cover data was collected for 44 years between 1953 and 1997. Based on snowfall frequency and accumulation during this period, a general risk of snow cover and snow depth in a given year was calculated. Rayburn and Lozier determined that there is a 50%

risk of having between 1 and 8 inches of snow on the ground for 8 days or more. This means that, in one year out of two, West Point will probably have snow of up to 8 inches on the ground for 8 days. In one year out of 4, West Point may have snow cover up to 8 inches deep for 15 days (in other words, there is a 25% chance of having snow for 15 days). In one year out of ten, West Point may have up to 8 inches of snow for 19 days (there is a 10% chance of having snow for 19 days). For deeper accumulations (greater than 8 inches), the risk is the same as reported for both Urbanna and Walkerton. There is a 10% risk of having snow cover for 2 days or more. This means that, in 1 year out of 10, this location probably will have snow cover of at least 8 inches for 2 days. The average annual snowfall for 2014 at the West Point Station was 10.1 inches.

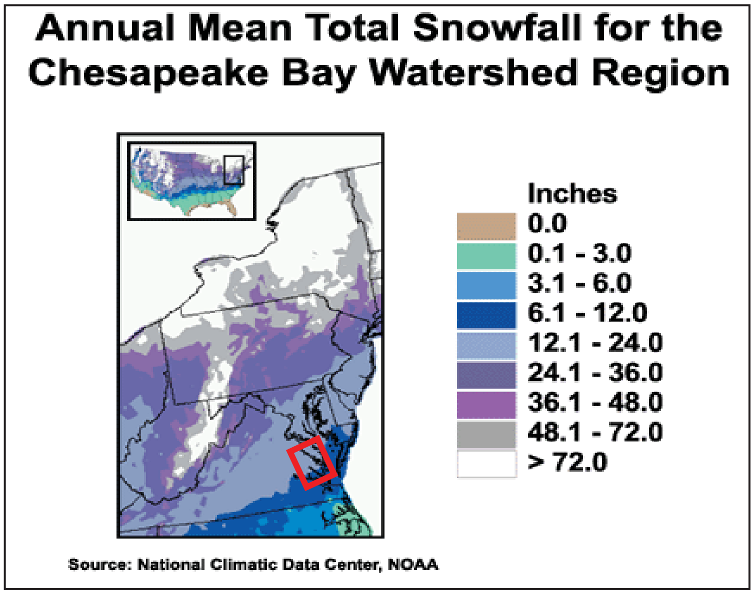


Figure 21: Map of annual mean total snowfall for the Chesapeake Bay Watershed region *(StormCenter Communications, 2003). The area encompassing the Middle Peninsula is highlighted on the map with a red square.*

Compared to western, northern, and mountainous regions of the state, the risk of high snow accumulations in the Middle Peninsula is low and will vary amongst localities (Figure 21). According to the National Climactic Data Center, mean annual snowfall in the Middle Peninsula ranges from between 6 and 12 inches at the lower reaches of the region (primarily in Gloucester and Mathews Counties) to as much as 12 to 24 inches in the upper reaches of the region (primarily in Essex, King and Queen, King William, and Middlesex Counties). The proximity of adjacent water bodies bordering the region (Chesapeake Bay and its tributaries) to the Atlantic Ocean allows the Bay to retain heat and buffer to the region from intense snow. The amount of snow that falls across the watershed varies both from year to year and from location to location. Generally, areas to the north, such as in Pennsylvania and New York, see more snow in an average year than locations in the southern part of the watershed. For areas to the south, such as Norfolk, winters typically pass without a measurable amount of snowfall.

Snow without ice has adverse impacts for the road transportation network, which therefore limits the ability of residents to have access to essential and for some, life-critical emergency medical care.

The ability of the local jurisdictions to provide critical public safety services (ie. fire, emergency medical and law enforcement) could be a focus of any mitigation strategies proposed in the update during the emergency response phase when severe snow events hit the Middle Peninsula.

In December of 2009, a major snowstorm slammed the East Coast and snarled the busy holiday travel season as airports shut down runways, rail service slowed and bus routes were suspended on the last weekend before Christmas. Record snowfall totals were reported at Washington Dulles and Reagan

National airports. Accumulation at Dulles reached 16 inches, breaking the old record of 10.6 inches set December, 12, 1964; 13.3 inches was reported at Reagan. The old record there was 11.5 inches set December 17, 1932.

Snowfall Extent (Impact)

The Northeast Snowfall Impact Scale (NESIS) developed by Paul Kocin and Louis Uccellini of the NWS (Kocin and Uccellini, 2004) characterizes and ranks high-impact Northeast snowstorms. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five categories: Extreme, Crippling, Major, Significant, and Notable. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus NESIS gives an indication of a storm's societal impacts.

NESIS categories, their corresponding NESIS values, and a descriptive adjective:

Category	NESIS Value	Description
1	1—2.499	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Winter Weather Section

Since the original plan was developed there has only been one significant snowfall event in the Middle Peninsula. According to the National Climatic Data Center (NCDC), on February 10, 2010 between 1 and 5 inches fell across the region. All of the land area within the region is subject to snowfall. Due to only two operating weather stations in King and Queen and King William Counties, there is little data available for additional analysis. Therefore the information described in the West Virginia Extension Service in the original plan will suffice.

Additional impacts include downed power lines, roof collapses during heavy snow loads, as well as frozen utility lines during extreme cold events.

4.3.3 Coastal/Shoreline Erosion

As flooding is the most frequent and costly natural hazard in the United States - besides fire, nearly 90% of Presidential Disaster Declarations result from natural events where flooding is a major component. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto adjacent floodplains and other low-lying land adjacent to rivers, lakes, ponds and the Chesapeake Bay.

Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall. These conditions are produced by hurricanes during the summer and fall, and nor'easters and other large coastal storms during the winter and spring. Storm surges may overrun barrier islands and push sea water up coastal rivers and inlets, blocking the downstream flow of inland runoff.

Soil Erosion

Hurricanes and nor'easters produce severe winds and storm surges that create significant soil erosion along rivers and streams in the Middle Peninsula. In addition to the loss of soil along these water bodies, there is damage to man-made shoreline hardening structures such as bulkheads and rap-rap as well as to piers, docks, boat houses and boats due to significant storm surges.

These damages are more severe along the broad open bodies of water on major rivers located closer to the Chesapeake Bay. In general terms, the damage is less intense as you move up the watershed from the southeastern area of the region towards the northwestern end of the Middle Peninsula. Therefore, the soil erosion would is most severe in Mathews, Gloucester and Middlesex Counties and to a lesser degree in the 3 remaining Middle Peninsula Counties of King and Queen, King William and Essex Counties.

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. It can generally be said that hurricane generated soil erosion is uneven in occurrence and that the storm surge affords 2 opportunities for erosion – once as water inundates low-lying amount coast lands and again as floodwaters ebb.

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.

Destructive as it was, Hurricane Isabel might have been worse. If it had been stronger at landfill, the storm surge generated in the Chesapeake Bay may have been higher. Had it stalled along its path and lingered through several tide cycles, prolonged surge conditions, exacerbated by high winds, might have cause more severe erosion. If rainfall has been higher, bank erosion due to slope failure might have been more common, particularly given the wetter than normal months that preceded Hurricane Isabel.

Coastal/Shoreline Erosion Vulnerability

Thousands of acres of crops and forest lands may be inundated by both saltwater and freshwater. Escape routes, particularly from barrier islands, may be cut off quickly, stranding residents in flooded areas and hampering rescue efforts. Coastal flooding is very dangerous and causes the most severe damage where large waves are driven inland by the wind. These wind driven waves 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.

Coastal/Shoreline Erosion Extent (Impacts)

While coastal/shoreline erosion can be seen by the naked eye, it can also be observed through the comparison of historical coastal aerial photographs and current ones.

4.3.4. Wildfire

A wildfire is an uncontrolled burning of grasslands, brush, or woodlands. The potential for wildfire depends upon surface fuel characteristics, recent climate conditions, current meteorological conditions, and fire behavior. Hot, dry summers, and dry vegetation increase susceptibility to fire in the fall, a particularly dangerous time of year for wildfire.

The three leading causes of wildfires in Virginia are escaped debris fires, arson, and machine use. Wildfires can also result from natural occurrences, such as lightning strikes. Wildfire danger can vary greatly season to season and is often exacerbated by dry weather conditions.

The VDOF indicates that there are three principle factors that can lead to the formation of wildfire hazards: topography, fuel, and weather. The environmental conditions that exist during spring (March and April) and fall (October and November) exacerbate the hazard. When relative humidity is low and high winds are coupled with a dry forest floor (brush, grasses, leaf litter), wildfires may easily ignite. Years of drought can lead to environmental conditions that promote wildfires. In Virginia, accidental or intentional setting of fires by humans is the largest contributor to wildfires. Residential areas that expand into wild land areas also increase the risk of wildfire threats.

Wildfire Vulnerability

As development has spread into areas which were previously rural, new residents have been relatively unaware of the hazards posed by wildfires and have used highly flammable material for constructing buildings. This has not only increased the threat of loss of life and property, but has also resulted in a greater population of people less prepared to cope with wildfire hazards.

The impacts of wildfires can be widespread leading to many secondary hazards. During a wildfire, the removal of groundcover that serves to stabilize soil can lead to hazards such as landslides, mudslides, and flooding. In addition, the leftover scorched and barren land may take years to recover and the resulting erosion can be problematic.

Because of wild fire risk, the Virginia Department of Forestry (VDOF) has provided new information on identifying high-risk fire areas. Their Fire Risk Assessment Mapping Database was designed to help communities determine areas with the greatest vulnerability to wildfire. Since wildfire occurrence is based on multiple factors, the VDOF developed a fire ranking map to assist to wildfire prevention efforts, as shown in Figure 22. In 2002 and 2003, VDOF examined which factors influence the occurrence and advancement of wildfires and how these factors could be represented in a Geographic Information System (GIS) model. VDOF determined that historical fire incidents, land cover (fuels surrogate), topographic characteristics, population density, and distance to roads were critical variables in a wildfire risk analysis. The resulting high, medium, and low risk category reflect the results of these analyses. Figure 22 and Table 14 show the varying degree of risk amongst Middle Peninsula localities.

Figure 22: Middle Peninsula Wildfire Risk. *Throughout the region risk to wildlife varies due to historic fire incidents, land cover, topographic, characteristics, population density and distance to roads.*

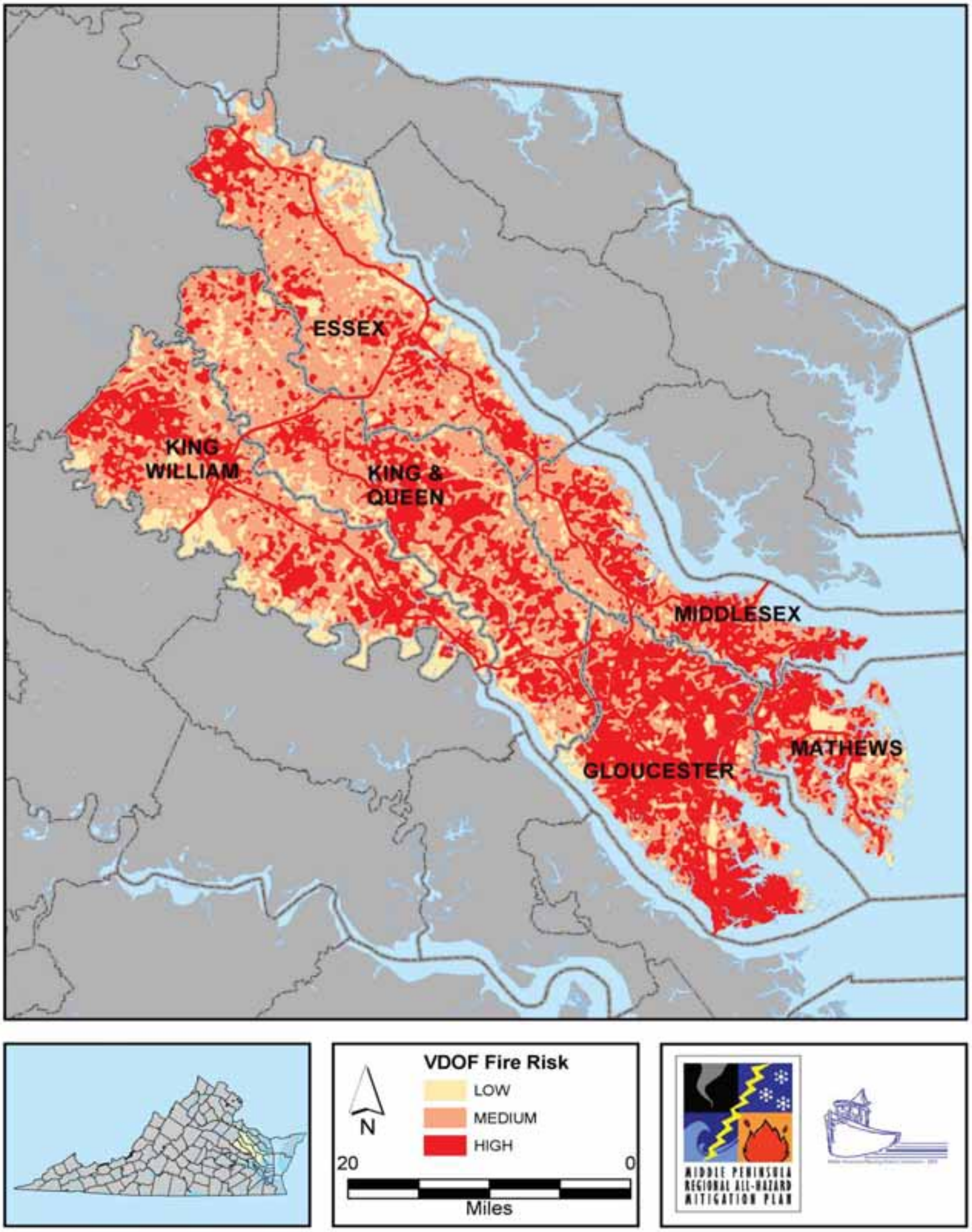


Table 14: Acres of each Middle Peninsula County within each VDOF Fire Risk Category.				
County	**LOW**	**MEDIUM**	**HIGH**	**Total Acreage**
Essex	33,894	105,885	31,999	171,778
Gloucester	16,267	46,195	90,182	152,644
King and Queen	28,569	117,897	59,440	205,906
King William	42,127	89,417	51,039	182,583
Mathews	14,903	28,819	21,966	65,688
Middlesex	8,619	50,251	33,320	92,190
Middle Peninsula Total	**144,389**	**438,464**	**287,946**	**870,789**

Table 15: Percent of each Middle Peninsula County's area within each VDOF Fire Risk Zone.			
County	**LOW**	**MEDIUM**	**HIGH**
Essex	19.7	61.6	18.6
Gloucester	10.7	30.3	59.1
King and Queen	13.9	57.3	28.9
King William	23.1	49.0	28.0
Mathews	22.7	43.9	33.4
Middlesex	9.3	54.5	36.1
Middle Peninsula	**16.6**	**50.4**	**33.1**

As a region, most of the area making up the Middle Peninsula falls within the "Medium" Fire Risk category (Table14 and 15). It is noteworthy that nearly 60 percent of the area of Gloucester County falls within the "High" Fire Risk category (Table 15).

Debris burning continues to be the leading cause of forest fires in Virginia. The Commonwealth of Virginia has several laws that help to reduce the risk of wildfires. Most notably is the 'Virginia's 4:00 PM Burning Law', which goes into effect each spring. The 4:00 PM Burning Law is different from the burning bans, which are invoked only during periods of extreme fire danger. Briefly, the 4:00 PM Burning Law states: from February 15 through April 30 of each year, no burning before 4:00 PM is permitted if the fire is in, or within 300 feet of, woodland, brushland or fields containing dry grass or other flammable material.

Since forest fuels cure during the winter months, the danger of fire is higher in early spring than in summer when the forest and grasses are green with new growth. The 4:00 PM Burning Law is an effective tool in the prevention of forest fires.

Areas where homes meet the Wildland are called the Wildland/Urban interface. Flammable forest fuels often surround homes located in the woods. The VDOF suggests the following safety tips to minimize the threat to homes:

- Have a least 30 feet of defensible space surrounding a home. This will reduce the wildfire threat to a home by changing the characteristics of the surround vegetation. Defensible space also allows firefighters room to put out fires.
- Build with fire-resistant exterior construction materials, such as cement, brick, plaster, and stucco and concrete masonry. Double pane glass windows can make a home more resistant to wildfire heat and flames. Roofs should be Class A.
- Use landscaping materials and design to also create defensible space. Remove flammable plants that contain resins, oils and waxes that burn readily. Large, leafy hardwood trees should be pruned so that the lowest branches are at least 6 to 10 feet high to prevent a fire on the ground from spreading up to the treetops.

- Identify a home and neighborhood with legible and clearly marked street names and numbers so emergency vehicles can rapidly find the location of the emergency. Include a driveway that is at least 12 feet wide with a vertical clearance of 15 feet – provide access to emergency apparatus.

Since the 2010 plan there has been a total of 100 wildfires within the region (Appendix I). Based on VDOF records, each locality has been impacted by wildfire (Table 16 and 17):

Table 16: The number wildfires in a given year (VDOF, 2015)

County	Number of Wildfires in a Given Year						Total
	2010	2011	2012	2013	2014	2015*	
Essex	7	7	5	2	3	2	26
Gloucester	7	9	7	13	4	6	46
Middlesex	3	7	4	0	3	1	18
Mathews	3	1	3	1	2	0	10
King & Queen	2	1	3	2	2	1	11
King William	8	3	3	0	4	3	21

*Please note that the 2015 data is only through mid-June.

Table 17: The number of acres burned at as result of wildfires in a given year (VDOF, 2015)

County	Number of Acres Burned in a Giver Year						Total
	2010	2011	2012	2013	2014	2015*	
Essex	88.7	28.9	4.7	.9	7.5	3.1	133.8
Gloucester	4	664	132.4	4.3	14.6	145	964.3
Middlesex	7.5	479.9	1.4	0	0.7	1	490.5
Mathews	30.5	0.2	3.5	0.5	4.4	0	39.1
King & Queen	3.1	5	20.1	7	50.5	16	101.7
King William	14.1	52	22	0	1.6	1.4	91.1

*Please note that the 2015 data is only through mid-June.

Previous wildfire events identified in the 2011 Mitigation Plan include:

- During 2009, Middlesex County experienced a major wildfire north of Urbanna between route 602 and US Route 17 near Hilliard Pond.

- During 2008, Gloucester County experienced a significant fire in the Guinea area that burned several acres. While this fire did not require any evacuations it did require mutual aid from other jurisdictions. This fire was coordinated through Abington Volunteer Fire and Rescue.

In 2008, drought conditions combined with strong winds resulted in sporadic wildfires in numerous locations throughout the Middle Peninsula region. Mutual aid assistance between area fire departments, as well as from the VDOF, was widely used during these wildfire events.

As discussed at the PENEX '09 Regional Training Exercise in September 2009, there is a need for more formalized written agreements between some neighboring jurisdictions when it comes to mutual aid assistance. Also, the lack of operable communications between neighboring jurisdictions willing to offer mutual aid to one another, as well as with state forces, is an issue that was also cited in the After-Action-Report from the PENEX '09 Regional Training Exercise. The PENEX '09 exercise covered jurisdictions in both the Middle Peninsula and Northern Neck regions.

Mitigation strategies formalizing MOUs between area fire departments to quickly respond to the adverse effects of the wildfire hazard should be included as part of the MPNHMP update.

Mitigation strategies to improve communication systems between the local jurisdictions and with their state fire-fighting partners should also be proposed with this update.

In addition, the VDOF safety tips - as noted above - lend themselves to a public education mitigation strategy dealing with wildfires and should be included with this update.

Wildfire Extent (Impact)

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.

4.3.5. Riverine Flooding

A flood is partial or complete inundation of normally dry land areas. *Riverine flooding* is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. This type of flooding is different from *coastal flooding*, which is caused by storm surge and wave action and affects coastal areas, especially those along the beachfront. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur because of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event.

Periodic flooding of lands adjacent to non-tidal rivers and streams is a natural and inevitable occurrence. When stream flow exceeds the capacity of the normal water course, some of the above-normal stream flow spills over onto adjacent lands within the floodplain. Riverine flooding is a function of precipitation levels and water runoff volumes within the watershed of the stream or river. The recurrence interval of a flood is defined as the average time interval, in years, expected to take place between the occurrence of a flood of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval.

The major rivers of the Middle Peninsula are tidal in nature, serving as estuarine tributaries of the Chesapeake Bay. Flood hazard varies by locality and type of flooding. Riverine flooding is more of a threat to mountainous regions, where population areas typically lie in narrow valleys, which lack the ability to store and dissipate large amounts of water. Consequently, stream flow tends to increase rapidly.

Riverine flooding was addressed during the flood mitigation planning process and mitigation strategies in this update will include:

1. Continuing to maintain and enforce a strong NFIP,
2. Investigating the feasibility of undertaking a FEMA-promoted Community Rating System (CRS) for enhanced floodplain protection policies, and
3. Actively promoting public education programs about development in and adjacent to areas with a history of flooding from rivers and creeks.

Riverine Flooding

As riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snow melt, rapid ice melt or a combination of all three and this type of flooding involves the partial or complete inundation of normally dry land areas. If differs from coastal flooding, which is caused by a combination of rain, storm surge and wave action and affects coastal areas, especially those along the beachfront.

Approximately 60% of Virginia's river flooding begins with flash flooding from tropical systems passing over or near the state. Riverine flooding also occurs because of successive rainstorms. Rainfall from any one storm may not be enough to cause a problem, but with each successive storm's passage over the basin, rivers rise until eventually they overflow their banks. If this occurs in late winter or spring, melting snow in the mountains can produce additional runoff that can compound flooding problems.

There are several types of riverine flooding including headwater, backwater, interior drainage, and flash flooding:

Headwater flooding results from significant rain events that occur at the upper reaches of a watershed that then flow downstream within a short period of time.

Backwater flooding results when the lower portion of a river or stream is blocked by debris or backed up due to a storm surge along the coast.

Interior drainage flooding results when a dam gives way and the water being held in the impoundment is released all at once to the downstream receiving channel.

Flash flooding is characterized by rapid accumulation and runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur because of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event.

Although flash flooding is more of a threat in the steeper mountainous regions of the state where population areas typically lie in narrow valleys that lack the ability to store and dissipate large amounts of water, some of the hilly areas in the upper reaches of the Middle Peninsula watersheds can experience rapid increase in stream flow resulting in some riverine flooding and subsequent threats to life and property.

Periodic flooding of lands adjacent to non-tidal rivers and streams is a natural and inevitable occurrence. When stream flow exceeds the capacity of the normal water course, some of the above-normal stream flow spills over onto adjacent lands within the floodplain. Riverine flooding is a function of precipitation levels and water runoff volumes within the watershed of the stream or river.

The recurrence interval of a flood is defined as the average time interval, in years, expected to take place between the occurrence of a flood of a particular magnitude and a second one of equal or greater magnitude. Flood magnitude increases with increasing recurrence interval. The interval most referred to and also the basis for many local government regulations is known as the 100-year flood or storm event.

The major rivers in the lower Middle Peninsula are tidal in nature and they serve as estuarine tributaries of the Chesapeake Bay. Flood hazards vary due to the river's location and the type of storm event taking place.

Riverine Flooding Vulnerability

Populations and property are extremely vulnerable to flooding. Homes business, 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 the flood may be contaminated with hazardous materials. Debris from vegetation and man-made structures may also be hazardous following the occurrence of a flood. In addition, floods may threaten water supplies and water quality, as well as initiate power outages, and create health issues such as mold.

Riverine Flooding Extent (Impact)

The FEMA Special Flood Hazard Area designations area associated with the probability of flooding (Tables18):

Table 18: FEMA Flood Zone Designations and probabilities (VDEM, 2013).

Zone V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined
Zone VE	Coastal flood zone with velocity hazard (wave action); wave heights above 3 feet; Base Flood Elevations determined.
Zone A	100 Year flood area (1% annual change of flood). Base Flood Elevations determined.
Zone AE	100 year flood area (1% annual chance of flood). Base Flood Elevations determined.
Zone AO	Subject to 100 year shallow flooding with flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); Base Flood Elevations undetermined
Zone X	Areas with 0.2% annual chance of flood or less; areas in 100 year 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.
Zone X500	The same description as Zone X, however, this area falls between the 100 and 500-year flood zone.
UNDES	Area in which flood hazards are undetermined.

4.3.6. Sea Level Rise

A look at the geologic record of Chesapeake Bay shows a long and dynamic history - from the bolide (asteroid or comet) impact about 35 million years ago which formed the Chesapeake Bay impact crater, to the melting of glaciers beginning about 18,000 years ago, resulting in a continued rise of sea level and drowning of the Susquehanna River valley. Given that the rise in sea level has been occurring for thousands of years and is fundamental to the present formation of the Chesapeake Bay and our local tidal waters, there has been a heightened level of concern in recent years. Concern is justified given that current and projected rates of sea level rise represent a significant increase over what we experienced during the last century. There is general consensus that rise in sea level will continue for centuries to come, and that human and natural communities within the Middle Peninsula will be vulnerable. Understanding the challenge is vital for local government to develop strategies to reduce the regions vulnerability to sea level rise.

Causes and Current Rates of Local Sea Level Rise

Processes responsible for rising sea levels are complex. To help simplify the matter, it is useful to make a distinction between the concepts of eustatic and relative sea level (RSL) change. Eustatic change, which can vary over large spatial scales, describes sea level changes at the oceanic to global scale that result from changes in the volume of seawater or the ocean basins themselves. The two major processes responsible for eustatic change are the thermal expansion of seawater due to warming and the melting and discharge of continental ice (i.e., glaciers and ice sheets) into the oceans. The global average for current (2003-mid 2011) eustatic sea level change is 0.11 in/yr(2.8 mm/yr) (NOAA Laboratory for Satellite Altimetry, 2008) with estimates for the Chesapeake Bay region on the order of 0.07 in/yr (1.8 mm/yr; Boon et al. 2010) for the approximate same time period.

RSL change describes the observed change in water level at a particular location and represents the sum of eustatic sea level change and local vertical land movement (subsidence or uplift) at that location. Within the Chesapeake Bay region, land subsidence represents a significant component of RSL change. Processes contributing to land subsidence include tectonic (movement of the earth's crust) and man-induced impacts (e.g., groundwater withdrawal, hydrocarbon removal). During the last glacial period (maximum extent approximately 20,000 yr BP), the southern East Coast limit of the Laurentide ice sheet coincided with northern portions of Pennsylvania (Mickelson and Colgan, 2003). As a consequence, land subsided under the ice load and, in turn, created a fore-bulge or upward displacement of lands south of the ice load. Upon retreat of the glacier, the land continued to redistribute, rebounding in previously glaciated areas and subsiding in the more southern forebulge region. Land subsidence rates on the order of 0.05-0.06 in/yr (1.2-1.4 mm/yr) are attributed to the postglacial forebulge collapse within the Bay region (Douglas, 1991). It can take many thousands of years for impacted regions to reach isostatic equilibrium.

At a more local level, overdrafting of groundwater is a significant factor driving land subsidence rates. Within the Eastern Virginia Groundwater Management Area, large industrial and domestic use groundwater withdrawals from the Potomac aquifer series occur in the areas of Franklin, Suffolk and West Point, VA. Elevated subsidence rates, which integrate both regional and local causes, were first observed near the centers of large groundwater withdrawals through repetitive high-precision relevelings and analysis of tide records, and later through studies that directly measured aquifer system compaction. Land subsidence rates within the Middle Peninsula, based on releveling analysis, vary between 0.09-0.15 in/yr (2.4-3.8 mm/yr) with maximum values being observed at West Point (Holdahl and Morrison 1974; Davis 1987). Pope and Burbey (2004) reported average aquifer system compaction rates of 0.06 in/yr (1.5 mm/yr; 1979-1995) and 0.15 in/yr (3.7 mm/yr; 1982-1995) near the Franklin and Suffolk pumping centers, respectively, and that compaction appeared to correlate with groundwater withdrawal; West Point was not included as part of this study. It has been suggested that the Chesapeake Bay impact structure, whose outer rim traverses the lower Middle Peninsula (Powars and Bruce, 1999) may contribute to local land subsidence. While observations suggest post impact subsidence at a geologic scale (Johnson et al. 1998), present day influence is currently unknown.

It is important to note however that the lower lying counties like Gloucester and Mathews County will most likely see the largest impact from sea level rise.

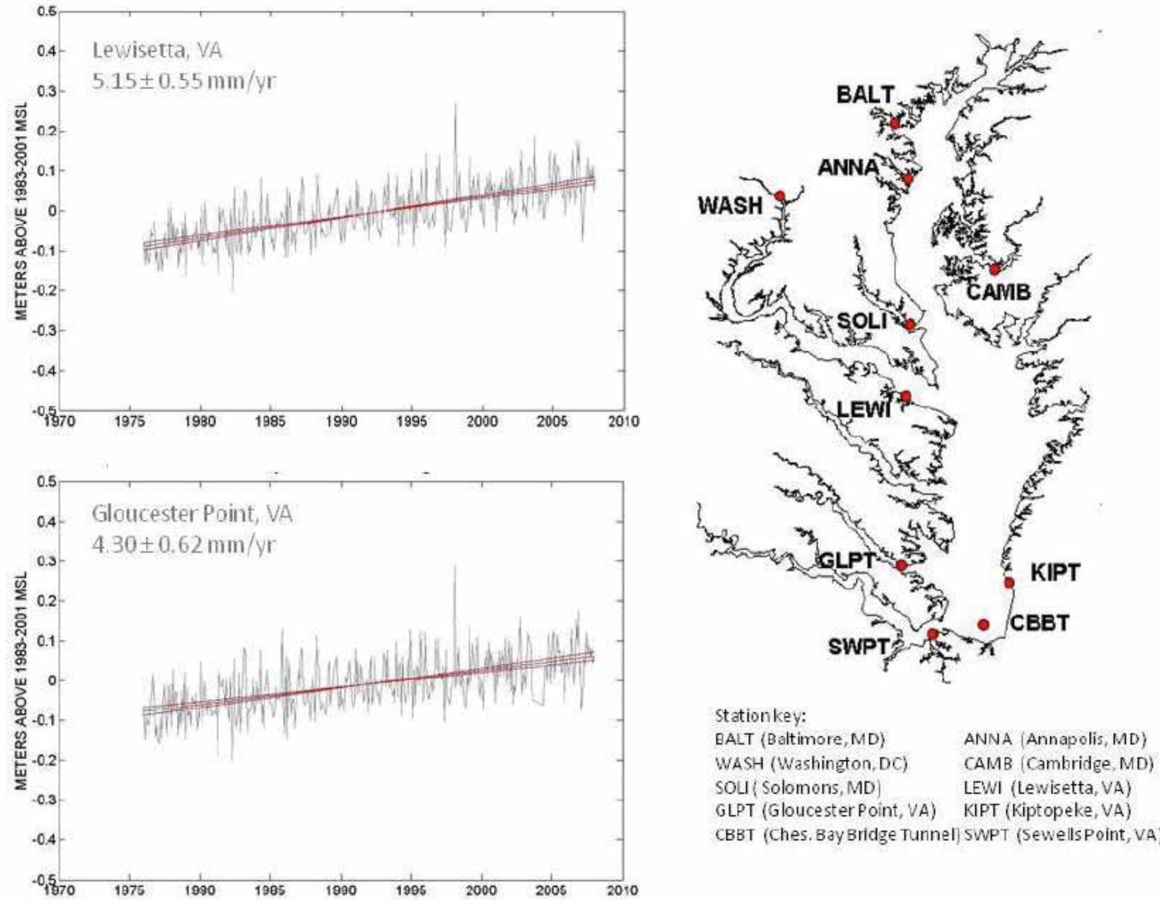


Figure 23: RSL Trends. *RSL trends and 95% confidence intervals for Lewisette, VA and Gloucester Point, VA (after removal of Seasonal cycle and decadal signal) from the 1976-2007 period and location map for Chesapeake Bay National Water Level Observation Network Stations (Boon et al. 2010).*

Sea Level Rise Vulnerability

Coastal habitat as well as activity may be impacted by sea level rise. As the water reaches further inland it will influence humans, the environment and the economy. Table 19 shows the potential impacts to sea level rise.

Table 19: Impacts of sea level rise on humans, the environment and the economy.	
Sector	Effect
IMPACTS TO HUMANS	
Recreation	-Public access point throughout the region may be inundated
Transportation	-Roads may be inundated -Travel disruptions
Infrastructure	-Property loss and increased need to mitigate -Increased demands on stormwater management systems -Inundation of public and private infrastructure
Health	-Sanitation concerns will increase as rising groundwater levels and sea waters may inundate onsite wastewater disposal systems and drainfields.
Emergency Response	-The ability to provide emergency services to all inundated areas may be reduced. There may be difficulty reaching these locations due to high waters.
IMPACTS TO THE ENVIRONMENT	
Hydrology and Water resources	-Water quality could be impacted as rising groundwater levels and sea waters may inundate onsite wastewater disposal systems and drainfields. -Changes in hydrology could impact local natural resources.
Agricultural crops	-Increased inundation of crop fields. This could drown the crops. -Salt water intrusion could destroy crops.
Forests	-Salt water intrusion could destroy forests creating "ghost forests".
IMPACT TO THE ECONOMY	
Transportation	-As roads are inundated this may cause travel and commerce disruptions -Increase road maintenance and cost
Business	-Reduced interest in the region to locate business -Higher insurance rates -Impacts to business infrastructure
Agriculture	-As the region's economy is based on natural resources, salt water intrusion could damage silviculture stands and crops that will have a negative impact on the local and regional economy.

Sea Level Rise Extent (Impact)

RSL rise rates at the local level are derived from accurate time series of water level measurements spanning several decades or more. A recent analysis of tide gauge data by the Virginia Institute of Marine Science reported RSL rise rates ranging from 0.11-0.23 in/yr (2.9-5.8 mm/yr; period: 1976-2007; 10 stations) within the Chesapeake Bay region, with a number of the values representing the highest rates reported along the U.S. Atlantic coast (Boon et al. 2010). With respect to the Middle Peninsula, the two nearest stations located at Gloucester Point and Lewisetta, VA indicate current RSL rise rates of 0.17 (4.30 mm/yr) and 0.20 in/yr (5.15 mm/yr), respectively (see Figure 23). Although there are no additional adequate tidal records available for the Middle Peninsula's bordering rivers (i.e. York and Rappahannock Rivers), one would expect RSL rise rates to increase as one approached areas of elevated land subsidence such as West Point, VA. Based on land subsidence and eustatic sea level information, the RSL rise rate would be expected to be on the order of 0.22 in/yr (5.6 mm/yr) at or near West Point, VA. Extrapolating current Gloucester Point and Lewisetta rates, RSL would increase by another 0.7- 0.8 ft (21-25 cm) by 2050 and 1.4-1.7 ft (43-51 cm) by 2100; this represents a conservative and low-end estimate. There is growing concern that RSL rise rates will accelerate in the future with projections of sea level increases in the Bay region of approximately 2.3-5.3 ft (70-160 cm) by 2100 (Pyke et al. 2008).

4.3.7. High Wind / Windstorms (excluding tornados and hurricanes)

High winds and windstorms, when not a result of hurricanes or tornadoes, are often associated with thunderstorms. The NWS defines a severe thunderstorm as having winds 50 kts (58 mph) or hail greater than ¾" in diameter (about dime-sized). A thunderstorm is considered severe if it produces hail larger than 3/4 of an inch (2 cm), winds greater than 58 mph (93 kph), or tornadoes. This strong frontal system could produce violent damaging effects to the community, such as hail, lightning, high winds (sometimes including tornadoes), and flash floods. Numerous thunderstorms occur in Middle Peninsula every year and vary amongst localities.

High Wind/Windstorms Vulnerability

The threat that any particular thunderstorm presents varies depending on its intensity, structure, and the ground below it. Many thunderstorms simply require people and their belongings to seek shelter inside a sturdy building. However, severe thunderstorms can be very dangerous and require seeking shelter underground because of the damage, they can cause to buildings. Historically the most severe occur during the spring and summer. In the U.S., only about 10% of all thunderstorms are classified as severe. Seeking shelter before a thunderstorm has arrived is best because high wind and lightning can form well in advance of any precipitation. Hail-resistant roofs can reduce property damage, as can properly attached roofs. As always, learning about what safety measures to take during a thunderstorm is the first and most important step in coping with thunderstorms.

In the U.S., the NWS issues severe thunderstorm watches and warnings. A watch is issued when atmospheric conditions are favorable for the development of a severe thunderstorm. A warning is issued when severe thunderstorms have developed. Similar to tornado watches and warnings, severe thunderstorm warnings are broadcast via media (ie. radio and television), Internet, and NOAA weather radios. Particularly of note for coastal communities, such as the Middle Peninsula, are wind advisories associated with water bodies. A Small Craft Advisory is issued for sustained winds 25-33 knots and/or Seas > 7 feet within 12 hours; There is no legal definition of "small craft" but the Coast Guard generally recommends boats smaller than 33 feet should avoid being on the water, but it depends on the experience of the crew. A Gale Warning is issued for 1-minute sustained surface winds in the range 34 kt (39 mph or 63 kph) to 47 kt (54 mph or 87 kph) inclusive, either predicted or occurring not directly associated with tropical cyclones. Reliable forecasting is essential to providing communities with adequate warnings about incoming thunderstorms and the specific threats that each storm possesses.

Damage from strong winds associated with thunderstorms can result in scattered, but severe damage to buildings and vegetation. Although these severe weather events usually occur during the spring and summer months, the emergency management staff should be prepared for them to occur at any time throughout the year.

Utilizing VDEM-generated information available on the state website and/or other information sources, community preparedness mitigation strategies should be developed by the localities for quick dissemination to their residents. Dissemination outlets should include jurisdictional websites, local radio and TV stations as well as social media sites such as Facebook and twitter.

Derecho

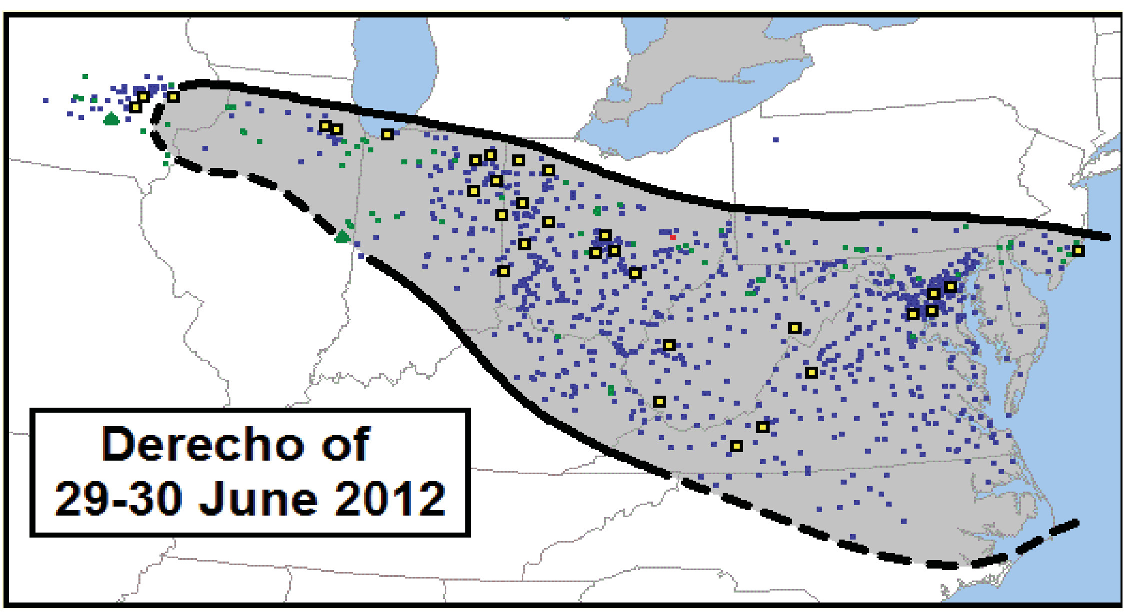
According to the National Weather Service, a derecho is a complex of thunderstorms or a mesoscale convective system (MCS) that produce large swaths of severe, straight-line wind damage at Earth's surface. To be classified as a derecho, the following conditions must be met:

- There must be a concentrated area of convectively induced wind damage or gust greater than or equal to 58 mph occurring over a path length of at least 250 miles.
- Wind reports much show a pattern of chronological progression in either a singular swath (progressive; this event was a classic example) or a series of swaths (serial.
- There must be at least three reports separated by 64 kilometers (km) or more of Enhances Fujita (EFI) damage/or measured convective wind gusts of 74 mph or greater.
- No more than 3 hours can elapse between successive wind damage/gust events.

Derechos can occur year-round but are most common from May to August (Coniglio et al., 2004)

On June 29, 2012, a derecho struck the Ohio Valley and Mid-Atlantic states. The derecho traveled 700 miles, impacting 10 states and Washington, D.C. (Figure 24). The hardest hit states were Ohio, West Virginia, Virginia, and Maryland, as well as Washington, D.C. The winds generated by this system were intense, with several measured gusts exceeding 80 mph, thirteen people were killed by the extreme winds, mainly by falling trees. An estimated 4 million customers lost power for up to a week. The region impacted by the derecho was also in the midst of a heat wave. The heat, coupled with the loss of power, led to a life-threatening situation. Heat claimed 34 lives in areas without power. The Middle Peninsula experienced wind gusts ≥65 kts (74 mph).

Figure 24: Area affected (black contours) and storm reports (colored symbols) associated with the June, 29, 2012 derecho. *Reports are for the 24-hour period from 7:00 a.m (Central Daylight Time (CDT)) Friday, June 29 to 7:00 a.m. CDT Saturday, June 30. Areal outline based in Iowa and Illinois to reflect the derecho's origin from convection in the region that did not immediately produce continuous derecho-like conditions. In addition, some of the report in those states occurred not with the system here discussed, but rather with a subsequent storm complex that formed on the evening of June 29. The areal outline also is dashed in North Carolina to reflect that many of the damaging wind gusts in the state occurred south of the thunderstorms that produced them. Storm reports depicted as follows. Wind damage or wind gust ≥ 50 kts (59 mph), small blue squares, estimated or measured with gusts ≥65 kts (74 mph), large black squares with yellow centers, hail ≥0.75 inches, small green squares, hail ≥2.0 inches, large green triangles, tornadoes, small red squares (NWS, 2012).*



High Wind / Windstorms Extent (Impact)

Wind risk can be determined by measuring the speed of the winds. The categories used to determine risk and ranking hazards include the following:

Hurricane Risk	Wind Speed (mph)	Category
Low	≤59.9	High Wind
Medium – Low	60.0-73.9	Tropical Storm
Medium – High	74.0-94.9	Category 1 Hurricane
High	≥95.0	Category 2 +

4.3.8. HAZMAT

HAZMAT can be defined as a material (as flammable or poisonous material) that would be a danger to life or to the environment if released without precautions. Furthermore, a hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The risk of hazardous material risks will vary amongst Middle Peninsula as it includes incidents involving substances such as toxic chemicals, fuels, nuclear wastes and/or products, and other radiological and biological or chemical agents. In addition to accidental or incidental releases of hazardous materials due to fixed facility incidents and transportation accidents, regions must be ready to respond to hazmat releases as potential terrorism. It's important to note that the risk of a Hazmat incident are unpredictable and will vary amongst Middle Peninsula localities.

According to VDEM, all jurisdictions in Virginia have a Local Emergency Planning Committee that identified local industrial hazardous materials and keeps the community informed of the potential risks. With a fixed facility, the hazards are pre-identified, and the facility is required to prepare a risk management plan and provide a copy of this plan to local governments.

Hazardous materials carried through Middle Peninsula localities by commercial vehicle may also cause a risk, particularly if the vehicle is involved in an accident. While the vehicle should have placards on the vehicle to identify the hazard on board, however they are less predictable. In accordance with 9VAC20-110 the Virginia Waste Management Board is responsible for promulgating regulations governing the transport of hazardous materials within the Commonwealth. Additionally the VAC also provides requirements for "every person who transports or offers for transportation of hazardous materials within or through the Commonwealth of Virginia" (9VAC20-110-110) Therefore there are measures in place to help reduce the risk of hazards materials being transported through the Middle Peninsula Region.

HAZMAT Vulnerability

The effects of hazardous materially is ultimately dependent on the type and amount of hazardous material, however injuries and/or deaths could occur as a result of a hazmat incident. They can pose risk to health, safety, and property during transportation. According to VDEM, "A business might have to evacuate depending on the quantity and type of chemical released or local officials might close a facility or area for hours, possibility days until a substance is properly cleaned up. Businesses that store, produce or transport hazardous materials will be fined for sills. The business involve in the release would typically be responsible for the cost of the clean up. A business that is located near the site of the hazardous site of a hazardous materials spill or release is likely to be unaffected unless the substance is airborne and poses a threat to areas outside the accident site. In that case local emergency official would order an immediate evaluation of areas that could potentially be affected. Depending on the type of hazardous substance, it could take hours or days for emergency official to deem the area safe for return." Ultimately this would impact business productivity and could impact the local/regional economy.

HAZMAT Extent (Impact)

Hazardous materials are categorized into nine major hazard classes that communicated the risk associated with it. Table 20 shows categories and provides examples of the hazardous material.

Table 20: Hazardous material are divided into 9 categories (VDEM, 2013).

CLASS	Division	NAME OF CLASS OR DIVISION	EXAMPLE
1	1.1 1.2 1.3 1.4 1.5 1.6	Explosives (mass detonation) Projections Hazards Mass Fire Hazards Minor Hazards Very Insensitive Extremely Insensitive	Dinitrophenol Ammunition Smoke, White Phosphorous Article, Explosive No. 5 Fireworks Blasting Agents Explosive, Blasting, Type E Article, Explosive Extremely Insensitive
2	2.1 2.2 2.3	Flammable Gases Non Flammable Gases Poisonous/Toxic Gases	Propane Helium, Compressed Fluorine, Compressed
3		Flammable Liquids	Gasoline, Alcohol, Diesel Fuel, Fuel Oils
4	4.1 4.2 4.3	Flammable Solids Spontaneously Combustible Dangerous when wet	Ammonium Picrate, Wetted Phosphorus, White Dry Sodium
5	5.1 5.2	Oxidizers Organic Peroxides	Ammonium Nitrate, Liquid Organic Peroxide Type B, Liquid
6	6.1 6.2	Poisons (Toxic Material) Infectious Substance	Potassium Cyanide Diagnostic Specimen
7		Radioactive	Uranium, Plutonium
8		Corrosives	Hydrochloric Acid, Battery Acid, Formaldehyde, Sulfuric Acid
9		Miscellaneous Hazardous Materials	Asbestos, Airbag Inflaters
None		ORM-D (Other Regulated Material – Domestic)	Consumer Commodity (Hair Spray or Charcoal)
Combustible Liquid		Combustible Liquid	Heating Oil, Diesel Fuel

In addition to the categories of hazardous material, when shipping hazardous material driver must keep shipping papers and use the following to identify that they have hazardous material on board:

Package labels are diamond-shaped hazard warning labels found on most hazardous materials packages. These labels inform others of the hazard. If the diamond label does not fit on the package, shippers may put the label on a tag attached to the package. For example, compressed gas cylinders often have tags or decals.

Placards warn others of hazardous materials. They are placed on the outside of the vehicle and identify the hazard class of the cargo. A placarded vehicle must have at least four identical placards. Placards must be readable from all four directions. Therefore, they are put on the front, rear and both sides of the vehicle. Placards measure 10 ¾ inches square and are turned in a diamond shape. Cargo tanks and other bulk packaging display the identification number of their contents on placards. Or they may use orange panels or white diamond-shape displays the same size as placards.

4.3.9. Ditch Flooding

As per the Commonwealth of DEQ Guidance Memorandum No. 08-2004 Regulation of Ditches under the Virginia Water Protection (VWP) Program, ditch is defined as a linear feature excavated for the purpose of draining or directing surface or groundwater. Ditches may also be constructed to collect groundwater or surface water for the purposes of irrigation.

Ditch Flooding Vulnerability

Throughout the Middle Peninsula of Virginia, the network of aging roadside ditches and outfalls, serving 670 miles of roads, creates the region's primary stormwater conveyance system. Currently each locality in the region experiences inadequate drainage and as a result, roads and private properties are frequently flooded after a storm event. The lowest lying localities (ie. Mathews and Gloucester County) are more vulnerable to ditch flooding as most of their land is either at or slightly above sea level. This low topography and lack of grade does not assist the flow of water out of areas. Therefore, roadway flooding frequently cuts residents and business off from the county and emergency services for extended periods of time. Flooding has also caused the county school system to be closed due safety concerns. Flooding, risks to public health and safety, property damage, and long-term loss of property use and values are consequences of the inadequate drainage systems, all of which ultimately negatively impact the economy of the Middle Peninsula.

Conditions contributing to the failure of the drainage system, include, but are not limited to, the following:

1. A lack of maintenance, including removal of sediment and overgrown vegetation, causing slopes to be inadequate or reverse slope and/or tides not allowed to recede;
2. Insufficient elevation change (topographic constraints);
3. Cross-culverts are filled with sediment, not adequately maintained, damaged, and/or installed with an inadequate / reverse slope;
4. Unclear ownership and ditch maintenance responsibility (VDOT or private);
5. Sea level rise; and
6. Land subsidence.

When high exposure to hurricanes, nor'easters, tropical storms, sea level rise, and land subsidence is coupled with clogged roadside ditches and outfalls, illicit filling of the ditches on private property, and/or failing ditches, there are significant social, economic, and environmental impacts.

Ditch Flooding Extent (Impact)

Ditch flooding is currently measured through observations. Currently in Mathews County a citizen group records observations and takes photos of the ditch flooding. Additionally in 2015 the Draper Aden Associated partnered with Mathews County to develop a Stormwater Ditch Steering Committee that consisted of private citizens, VDOT, and MPPDC representatives. Areas within Mathews were selected to focus on that were prone to ditch flooding and were called priority areas. These priority areas were visited and existing conditions were noted. Based on findings in the field, DAA provided site recommendations to improve the given ditch as well as associated costs of the improvements. This information will be the basis of a roadside ditch database underdevelopment in 2016.

4.4. Hazards Considered "Critical" Hazards to the Middle Peninsula

The following sections describe hazards that are common throughout the Middle Peninsula region and deemed "Critical Hazards" to the Middle Peninsula by the Steering Committee.

4.4.1. Winter Ice Storms

Virginia's biggest winter storms are the great "Nor'easters". At times, Nor'easters have become so strong that they have been labeled the "White Hurricane". In order for these storms to form, several things need to occur. High pressure builds over New England. Arctic air flows south from the high center into Virginia. The colder and drier the air is, the denser and heavier it becomes. This cold, dry air is unable to move west over the Appalachian Mountains and it remains trapped to the east side, funneling down the valleys and along the coastal plain toward North Carolina. To the east of the arctic air is the warm water of the Gulf Stream. The contrast of cold air sinking into the Carolinas and the warm air sitting over the Gulf Stream creates a breeding ground for storms. Combine this with the right meteorological conditions such as the position of the jet stream, and storm development may become "explosive" (sudden, rapid intensification; dramatic drop in the central pressure of the storm) (Watson and Sammler, 2004) (Figure 25).

Winter Ice Storms occur generally as freezing rain, when precipitation, starts falling as snow, melts as it passes through a warm layer of air several thousand feet above the ground. Beneath the warm layer of air is a shallow layer of freezing air just above the ground. As the liquid precipitation falls through this layer of freezing air, it becomes super-cooled, meaning that its temperature falls below freezing, but it remains a liquid. Before it has a chance to freeze solid (into sleet or ice pellets), the super-cooled liquid droplets hit the ground (or some object such as a tree limb or power line), whose temperature is also below freezing; the water then freezes on contact.

For a good Nor'easter to develop, the jet stream entering the West Coast of the United States splits. The northern branch crosses the northern Rockies and Canada while the southern branch dips to cross the Gulf Coast states, where it picks up a disturbance that it carries northeast across Virginia to rejoin the northern branch over Newfoundland. The northern branch of the jet supports the southward sinking cold air. When this disturbance interacts with the temperature boundary formed by the warm Gulf Stream waters and the arctic air mass inland, a low-pressure system forms. The strong wind from the northeast gives the low-pressure storm its name, *Nor'easter*. Wind blowing counter-clockwise around the storm center carries warm, moist air from the Gulf Stream up and over the cold inland air. The warm air rises and cools, and snow begins. The storm's speed and exact track to the north become critical in properly forecasting and warning for heavy snow across Virginia. On the Middle Peninsula, it is quite common for the rain-snow line to fall right over the northern sections of King William, King and Queen, and Essex Counties. Heavy snow often falls in a narrow 50-mile wide path about 150 miles northwest of the low-pressure center. Closer to the low's center, the warmer ocean air changes the precipitation to sleet, freezing rain and eventually rain. If the forecasted storm track is off by just a little bit, it may mean - 64 - the difference between forecasting heavy rain, freezing rain or sleet, and a foot of snow (Watson and Sammler, 2004). Therefore Middle Peninsula localities will not experience winter ice storms the same.

Intense winds around the storm's center build waves that rack the coastline and sometimes drive water inland, causing extensive coastal flooding and severe beach erosion. Unlike a hurricane, which usually comes and goes within one tidal cycle, the Nor'easter can linger through several tides, each one piling more water on shore and into the bays. The March 5-9, 1962 Nor'easter, known as the "Ash Wednesday Storm", lingered off the Virginia Capes for days. It caused over $200 million (in 1962 dollars) in property damage and major coastal erosion from North Carolina to Long Island, N.Y.

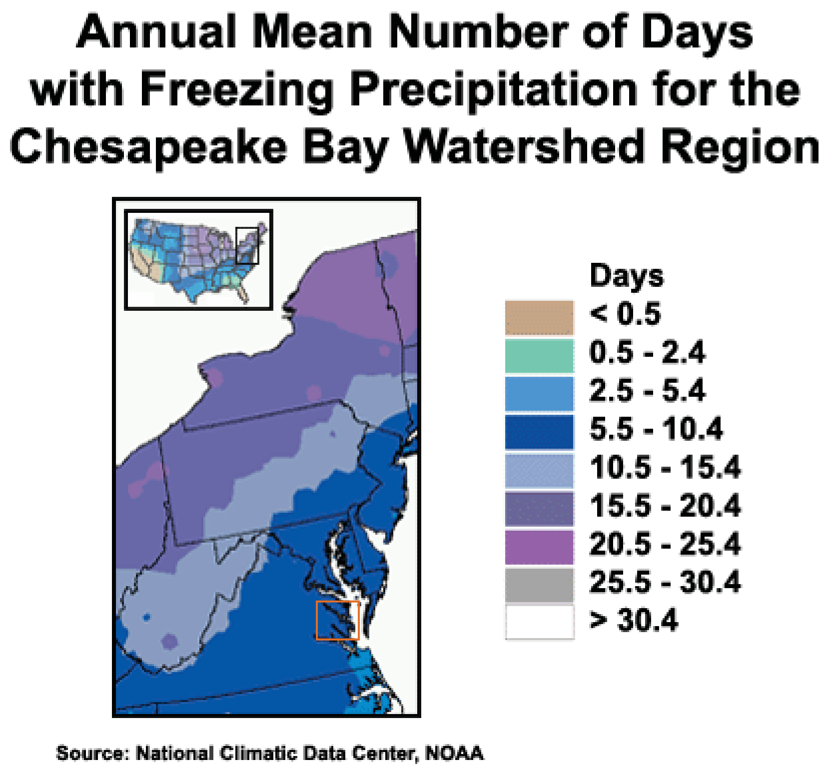


Figure 25: Annual mean number of days with freezing precipitation *(rain or drizzle) for the Chesapeake Bay Watershed region. The area encompassing the Middle Peninsula is highlighted on the map with a red square.*

As with snow, the frequency with which freezing rain occurs varies throughout the Chesapeake Bay watershed. In the northern part of the watershed, around Binghamton, NY, the incidence of freezing rain is one of the highest in the country. Although less common, freezing rain is still a threat even to the southern parts of the watershed. Figure 25 shows how the number of days with freezing precipitation (both rain and drizzle) in an average year varies throughout the Chesapeake Bay region. The Middle Peninsula generally experiences between 5.5 and 10.4 days of freezing rain annually. During the winter of 1993-1994, a series of ice storms struck Virginia. The conditions for the formation of an *ice storm* are not completely unlike those for the formation of a Nor'easter. High pressure over New England funnels cold, dry arctic air south over the state. The air tries to push west but cannot rise over the - 65 - Appalachian Mountains and becomes trapped on the east side. A storm moves northeast from the southern plains or Gulf Coast region. Instead of passing south and east of Virginia, it often moves up the western slopes of the mountains. As this warm, moist air rises over the mountains and the trapped cold air on the east side, precipitation begins (Watson and Sammler, 2004) (Figure 26). The type of precipitation depends on the depth of the cold air. At first the thickness of the 3cold air mass is often enough to produce snow, but as the warm air passes over the cold air and erodes it, the cold air mass gets more and more shallow. Soon the cold air mass is too thin to produce snow. Rain droplets freeze into small ice pellets, or *sleet*, as it falls through the cold air. When sleet hits the ground, it bounces and does not stick to objects (Watson and Sammler, 2004).

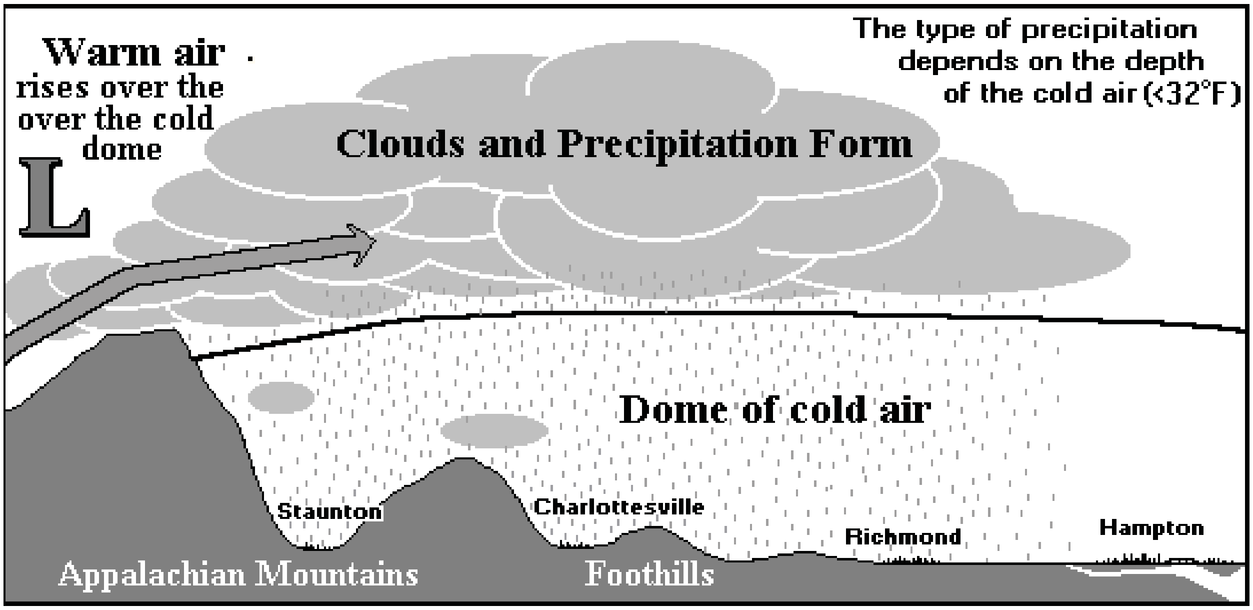


Figure 26: Ice Storm-Formation *(Watson and Sammler 2004).*

Eventually, the cold air mass is so shallow that the rain does not freeze. If the temperature of the earth's surface is below freezing, then rain will freeze as it hits the ground, producing *freezing rain*, a very dangerous on roadways or walkways. As the ice accumulates on trees and wires, the weight eventually causes them to break, knocking out power and phone service. Sometimes, so much ice can accumulate that structural damage and collapse can occur to buildings and communication towers. This is precisely what occurred during the "Christmas Ice Storm" of December 1998, which hit southeast Virginia, including the Middle Peninsula. Icy conditions caused injuries from slips, falls, and numerous vehicle accidents. Ice accumulations of up to an inch brought down trees and power lines. Outages were so widespread (400,000 customers on Christmas Eve) that some people were without power for up to ten days (Watson and Sammler, 2004). Other types of weather systems generally do not cause major problems for Virginia. Storms such as the "*Alberta Clipper*," a fast moving storm from the Alberta, Canada region, or a cold front sweeping through from the west generally do not bring more than one to four inches of snow in a narrow 50 to 60 mile-wide band. Sometimes, the high pressure and cold arctic air that follow in the wake of a clipper become the initial set up for a Nor'easter. In very rare cases, elements combine to produce very localized heavy snow without any fronts or storm centers nearby. These events are nearly impossible to forecast with any accuracy (Watson and Sammler, 2004).

However in November 2009, Tropic Storm Ida made landfall in Alabama, but weakened, losing its tropical storm characteristics, as it crossed to North Carolina. The storm redeveloped off the coast of Carolina in the Atlantic Ocean. The resulting coastal low combined with an unusually strong Canadian high over New England resulted in a strong pressure gradient over Coastal Virginia and the Carolinas. This caused storming northeasterly winds, high waves and record high water levels. Stations of the coastline of the Virginia recorded wind speeds, gusts and barometric pressures of this Nor'easter (Table 21).

Table 21: Maximum observed wind speeds, gusts and barometric pressure by stations located near Middle Peninsula Localities during the November 2009 Nor'easter.							
Station Name	Maximum Wind Speed			Maximum Wind Gust			Minimum Barometric Pressure	
	Date & Time (GMT)	m/s*	Kt**	Date & Time (GMT)	m/s	Kt	Date & Time (GMT)	mb***
Kiptopeke, VA	11/13 00:00	14.7	29	11/12 21:12	22.3	43	n/a	n/a
Lewisetta, VA	11/12 00:00	12.3	24	11/12 21:30	19.5	38	11/12 8:24	1006.7
Yorktown USCG Training Center, VA	11/12 23:06	21.4	42	11/12 23:12	25.9	50	11/12 23:06	1001.5
Chesapeake Bay Bridge Tunnel, VA	11/12 22:42	26.6	52	11/13 4:24	33.4	65	11/12 4:24	997.0

* 1 m/s (meters/second) = 2.2 miles per hour (mph) = 1.9 knots
** 1 kt (knot) = 1.2 mph = 0.05 m/s
*** mb (millibar) = 0.03 inches

Winter Ice Storms Vulnerability

Winter ice storms can impact individuals, property as well as the overall community. At the individual level ice has the potential to cause automobile accidents and reduce the walkability of community due to ice-covered walkways. Personal property may be impacted as pipes freeze or structural failures occur due to the weight of the ice. The overall community may also be impacted as transportation will be interrupted or halted, and the weight of ice to snap tree limbs could damage power lines or infrastructure.

Winter Ice Storm Extent (Impact)

While a winter ice storm may be measured based the damages caused by the ice storm, wind speed and the barometric pressure, winter ice storms may also be measure on the Sperry-Piltz Ice Accumulation Index (2009). This scale can predict the projected footprint, total ice accumulation and the resulting potential damages from approaching ices storms (Table 22).

Table 22: The Sperry-Piltz Ice Accumulation Index, or "SPIA Index". The below categories of damages are based upon combinations of precipitation totals, temperatures and wind/speeds/directions (SPIA, 2009).	
ICE DAMAGE INDEX	**DAMAGE AND IMPACT DISCRIPTIONS**
0	Minimal risk of dame to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
2	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
3	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1-5 days
4	Prolonged and widespread utility interruptions with extensive damage to main distribution feeder lines and some high voltage transmission lines/structures. Outages lasting 5-10 days.
5	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeks in some areas. Shelters needed.

4.4.2. Coastal Flooding

According to the Virginia Hazards Mitigation Plan coastal flooding occurs when strong onshore winds push water from an ocean, bay or inlet onto the land. In addition, coastal areas experience flooding from overland flow, ponding and inadequate storm water drainage. Coastal flooding may arise from tropical cyclones (hurricanes and tropical storms) or Nor'easters (extra tropical storms).

Flooding is the most frequent and costly natural hazard in the United States - besides fire. Nearly 90% of Presidential Disaster Declarations result from natural events where flooding is a major component. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto adjacent floodplains and other low-lying land adjacent to rivers, lakes, ponds and the Chesapeake Bay. Based on data

Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall. These conditions are produced by hurricanes during the summer and fall, and nor'easters and other large coastal storms during the winter and spring. Storm surges may overrun barrier islands and push sea water up coastal rivers and inlets, blocking the downstream flow of inland runoff.

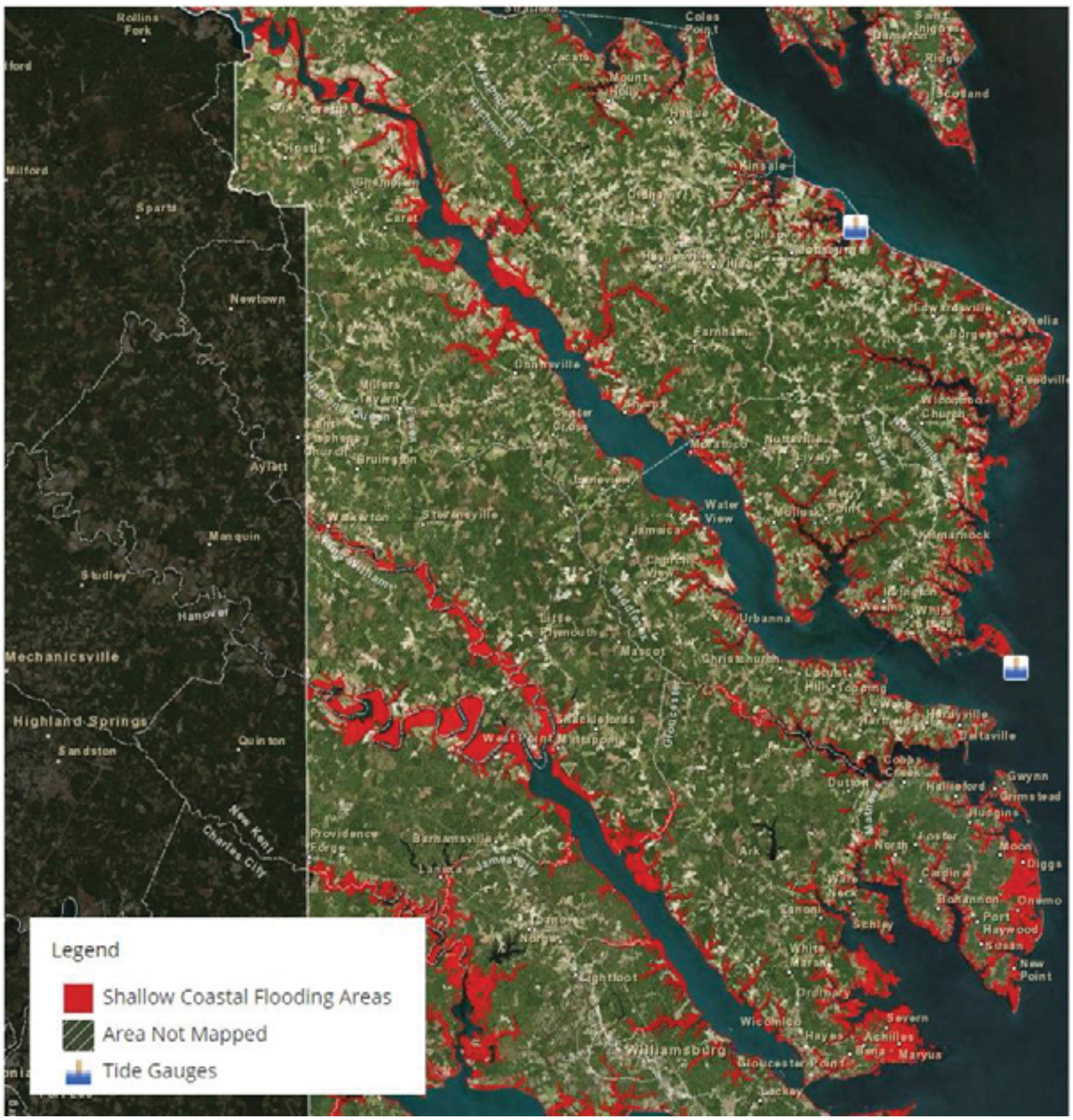
Coastal Flooding Vulnerability

Thousands of acres of crops and forest lands may be inundated by both saltwater and freshwater. Escape routes, particularly from barrier islands, may be cut off quickly, stranding residents in flooded areas and hampering rescue efforts. Coastal flooding is very dangerous and causes the most severe damage where large waves are driven inland by the wind. These wind driven waves 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.

Based on NOAA's Coastal Management Digital Coast Database frequent shallow flooding occurs in the Middle Peninsula region. As many coastal areas experience periodic mini-to-moderate shallow coastal flooding events – typically as result of meteorological factors that include high tides, winds, and rain. Figure 27 is a map of the Middle Peninsula showing the areas impacting the coastal areas. One can see that there is varying degree of impact amongst Middle Peninsula localities.

Figure 27:

Frequent Shallow Coastal Flooding in Middle Peninsula Virginia (NOAA, 2015)



Coastal Flooding Extent (Impacts)

To help identify coastal flooding, FEMA will conduct engineering studies referred to as Flood Insurance Studies (FISs). Using the information gathered in these studies, FEMA engineers and cartographers delineate Special Flood Hazard Areas (SFHAs) on flood maps. SFHA are subject to inundation by a flood that has a 1-percent or greater chance of being equaled or exceeded in any given year. This type of flood is commonly referred to as the 100-year flood or base flood. A 100-year flood is not a flood that occurs every 100 years. In fact, the 100-year flood has a 26 percent chance of occurring during a 30 year period, the length of many mortgages. The 100- year flood is a regulatory standard used by Federal agencies and most states, to administer floodplain management programs. The 100-year flood is also used by the NFIP as the basis for insurance requirements nationwide. The FEMA Special Flood Hazard Area designations area associated with the probability of flooding (Table 18):

4.4.3. Lightning

Virginia averages 35 to 45 thunderstorm days per year statewide (Watson, 2001). Thunderstorms are generally beneficial because they provide needed rain for crops, plants, and reservoirs. Thunderstorms can occur any day of the year and at any time of the day, but are most common in the late afternoon and evening during the summer months. About five percent of thunderstorms become severe and can produce tornadoes, large hail, damaging downburst winds, and heavy rains causing flash floods. Thunderstorm can develop in less than 30 minutes, allowing little time for warning. All thunderstorms produce lightning, which can be deadly. The NWS does not issue warnings for ordinary thunderstorms nor for lightning. The NWS does highlight the potential for thunderstorms in the daily forecasts and statements. The VDEM suggests that the public be alert to the signs of changing weather, such as darkening skies, a sudden wind shift, and drop in temperature, and having a warning device such as NOAA Weather Radio.

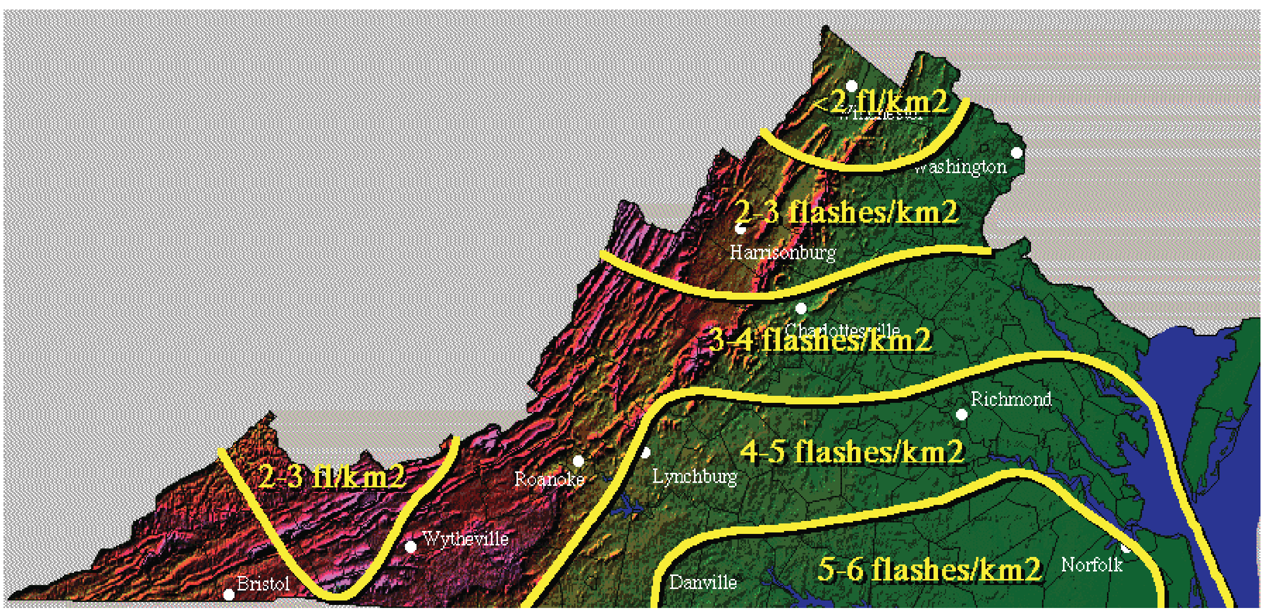


Figure 28: Lightning Flash Density Map *computed for 1989 (Electric Power Institute) (University of Virginia Climatology Office, 1989).*

Lightning can strike up to 10 to 15 miles from the rain portion of the storm. The lightning bolt originates from the upper part of the thunderstorm cloud known as the anvil. A thunderstorm can grow up to 8 miles into the atmosphere where the strong winds aloft spread the top of the thunderstorm cloud out into an anvil. The anvil can spread many miles from the rain portion of the storm but it is still a part of that storm. Lightning, from the anvil, may strike several miles in advance of the rain. Lightning bolts may also come from the side or back of the storm, striking after the rain and storm have seemed to pass, or hitting areas that were totally missed by the rain.

Lightning Vulnerability

Between 1959 and 2014, lightning killed 66 people in Virginia and from 1959 to 1994 has injured at least 238 people. Many additional injuries from lightning go unreported or are not captured by NWS data collection techniques. Nationally, from 1959 through 2014, there have been 4049 deaths due to lightning. Most deaths were males between the ages of 20 and 40 years old who were caught outdoors on fishing, camping, boating or farming /ranching. A national network of 114 lightning ground stroke detectors was put in place by the Electric Power Research Institute (EPRI), a private organization, that serves the needs of power companies and other subscribers interested in lightning across the country (Virginia Climate Advisory, 1992). These detectors sense the characteristic electromagnetic impulses of cloud-to-ground lightning strikes that occur up to several hundred kilometers away. Then, by using triangulation techniques, the network is able to describe the location of every ground strike that it detects in the continental U.S. (Figure 28). It's important to realize that the contours on the map are very general and because accurate, long term records of lightning strikes do not exist, the illustration may not be representative of long-term patterns. Historic data shows that the Middle Peninsula is at a low risk of suffering damages from lightning and thunderstorms, yet it is important to note that thunderstorms and lightning can be very dangerous and can accompany hurricanes and other severe weather events.

Although lightning can be dangerous and/or life threatening, it is hard to generate specific mitigation strategies for this potential natural hazard other than a general public awareness/education campaign associated with thunderstorm/lightning activity.

4.4.4. Hurricanes

Hurricanes are cyclonic storms that originate in tropical ocean waters. Most hurricanes develop in an area 300 miles on either side of the equator. Hurricanes are heat engines, fueled by the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, sufficiently warm sea surface temperature, a rotational force resulting from the spinning of the earth and the absence of wind shear in the lowest 50,000 feet of the earth's atmosphere.

Hurricanes that impact Virginia form in the so-called Atlantic Basin - from the west coast of Africa towards the Caribbean Sea and Gulf of Mexico. Hurricanes in this basin generally form between June 1 and November 30 – with a peak around mid-September. In an average season, there are about 10 named tropical storms in the Atlantic Basin with 6 of these likely to develop into hurricanes. The busiest hurricane season in the 20th century was in 1933, which saw 21 hurricanes/tropical storms. Two of these storms hit the Tidewater Region and caused significant devastation in the Middle Peninsula - known as the "Chesapeake-Potomac Hurricanes of 1933". By contrast, the 1914 season saw no hurricanes and only one tropical storm.

As a hurricane develops, barometric pressure at its center falls and winds increase. A weather system with winds at or exceeding 39 mph is designated as a tropical storm, which is given a name and closely monitored by the NOAA National Hurricane Center in Miami, Florida. When winds are at or exceed 74 mph, the tropical storm is deemed to be a hurricane. Hurricane intensity is measured using the Saffir-Simpson Scale, ranging from a Category 1 (minimal) to a Category 5 (catastrophic) hurricane.
The scale categorizes the intensity of hurricanes using a linear method based upon maximum sustained winds, minimum barometric pressure and storm surge potential, which are combined to estimate the potential flooding and damage to property given a hurricane's estimated intensity. See the table below for greater details on the characteristics of Category 1 thru Category 5 hurricanes.

Hurricane Vulnerability

Hurricanes have the greatest potential to inflict damage as they cross the coastline from the ocean, which is called landfall. Because hurricanes derive their strength from warm ocean waters, they are generally subject to deterioration once they make landfall. The forward momentum of a hurricane can vary from just a few miles per hour to 40 mph. This forward motion, combined with a counterclockwise surface air flow, makes the right front quadrant of the hurricane the location of the most potentially damaging winds.

Hurricanes have the potential to spawn dangerous tornadoes. The excessive rainfall and strong winds can also cause flash floods, flooding and abnormal rises in sea levels known as storm surges. Although a hurricane may cause a tremendous amount of wind and water damage, the accompanying storm surge is much more dangerous to life and property in coastal regions. The storm surge is a great dome of water typically 50 miles wide that comes sweeping across the coastline near the area where the eye of the hurricane makes landfall. This storm surge, aided by the hammering effect of breaking waves, acts like a giant bulldozer as it sweeps everything in its path. The stronger the hurricane, the higher and more dangerous the storm surge will be. Nine out of ten hurricane fatalities are caused by the storm surge.

The vulnerability will vary amongst localities within the Middle Peninsula. In particular, as Gloucester and Mathews County are located within the Chesapeake Bay Carter, and therefore these lower lying areas of the region will be the most vulnerability. Also, generally, as hurricane hit land the storm is slowed therefore those coastal areas of the region will be at most risk. However secondary impacts may be experienced inland and in upland counties (i.e. King William, King & Queen, and Essex Counties).

Hurricane Extent (Impact)

The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 categorization based on the hurricane's intensity at the indicated time. The scale – originally developed by wind engineer Herb Saffir and meteorologist Bob Simpson – has been an excellent tool for alerting the public about the possible impacts of various intensity hurricanes. The scale provides examples of the type of damage and impacts in the United States associated with winds of the indicated intensity. In general, damage rises by about a factor of four for every category increase.

Category One Hurricane

Very dangerous winds will produce some damage

(Sustained winds 74-95 mph, 64-82 kt, or 119-153 km/hr)

People, livestock, and pets struck by flying or falling debris could be injured or killed. Older (mainly pre-1994 construction) mobile homes could be destroyed, especially if they are not anchored properly as they tend to shift or roll off their foundations. Newer mobile homes that are anchored properly can sustain damage involving the removal of shingle or metal roof coverings, and loss of vinyl siding, as well as damage to carports, sunrooms, or lanais. Some poorly constructed frame homes can experience major damage, involving loss of the roof covering and damage to gable ends as well as the removal of porch coverings and awnings. Unprotected windows may break if struck by flying debris. Masonry chimneys can be toppled. Well-constructed frame homes could have damage to roof shingles, vinyl siding, soffit panels, and gutters. Failure of aluminum, screened-in, swimming pool enclosures can occur. Some apartment building and shopping center roof coverings could be partially removed. Industrial buildings can lose roofing and siding especially from windward corners, rakes, and eaves. Failures to overhead doors and unprotected windows will be common. Windows in high-rise buildings can be broken by flying debris. Falling and broken glass will pose a significant danger even after the storm. There will be occasional damage to commercial signage, fences, and canopies. Large branches of trees will snap and shallow rooted trees can be toppled. Extensive damage to power lines and poles will likely result in power outages that could last a few to several days. Hurricane Dolly (2008) is an example of a hurricane that brought Category 1 winds and impacts to South Padre Island, Texas.

Category Two Hurricane

Extremely dangerous winds will cause extensive damage

(Sustained winds 96-110 mph, 83-95 kt, or 154-177 km/hr)

There is a substantial risk of injury or death to people, livestock, and pets due to flying and falling debris. Older (mainly pre-1994 construction) mobile homes have a very high chance of being destroyed and the flying debris generated can shred nearby mobile homes. Newer mobile homes can also be destroyed. Poorly constructed frame homes have a high chance of having their roof structures removed especially if they are not anchored properly. Unprotected windows will have a high probability of being broken by flying debris. Well-constructed frame homes could sustain major roof and siding damage. Failure of aluminum, screened-in, swimming pool enclosures will be common. There will be a substantial percentage of roof and siding damage to apartment buildings and industrial buildings. Unreinforced masonry walls can collapse. Windows in high-rise buildings can be broken by flying debris. Falling and broken glass will pose a significant danger even after the storm. Commercial signage, fences, and canopies will be damaged and often destroyed. 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. Potable water could become scarce as filtration systems begin to fail. Hurricane Frances (2004) is an example of a hurricane that brought Category 2 winds and impacts to coastal portions of Port St. Lucie, Florida with Category 1 conditions experienced elsewhere in the city.

Category Three Hurricane

Devastating damage will occur

(Sustained winds 111-130 mph, 96-113 kt, or 178-209 km/hr)

There is a high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older (pre-1994) mobile homes will be destroyed. Most newer mobile homes will sustain severe damage with potential for complete roof failure and wall collapse. Poorly constructed frame homes can be destroyed by the removal of the roof and exterior walls. Unprotected windows will be broken by flying debris. Well-built frame homes can experience major damage involving the removal of roof decking and gable ends. There will be a high percentage of roof covering and siding damage to apartment buildings and industrial buildings. Isolated structural damage to wood or steel framing can occur. Complete failure of older metal buildings is possible, and older unreinforced masonry buildings can collapse. Numerous windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Most commercial signage, fences, and canopies will be destroyed. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to a few weeks after the storm passes. Hurricane Sandy (2012) is an example of a hurricane that brought Category 3 winds and impacts to coastal portions of Cuba, but it downgraded to a Category 2 storm off the coast of the Northeast.

Category Four Hurricane

Catastrophic damage will occur

(Sustained winds 131-155 mph, 114-135 kt, or 210-249 km/hr)

There is a very high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older (pre-1994) mobile homes will be destroyed. A high percentage of newer mobile homes also will be destroyed. Poorly constructed homes can sustain complete collapse of all walls as well as the loss of the roof structure. Well-built homes also can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Extensive damage to roof coverings, windows, and doors will occur. Large amounts of windborne debris will be lofted into the air. Windborne debris damage will break most unprotected windows and penetrate some protected windows. There will be a high percentage of structural damage to the top floors of apartment buildings. Steel frames in older industrial buildings can collapse. There will be a high percentage of collapse to older unreinforced masonry buildings. Most windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Nearly all commercial signage, fences, and canopies will be destroyed. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Long-term water shortages will increase human suffering. Most of the area will be uninhabitable for weeks or months. Hurricane Charley (2004) is an example of a hurricane that brought Category 4 winds and impacts to coastal portions of Punta Gorda, Florida with Category 3 conditions experienced elsewhere in the city.

Category Five Hurricane

Catastrophic damage will occur

(Sustained winds greater than 155 mph, greater than 135 kt, or greater than 249 km/hr)
People, livestock, and pets are at very high risk of injury or death from flying or falling debris, even if indoors in mobile homes or framed homes. Almost complete destruction of all mobile homes will occur, regardless of age or construction. A high percentage of frame homes will be destroyed, with total roof failure and wall collapse. Extensive damage to roof covers, windows, and doors will occur. Large amounts of windborne debris will be lofted into the air. Windborne debris damage will occur to nearly all unprotected windows and many protected windows. Significant damage to wood roof commercial buildings will occur due to loss of roof sheathing. Complete collapse of many older metal buildings can occur. Most unreinforced masonry walls will fail which can lead to the collapse of the buildings. A high percentage of industrial buildings and low-rise apartment buildings will be destroyed. Nearly all windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Nearly all commercial signage, fences, and canopies will be destroyed. Nearly all trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Long-term water shortages will increase human suffering. Most of the area will be uninhabitable for weeks or months. Hurricane Andrew (1992) is an example of a hurricane that brought Category 5 winds and impacts to coastal portions of Cutler Ridge, Florida with Category 4 conditions experienced elsewhere in south Miami-Dade County

Hurricane Isabel in 2003 was one of Virginia's costliest disasters, causing widespread devastation and disrupting the lives of thousands of citizens – including those living in the Middle Peninsula. This deadly storm was a Category 2 hurricane when it made landfall between Cape Lookout and Cape Hatteras on North Carolina's Outer Banks on Thursday, September 18, 2003. By the time it reached Virginia, it was downgraded to a Category 1 hurricane. Even though the storm followed a path west of the City of Richmond, Isabel's destructive effects were felt throughout Tidewater Virginia and the entire Mid-Atlantic Region.

Hampton Roads remained in the right front quadrant through most of the storm's landfall, which helped to push the storm surge into many inland areas along the rivers. Property damage resulting from the 4 to 12-foot storm surge was extensive in many parts of the region. Homes, bulkheads and piers were damaged and the winds resulted in significant damage to properties and power lines. Rainfall totaled between 2 and 11 inches along the storm's track. Trees, especially those with shallow root systems, were blown over. Damages due to wind, rain, and storm surge resulted in flooding, electrical outages, piles of debris, transportation interruptions and damaged homes/businesses. Many citizens were without power for several days - with others in remote locations of the Middle Peninsula without power for up to three weeks.

Statewide losses to residential property were estimated to exceed $590 million and businesses reported over $84 million in losses. Thirty-two deaths were directly or indirectly attributed to this storm in Virginia. One of these deaths was in Gloucester County when an individual died of a heart attack after their vehicle was swept up in high water. Hurricane Isabel is considered one of the most significant tropical cyclones to affect portions of northeastern North Carolina and east-central Virginia since Hurricane Hazel in 1954 and the Chesapeake-Potomac Hurricane of 1933 (Beven and Cobb, 2004).

Although Virginia was spared a direct hit, the hurricane season of 2004 may be the costliest on record in the United States. Fifteen tropical or subtropical storms formed in the North Atlantic. Nine of these storms become hurricanes with six becoming major hurricanes of Category 3 or higher on the Safflir-Simpson Hurricane Scale. Six of the hurricanes, Alex, Charley, Frances, Gaston, Ivan and Jeanne, and three tropical storms struck the United States in 2004. The strongest hurricane was Ivan, which reached Category 5 status. Ivan was directly blamed from 26 deaths and damage estimates were $13 billion in the United States.

With 4 hurricanes and tropical storms hitting the United States in a 5-week period, 2004 has been labeled as the year of the hurricane according to leading experts who participated in a Center for Health and the Global Environment briefing at Harvard Medical School (Compass Publications, Inc. 2004). They report that the intense period of destructive weather may be a harbinger of what is to come. Hurricanes have been on the increase over the past decade as part of a natural multi-decadal cycle (Ananthaswamy, 2003). These storms are more likely to form when the Atlantic is warm, as it was from the 1930s to the 1960s.

Although the decades since the 1960s have seen fewer hurricanes, numbers have risen since 1995 and may not have reached the predicted peak yet. There is growing evidence and concern that tropical storms will be more intense and pronounced as future climate changes are expected to persist.

By virtue of its position along the Atlantic Ocean and near the Gulf Stream, southeastern Virginia is frequently impacted by hurricanes. Continuous weather records for the Hampton Roads Area of Virginia began on January 1, 1871 when the National Weather Service was established in downtown Norfolk. However, the recorded history of significant tropical storms that affected the area goes back much further.

Prior to 1871, very early storms have been described in ship logs, newspaper accounts, history books, and countless other writings. The residents of coastal Virginia during Colonial times were very much aware of the weather. They were a people that lived near the water and largely derived their livelihood from the sea. To them, a tropical storm was indeed a noteworthy event. The excellent records left by some of Virginia's early settlers and from official records of the National Weather Service are summarized in the "*Chronology of Middle Peninsula Hazard Events.*"

Since 1953, Atlantic tropical storms have been named from lists originated by the National Hurricane Center. The lists featured only women's names until 1979, after which male and female names were included in the lists for both the Atlantic and Gulf of Mexico storms. Whenever a hurricane has had a major impact, any country affected by the storm can request that the name of the hurricane be "retired" by agreement of the World Meteorological Organization (WMO). Retiring a name actually means that it cannot be reused for at least 10 years, to facilitate historic references, legal actions, insurance claim activities, etc. and to avoid public confusion with another storm of the same name. Retired names for storms that hit the Tidewater Region include Agnes (1972), Cleo (1964), David (1979), Donna (1960), Floyd (1999), Fran (1996), Gloria (1985), Gracie (1959), Hazel (1954), and Isabel (2003) (NOAA Atlantic Oceanographic and Meteorological Laboratory, Hurricane Research Division).

Middle Peninsula Storm Surge Hazard Maps

In order to estimate the geographic extent of potential damage from these hurricanes, a review of the 2008 Middle Peninsula Storm Surge Hazard Maps show the worst case scenario of hurricane storm surge inundation at mean tide. Figures 29- 32 are maps developed by the U.S. Corp of Engineers in conjunction with the VDEM as part of their 2008 Virginia Hurricane Evacuation Study.

Due to the nature of the study, only Mathews, Gloucester and Middlesex Counties in the Middle Peninsula were included since they are considered coastal counties that suffer greatly from tidal surge impacts and therefore have impacts for evacuating residents from low-lying areas. Although the limits of the study only included the lower half of our region, it should be noted that all of the Middle Peninsula localities experienced storm surges during the latest severe storm - Hurricane Isabel in September 2003.

The data reflects only still salt water flooding. Freshwater flooding may also occur with hurricane events from heavy rainfall runoff, and waves may accompany the surge and cause further inundation. The maps represent the surge from Category 1 through 4 hurricanes. State and federal officials do not include storm surges from a Category 5 hurricane since they do not believe that the ocean water temperature off of the Virginia Coast is warm enough for such an intense storm.

Figures 21 through 24 summarize surge height estimates using the SLOSH (Sea, Lake, and Overland Surges from Hurricane) Model. The model was developed by Chester Jelesnianski of the NOAA, NWS. The storm surge computations and analysis were conducted by the Storm Surge Group of the National Hurricane Center.

The SLOSH model was used to develop data for various combinations of hurricane strength, wind speed, and direction of movement. Hurricane strength was modeled by use of central pressure (defined as the difference between the ambient sea level pressure and the minimum value in the storm's center), the storm eye size, and the radius of maximum winds (using four of the five categories of each hurricane intensity as depicted in the Saffir-Simpson Hurricane Scale). The modeling for each hurricane category was done using the mid-range wind speed for that category. Six storm track headings (WNW, NW, NNW, N, NNE, NE) were selected as being representative of storm behavior in the Virginia region, based on observations by forecasters at the National Hurricane Center. Additional inputs into the model included depths of water offshore, the heights of the terrain and onshore barriers.

Figure 29: Storm Surge Inundation Map of Middlesex, Gloucester, and Mathews Counties (VDEM, 2014).

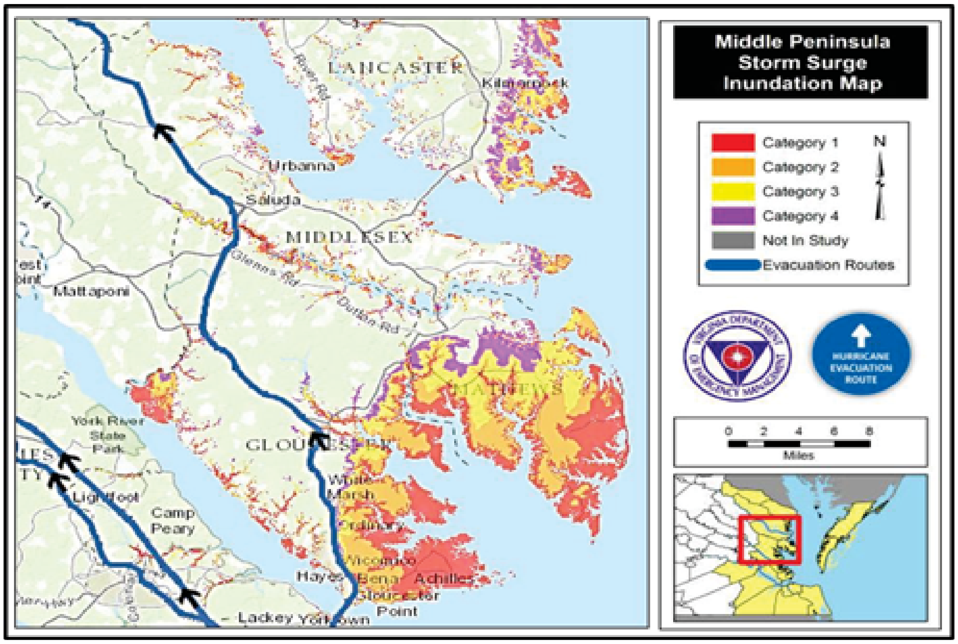


Figure 30: Storm Surge Inundation Map *of Middlesex County (VDEM, 2014).*

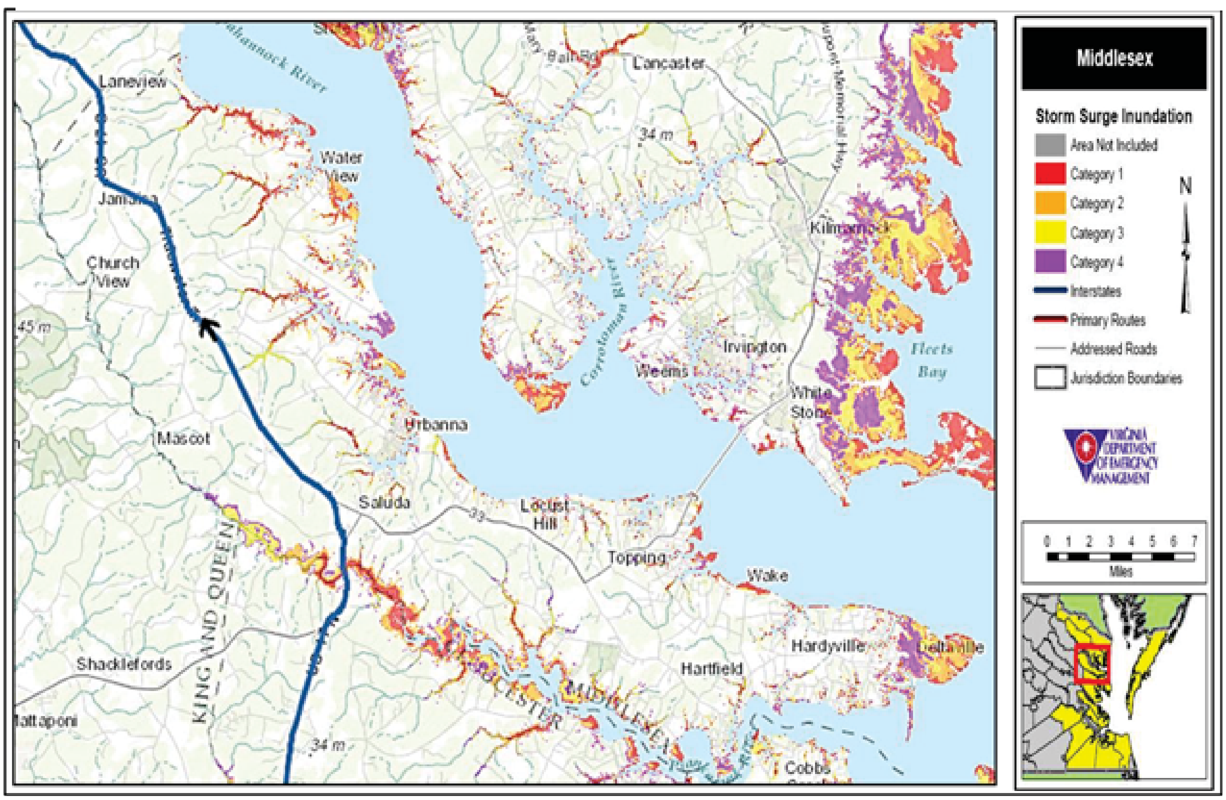


Figure 31: Storm Surge Inundation Map *of Mathews County (VDEM, 2014).*

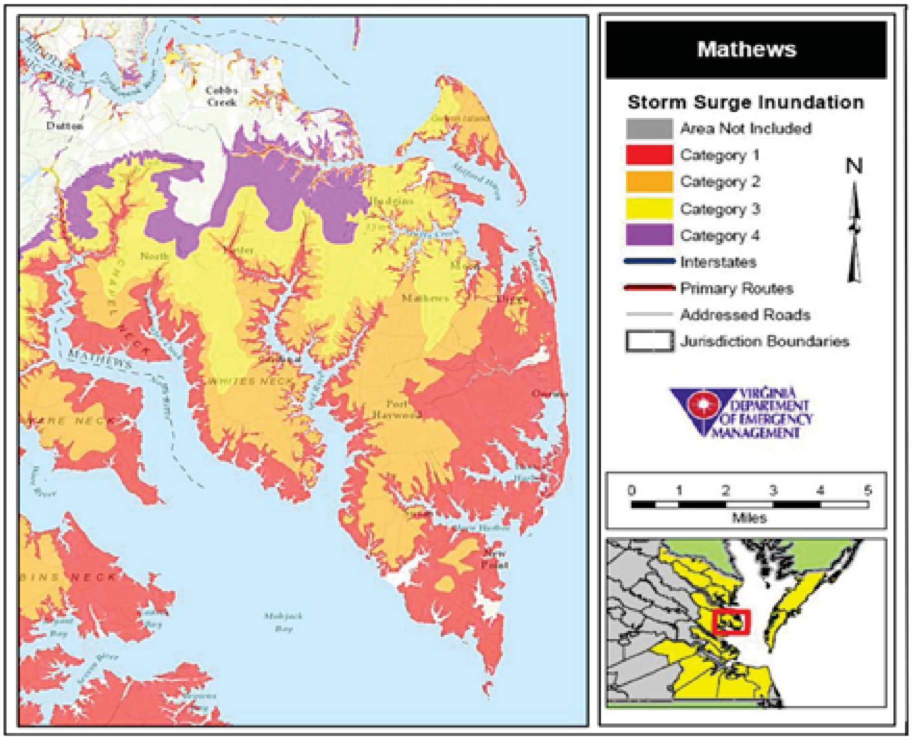
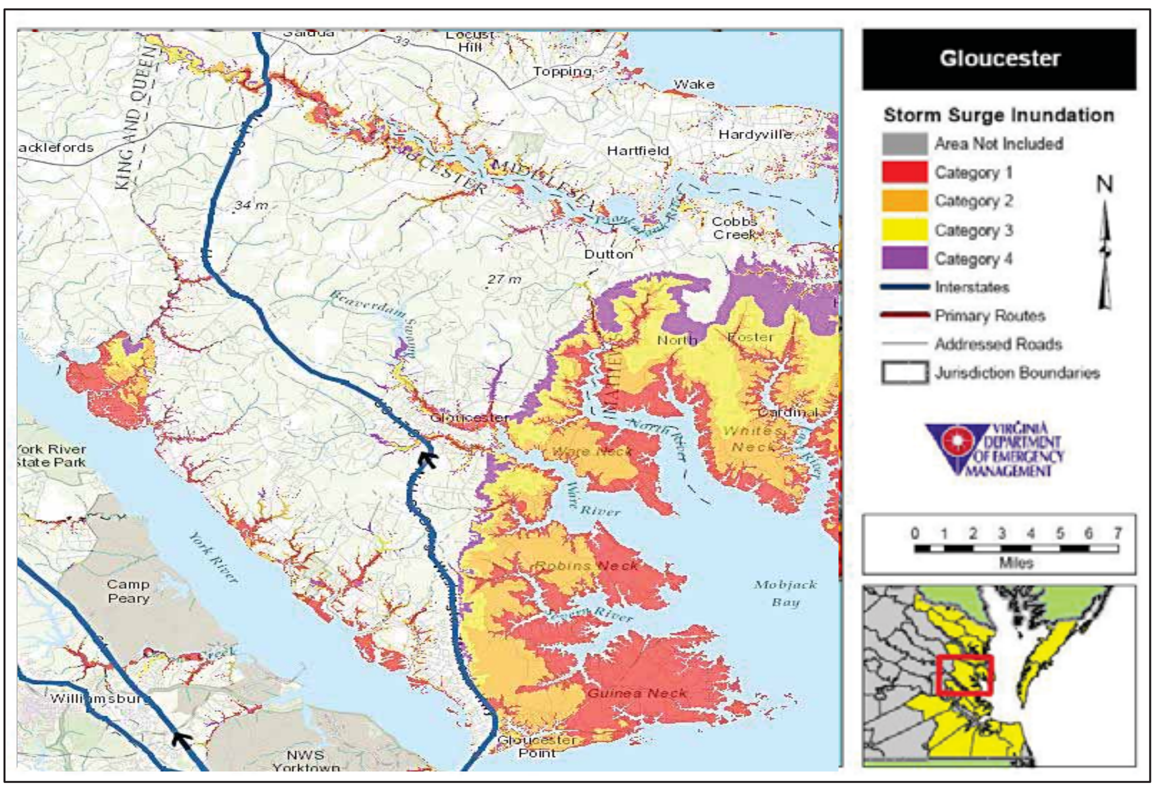


Figure 32: Storm Surge Inundation Map *of Gloucester County (VDEM, 2014).*



Historical Occurrences

In evaluating localized threats of hurricanes and tropical storms to the Middle Peninsula Region, NOAA hurricane tracking data from 1851 to 2014 was analyzed to identify storms that may have posed a threat to the region.

Based on these data, 43 storms - including hurricanes, tropical storms and tropical depressions - passed within 25 nautical miles of the Middle Peninsula Region. Of these storms 2 were hurricanes, 22 were tropical storms, 8 were tropical depressions, and 11 were extra-tropical storms (Table 23). Over the same period of time, 60 storms passed within 50 nautical miles of the region, including 4 hurricanes, 31 tropical storms, 11 tropical and subtropical depressions, and 14 extra-tropical storms (Table 23).

Table 23: Historic Storm Tracks within 50 and 25 nautical mile radii of the Middle Peninsula between 1851 and 2014.

Type of Storm	Quantity passing within 50 nm	Quantity passing within 25 nm
Hurricane – Category 5 (winds >155 mph)	0	0
Hurricane – Category 4 (winds 131-155 mph)	0	0
Hurricane – Category 3 (winds 111-130 mph)	0	0
Hurricane – Category 2 (winds 96-110 mph)	1	1
Hurricane – Category 1 (winds 74-95 mph)	3	1
Tropical Storm (winds 39-73 mph)	31	22
Tropical Depression (winds <38 mph)	10	8
Subtropical Storm (winds 39-73 mph)	0	0
Subtropical Depression (winds <38 mph)	1	0
Extra-tropical Storm (winds <39 mph)	14	11
Total:	**60**	**43**

General Chronology of Middle Peninsula Coastal Storm Hazard Events

Because of its proximity to the Atlantic Coast and Chesapeake Bay, the Middle Peninsula has been impacted by coastal storms throughout recorded history, and therefore it is not surprising that hurricanes, coastal flooding, nor'easters, and coastal/shoreline erosion were among the top ranked hazards affecting the Middle Peninsula Region as ranked by the Regional Risk Assessment and Mitigation Planning Committee in 2005 and re-affirmed by the Middle Peninsula Flood Mitigation Plan Team Members in 2009.

Hurricanes come close enough to produce hurricane force winds approximately three times every 20 years. Two or three times a century, winds and tides produce considerable damage and significantly threaten life. Historical records are invaluable to researchers trying to understand long-term patterns in the frequency and intensity of coastal storms and such data on storms and weather go back a long time in Virginia, thanks to record keeping by early weather observers such as George Washington, James Madison and Thomas Jefferson as well as journals/articles written by early settlers. The following is a brief synopsis of the major coastal storm events that have impacted the Middle Peninsula Region.

From 1564 to 1799

Hurricanes played an important role during the European exploration and colonization of the Americas. Great storms that besieged Virginia influenced the establishment of new settlements and changed the coastal geography, particularly on the Middle Peninsula. While official weather records did not begin until 1871 in Norfolk, tremendous coastal storms were often recorded through the shipwrecks they induced and in the writings of the early Virginia colonists.

The records of hurricane and tropical storm occurrences during this era are sparse compared to modern-day accounts, since the colonies were not settled until the early 1600's. The original settlers at Jamestown experienced the wrath of such storms firsthand and it is suggested that the lost colony of Roanoke Island may have been doomed by a coastal storm. The first such storm to be recorded occurred in 1564. Others followed in June 1566, June 1586, August 1587, and August 1591. A September 1667 storm, deemed the "Dreadful Hurry Cane of 1667", destroyed thousands of homes in Virginia (Brinkley, 1999). Twelve days of rain was said to have followed this storm, causing the Chesapeake Bay to rise 12 feet. This storm and a July 1788 hurricane may have followed a similar track as the 1933 hurricane, which caused massive devastation to the Middle Peninsula.

The October Hurricane of 1749 was a great disaster for Virginians. It formed Willoughby Spit in Norfolk and put the city streets of Hampton 4 feet below water. The Bay was said to have risen 15 feet above normal, destroying waterfront buildings (Ludlum, 1963). At least 50 vessels were driven ashore along the Virginia coast, with a loss of 22 lives. Damage in and around the city of Norfolk was estimated to be at least 30,000 Virginia Pounds (approximately $3 million in today's currency – Brinkley, 1999).

The September 8, 1769 hurricane, considered one of the worst storms of the eighteenth century, passed over Williamsburg. Damage was "inconceivable" and crops were destroyed. Many old homes and trees were leveled. Heavy rain ruined tobacco crops and flooded roads. Tobacco in storage warehouses was also damaged. Heavy damage was seen in Chesapeake Bay. High winds tore off the top of a wharf at Yorktown and a schooner rammed a nearby storehouse. Four ships in the York River were driven ashore. Two ships on the James River were also wrecked. A vessel from Norfolk, filled with coal from Williamsburg, was forced up to Jamestown before it went to pieces (Roth and Cobb, 2001).

"The Independence Hurricane" of September 1775 ravaged the coast between Currituck, N.C. and Chincoteague on the Eastern Shore. Wharves and storehouses on the waterfront of Norfolk were devastated. Raging waters carried bridges away. At Williamsburg, mill-dams broke and corn stalks were blown flat. Many ships were damaged as they were thrown ashore at Norfolk, Hampton, and York. A full blockade of Hampton Roads thereafter brought shipping to a halt for three months. At least 25 died due to a shipwreck. On September 9, 1775, a Williamsburg correspondent of the Virginia Gazette wrote, "The shocking accounts of damage done by the rains last week are numerous; most of the mill-dams are broke, the corn laid almost level with the ground, and fodder destroyed; many ships and other vessels drove ashore and damaged at Norfolk, Hampton, and York. The death toll in Virginia and North Carolina was 163 lives (Roth and Cobb, 2001).

A strong gale played a role in a battle between the Royal Governor of Virginia, Dunmore, and General Lewis of the rebel forces on July 10, 1776. The royal fleet had been injured prior to the storm by General Lewis' forces and was sailing from Gwynn's Island (Mathews County) toward St. George's Island, in the Potomac. The British crew was without water and enduring smallpox when the gale struck. A flour-laden supply ship ran aground. One ship foundered at the Mouth of the Rappahannock, while another was stranded on the Eastern shore (Roth and Cobb, 2001).

On October 16, 1781, a storm of "unknown character" struck Virginia. The French Fleet and the Patriot Army, under the command of George Washington, trapped the Earl of Cornwallis at Yorktown. The Earl decided to flee to the north to Gloucester Point under the cover of darkness. A "furious storm" doomed the plan to failure, as seas ran high and every boat was "swamped." He sent forward his flag of truce and surrendered, thus ending the battle (Roth and Cobb, 2001).

The "most tremendous gale of wind known in this country" passed over the Lower Chesapeake Bay September 22-24, 1785 and went along a track very similar to the Chesapeake-Potomac Hurricane of 1933 and likely severely impacted the Middle Peninsula. At Norfolk, lower stories of dwellings were flooded. Warehouses were totally carried away by the storm surge, causing large amounts of salt, sugar, corn, and lumber to disappear. A large number of cattle drowned, and people hung onto trees for dear life during the tempest. Vessels floated inland into cornfields and wooded areas (Roth and Cobb, 2001).

"George Washington's Hurricane" of July 23-24, 1788, made landfall in Virginia and passed directly over the Lower Chesapeake Bay and Mount Vernon, the home of George Washington. This track is very similar to the track of the Chesapeake-Potomac Hurricane of 1933. At Norfolk, winds increased at 5 p.m. on the 23rd with the wind originating from the northeast. At 12:30 a.m., the wind suddenly shifted to the south and "blew a perfect hurricane, tearing down chimneys, fences, and leveling corn." In addition, large trees were uprooted and houses were moved from their foundations. Port Royal (Caroline County) and Hobb's Hole (Essex County) experienced a violent northeast gale, which drove several vessels ashore. In Fredericksburg, great quantities of corn, tobacco, and fruit were destroyed. Houses and trees fell in great numbers across Northumberland, Lancaster, Richmond and Westmoreland Counties on the Northern Neck. Crops were destroyed and many livestock perished in lower Mathews County. Many plantations saw their houses leveled. Homes were flooded with water six feet deep and several inhabitants drowned. Gloucester County was inundated, and an estimated $400,000 (in 1788 dollars) in damage was incurred (Roth and Cobb, 2001).

1800-1899

Great Coastal Hurricane of 1806 (August 23) caught British and French ships off guard, while engaged in the Napoleanic Wars in the U.S. shipping lanes. The British man-of-war *L'Impeteax* drifted under jury masts for 23 days before finally beaching near Cape Henry. Ships of the two warring nations put in for repair and refitting at the port of Norfolk after the storm. This hurricane, due to its slow movement and consequent erosion of the coastline, completed the creation of Willoughby Spit at Hampton Roads. A seawall built to prevent further erosion at Smith Point lighthouse at the mouth of the Potomac River was damaged (Roth and Cobb, 2001).

A severe coastal storm dropped heavy rains on the Fredericksburg area in January 1863. It rained for 30 hours, dropping more than twelve inches, making mud so deep that mules and horses died attempting to move equipment. The rivers became too high and swift to cross, disrupting the Union Army offensive operation in the ill-famed "Mud March" (Watson and Sammler, 2004).

The Gale of '78 was one of the most severe hurricanes to affect eastern Virginia in the latter half of the 19th century and struck on October 23, 1878. This hurricane moved rapidly northward from the Bahamas on October 22nd and struck the North Carolina coast later that same day moving at a forward speed of 40 to 50 mph. The storm continued northward passing through east central Virginia, Maryland, and eastern Pennsylvania. Cobb and Smith Islands on the Eastern Shore were completely submerged during this storm (Roth and Cobb, 2001).

A September 1882 tropical storm, the "protracted and destructive rain storm", swept away four mills near Ware's Wharf along the lower Rappahannock. The brunt of the cyclone only extended fifty miles inland. Heavy rains were also seen at Washington, D.C. (Roth and Cobb, 2001).

During an April 1889 Nor'easter, the Tidewater Region had sustained winds from the north of 75 mph measured at Hampton Roads and 105 mph at Cape Henry. Tides at Norfolk reached 8.37 feet above Mean Low Water, which is over 4 feet above flood stage level (Watson and Sammler, 2004).

Noteworthy hurricanes or tropical storms also occurred in September 1821 (one of the most violent on record for the 19th century), June 1825, August 1837, September 1846 (which formed Hatteras and Oregon

Inlets in North Carolina), August 1850, September 1856, September 1876, August 1879, October 1887, August 1893, September 1894, October 1897 (tides in Norfolk rose 8.1 feet above Mean Lower Low Water), and October 1899 (tide in Norfolk rose 8.9 feet above Mean Lower Low Water).

From 1900 to 1999

A number of coastal storms hit the Tidewater Region in the early part of the 20th century. Hurricanes and tropical storms in October 1903, August 1924, September 1924, August 1926, and September 1928 each brought high winds (in excess of 70 mph measured in Norfolk and in Cape Henry). The 1903 and 1928 storms also raised tides as much as 9 feet and 7 feet, respectively, higher than normal in the region (Roth and Cobb, 2001).

The summer of 1933 was the most active storm season for eastern Virginia in the 20th century. Two hurricanes, one on August 23 and one on September 16, struck the North Carolina and Virginia coasts and caused much devastation on the Middle Peninsula. In Chesapeake lore, the "Storm of '33" is recalled by older residents and enshrined in legend as the worst storm in memory (Mountford, 2003). The August storm brought winds in excess of 80 mph and a storm surge that forced the tide nearly 10 feet above normal.

The September storm struck the area 24 days later and had sustained winds as high as 88 mph (measured at the Naval Air Station in Norfolk) and the tide reached 8.3 feet above Mean Lower Low Water (Roth and Cobb, 2001). Much of the land around the New Point Comfort lighthouse, the third oldest light on the Bay located at the entrance to Mobjack Bay and the mouth of the York River in Mathews County, was washed away and caused the lighthouse to be stranded on a very small island a few 100 yards from the tip of the mainland.

Hurricane Hazel hit eastern Virginia on October 15, 1954. This storm brought with it gusts of 100 mph which is the highest wind speed record at the Norfolk Airport location. A reliable instrument in Hampton recorded 130 mph winds (Roth and Cobb, 2001).
A severe nor'easter gave gale force winds (40+ mph) and unusually high tides to the Tidewater Virginia area on April 11, 1956. At Norfolk, the strongest wind gust was 70 mph. The strong northeast winds blew for almost 30 hours and pushed up the tide, which reached 4.6 feet above normal in Hampton Roads. Thousands of homes were flooded by the wind-driven high water and damages were huge. Two ships were driven aground. Waterfront fires were fanned by the high winds. The flooded streets made access by firefighters very difficult, which added to the losses (Watson and Sammler, 2004).

The "Ash Wednesday Storm" hit Virginia during "Spring Tide" (sun and moon phase to produce a higher than normal tide) on March 5-9, 1962. The storm moved north off the coast past Virginia Beach and then reversed its course moving again to the south and bringing with it higher tides and higher waves which battered the coast for several days. The storm's center was 500 miles off the Virginia Capes when water reached 9 feet at Norfolk and 7 feet on the coast. Huge waves toppled houses into the ocean and broke through Virginia Beach's concrete boardwalk and sea wall. Houses on the Middle Peninsula also saw extensive tidal flooding and wave damage. The beaches and shorefront had severe erosion (Watson and Sammler, 2004).

Hurricane Cleo in September 1964 produced the heaviest coastal rainfall in the area (11.40 inches in 24 hours) since records began in 1871 (Roth and Cobb, 2001).

Hurricane Agnes was downgraded to a tropical depression by the time it moved into Virginia in June 1972, but the rainfall produced by Agnes made this storm more than twice as destructive as any previous hurricane in the history of the United States (Roth and Cobb, 2001).

In July 1996, Hurricane Bertha passed over portions of Suffolk and Newport News. Bertha spawned 4 tornadoes across east-central Virginia. The strongest, an F1 tornado, moved over Northumberland County injuring 9 persons and causing damages of several million dollars. Other tornadoes moved over Smithfield, Gloucester and Hampton (Roth and Cobb, 2001).

In September 1999, Hurricane Floyd produced 10 to 20 inches of rain on saturated ground and resulted in a recorded 500-year flood for Franklin, VA. While North Carolina and southeastern Virginia were hit with the brunt of this storm, significant damage from downed trees and localized flooding occurred and all of the counties of the Middle Peninsula were included in the Federal Disaster Declaration (FEMA FEMA-1293-DR, Virginia).

From 2000 to 2009

Hurricane Isabel hit the coasts of North Carolina and Virginia on September 18, 2003. It was a Category 1 hurricane when it made landfall. The highest sustained wind was 72 mph at Chesapeake Light. Storm surge varied significantly across the region. At Sewell's Point in Norfolk, the maximum water level was 7.9 feet above MLW. This represented a 5-foot storm surge - the biggest in the region since Hurricane Hazel in 1954. Thirty six deaths were attributed to Hurricane Isabel in Virginia, including one in Gloucester County. Total damages for the Hampton Roads area amounted to $506 million.

In 2004, Tropical Storm Gaston caused serious damage to a handful of VDOT Secondary Roads in the Central Garage/Manquin sections of King William County.

In 2006, Tropical Storm Ernesto caused residential and roadway flooding damage as well as beach erosion damage in Mathews County.

There were an additional 5 named tropical events during this period to hit the Middle Peninsula region resulting in minor severe weather damage.

In 2009 Middle Peninsula coastal localities experienced a significant Nor-Easter with high winds and coastal flooding.

From 2010-2015

Hurricane Irene was hit the coast of North Carolina and had impacts on the Virginia coastal on August 26-27, 2011. Heavy rain, including some totals more than 10 inches, fell on eastern sections of Virginia. Irene lashed the eastern third of Virginia with tropical storm and isolated hurricane force gusts.

In early September 2011, the remand of Tropical storm Lee produced flash flooding in some sections of eastern Virginia, with the Washington, DC, suburbs particularly hard hit.

Hurricane Sandy ate season hurricane that passed off the Mid Atlantic coast, before turning west, and striking the New Jersey & New York coast on October 29, 2012. Sandy was a very large storm that was transitioning from a tropical to a non-tropical storm as it moved north paralleling the U.S. East coast during the October 27-29 time frame. Sandy's impact was relatively small in Virginia, with very heavy rainfall and some flooding the biggest impacts. The most significant impact was felt on the DELMARVA, especially on the east side of the Chesapeake Bay from Salisbury, MD southward to Onancock, VA, where severe coastal flooding and storm surge inundated many areas, as Sandy passed by to the north. Crisfield, MD and Saxis, VA were hardest hit, with millions of dollars in damage to homes and businesses. Damage and flooding were worse than that which occurred in the same area during Hurricane Floyd (1999).

On record for the 2014 season, eight name tropical or subtropical storms formed in the North Atlantic. Six of these became hurricanes and two of these reached major hurricanes of Category 3 or higher on the Saffir-Simpson Hurricane Scale. Six of the hurricanes, Arthur, Bertha, Cristobal, Edouard, Fay, Gonzalo and Hanna, and one tropical storm struck the United States. According to the NWS, activity in the basin in 2-14 was only about 63% of the 1981-2010 average.

Soil Erosion

Hurricanes and nor'easters produce severe winds and storm surges that create significant soil erosion along rivers and streams in the Middle Peninsula. In addition to the loss of soil along these water bodies, there is damage to man-made shoreline hardening structures such as bulkheads and rap-rap as well as to piers, docks, boat houses and boats due to significant storm surges.

These damages are more severe along the broad open bodies of water on major rivers located closer to the Chesapeake Bay. In general terms, the damage is less intense as you move up the watershed from the southeastern area of the region towards the northwestern end of the Middle Peninsula. Therefore, the soil erosion would is most severe in Mathews, Gloucester and Middlesex Counties and to a lesser degree in the 3 remaining Middle Peninsula Counties of King and Queen, King William and Essex Counties.

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. It can generally be said that hurricane generated soil erosion is uneven in occurrence and that the storm surge affords 2 opportunities for erosion – once as water inundates low-lying amount coast lands and again as floodwaters ebb.

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.

Destructive as it was, Hurricane Isabel might have been worse. If it had been stronger at landfill, the storm surge generated in the Chesapeake Bay may have been higher. Had it stalled along its path and lingered through several tide cycles, prolonged surge conditions, exacerbated by high winds, might have cause more severe erosion. If rainfall has been higher, bank erosion due to slope failure might have been more common, particularly given the wetter than normal months that preceded Hurricane Isabel.

Middle Peninsula Resources at Potential Risk of Loss

Floodplain Properties and Structures

While floodplain boundaries are officially mapped by FEMA's National Flood Insurance Program (NFIP), flood waters sometimes go beyond the mapped floodplains and/or change courses due to natural processes (e.g., accretion, erosion, sedimentation, etc.) or human development (e.g., filling in floodplain or floodway areas, increased imperviousness areas within the watershed from new development, or debris blockages from vegetation, cars, travel trailers, mobile homes and propane tanks).

Since the floodplains in the United States are home to over 9 million households and there continues to be a high demand for residential and commercial development along water features, most property damage results from inundation by sediment and debris-filled water. Flooding is one of the most significant hazards faced by the Middle Peninsula. A majority of the flooding that has damaging effects on the region is tidal flooding, which primarily occurs in conjunction with severe coastal storms such as hurricanes or nor'easters.

In addition to tidal flooding, some regions of the Middle Peninsula are subject to flooding events induced by rain associated with a hurricane or a tropical storm, which can produce extreme amounts of rainfall in short periods of time. In August 2004, Tropical Storm Gaston dumped 14 inches of rain in a matter of hours on King William County, washing out numerous roads and bridges. This storm qualified the county for disaster aid through a Presidential Disaster Declaration.

Flooding of vacant land or land that does not have a direct effect on people or the economy is generally not considered a problem. Flood problems arise when floodwaters cover developed areas, locations of economic importance, infrastructure or any other critical facility. Low-lying land areas of Essex, Gloucester, Mathews, and Middlesex Counties and the lower reaches of King and Queen and King William Counties are highly susceptible to flooding, primarily from coastal storm when combined with tidal surges.

These flood-prone regions include marsh areas adjacent to waterways, and the wide, flat outlets where its streams and rivers meet the Chesapeake Bay and its tributaries. Fluctuations in the surrounding water levels produce a mean tidal range of approximately 3 feet. The timing or coincidence of maximum surge-producing forces with the normal high tide is an important factor in consideration of flooding from tidal sources. Strong winds from the east or southeast can push Chesapeake Bay water into the mouth of the York and Rappahannock Rivers and Mobjack Bay – thereby flooding lower portions of the Middle Peninsula. This surge combined with the normal high tide can increase the mean water level by 15 feet or more.

The Flood Insurance Rate Maps (FIRMs) show flooding during a 100-year storm event or, in other words, the storm that has a 1% chance of being equaled or exceeded in any given year. The FIRMs account for both coastal surge driven flooding, as well as flooding generated from rain events. The 1% annual-chance-flood (or the 100-year flood as it is commonly referred to) represents a magnitude and frequency that has a statistical probability of being equaled or exceeded in any given year. Another way of looking at it is that the 100-year flood has a 26% (or a 1 in 4) chance of occurring over the life of a 30-year mortgage on a home (FEMA, 2002).

Along with nearly 20,000 communities across the country, all of the localities in the Middle Peninsula voluntarily participate in the National Flood Insurance Program by adopting and enforcing floodplain management ordinances in order to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities (FEMA, 2002).

The U.S. Congress established the National Flood Insurance Program (NFIP) with the passage of the National Flood Insurance Act of 1968. Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Flood damage is reduced by nearly $1 billion a year by communities implementing sound floodplain management requirements and property owners purchasing flood insurance.

Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80% less damage annually than those not built in compliance with these standards. It is estimated that for every $3 paid in flood insurance claims, there is $1 spent in disaster assistance payments (FEMA, 2002).

Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for local floodplain management programs and to provide flood insurance actuarial rates for new construction (FEMA, 2002).
Floodplain maps covering the Middle Peninsula Region have recently been updated. FEMA produced these new digital maps in the following years:

2015
Essex County
Middlesex County

2014
Gloucester County
Mathews County

2013
King & Queen County
King William County

The recently completed digital floodplain maps/data can be integrated into the GIS of those Middle Peninsula localities that utilize GIS technology.

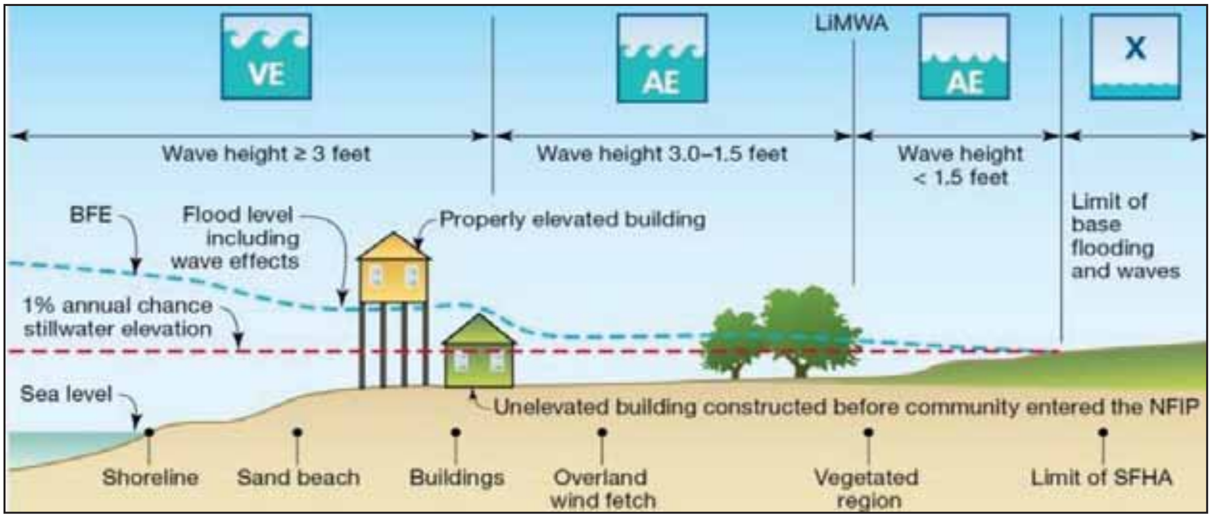
In recent years, FEMA has comprehensively analyzed Region III's coastal flood hazard and integrated the lasted topographic data sets with state-of-the-art storm modeling techniques (FEMAI, 2015). This new information replaces maps and studies that are based on data and modeling technology from as far back as the 1970's (FEMA, 2015). With this new data and technology, new FIRMs have been generated. The FIRMs reflect floodplain zones are standardized to the 100-year flood and assigned an area called the Special Flood Hazard Area (SFHA). A SFHA is a high-risk area defined as any land that would be inundated by a flood having a 1-percent chance of occurring in any given year (FEMA, 2002). In the Middle Peninsula, the SFHA includes zones designated as VE, A, Coastal A, AE, AO, X, and X500. Table 24 provides definitions for the zones.

Table 24: FEMA Flood Zone Designations found in the Middle Peninsula Region.	
Zone VE & V	SFHA along coasts subject to inundation by the 100-year flood with additional hazards due to velocity (wave action). Base flood elevations derived from detailed hydraulic analyses are shown within these zones. This delineated flood hazard includes wave heights equal to or greater than three feet. *Mandatory flood insurance purchase requirements apply.*
Zone A	SFHA subject to inundation by the 100-year flood. Because detailed hydraulic analyses have not been performed, no base flood elevation or depths are shown. *Mandatory flood insurance purchase requirements apply.*
Zone AE	SFHA subject to inundation by the 100-year flood determined in a Flood Insurance Study by detailed methods. Base flood elevations are shown within these zones. This delineate flood hazard includes wave heights less than three feet. *Mandatory flood insurance purchase requirements apply.*
Zone AO	SFHA inundated by the 100year flood where flooding is anticipated to average depth of 1 to 3 feet, where a clearly defined channel does not exist, where the path of flooding is unpredictable, and where velocity flow may be evident.
Zone X	These areas have been identified in the Flood Insurance Study as areas of moderate or minimal hazard from the principal source of flood in the area. However, buildings in these zones could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. Local storm water drainage systems are not normally considered in the community's FIS. The failure of a local drainage system creates areas of high flood risk within these rate zones. *Flood insurance is available in participating communities, but is not required by regulation in these zones.*
Zone X500	The same description as Zone X, however, this area falls between the 100 and 500-year flood zone.
UNDES	Undescribed. No information available.

To further assist community official and property owners in recognizing an increased potential for damage due to wave action in the AE zone, FEMA issued guidance in December 2008 on identifying and mapping the 1.5-foot wave high line, referred to as the Limit and Moderate Wave Action (LiMWA) (Figure 33). As

LiMWA addresses the fact that wave action does cease at the AE Zone delineate, a new SFHA has been developed between the VE and AE Zone called Zone Coastal A. Zone Coastal A is landward of a V Zone, or land ward of an open coastal without mapped V Zones. While the Coastal A Zone in not a NFIP mandate, it offers design and construction practice for communities that wish to adopt high floodplain management standards. Within the Middle Peninsula, Gloucester County, Mathews County and the Town of Wet Point are the only locality that has included Coastal A Zone within their FIRMs and floodplain management policy.

Figure 33: Diagram of coastal flood zones (FEMA, 2015).



Under the NFIP regulations, participating NFIP communities are required to regulate all development in the SFHAs. Development is defined as:

> *"any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment or materials."*

Before a property owner can undertake any development in the SFHA, a permit must be obtained from the locality. The locality is responsible for reviewing the proposed development to ensure that it complies with the locality's floodplain management ordinance. Localities are also required to review proposed developments in the SFHAs to ensure that all necessary permits have been received from those governmental agencies from which approval is required by Federal or State law, such as 404 Wetland Permits from the Army Corps of Engineers or permits under the Endangered Species Act.

Under the NFIP, localities must review all new development proposals to ensure that they are reasonably safe from flooding and that the utilities and facilities serving these developments are constructed to minimize or eliminate flood damage.

In general, the NFIP minimum floodplain management regulations require that new construction or substantial improvements to existing buildings in the Zone A must have their lowest floor, including basements, elevated to or above the Base Flood Elevation (BFE). Non-residential structures in Zone A can be either elevated or dry-flood proofed. In Zone V, the building must be elevated on piles/columns and the bottom of the lowest horizontal structural member of the lowest floor of all new construction or substantially improved existing buildings must be elevated to or above the BFE.

When the NFIP was created, the U.S. Congress recognized that insurance for "existing buildings" constructed before a community joined the Program would be prohibitively expensive if the premiums were not subsidized by the Federal Government. Congress also recognized that most of these flood-prone buildings were built by individuals who did not necessarily have sufficient knowledge of the flood hazard to make informed decisions.

Under the NFIP, "existing buildings" are generally referred to as pre-FIRM buildings. These buildings were built before the flood risk was known and identified on the locality's FIRM. Currently, about 26% of the 4.3 million NFIP policies in force are pre-FIRM subsidized policies as compared to 70% of the policies that were being subsidized in 1978 (FEMA, 2002).

Middle Peninsula Flood Insurance Data

According to data from FEMA dated March 31, 2015 there are a total of 4,354 flood insurance policies covering Middle Peninsula properties (Table 25). The following is a summary of flood insurance policy data by locality:

Table 25: Flood Insurance Policies within the Middle Peninsula (FEMA, 2015).

Locality	Total Policies	# of Claims Since 1978	Total Value of Claims
Essex	229	239	$6,197,534.36
Tappahannock	66	16	$193,571
Gloucester	1693	1339	$30,285,748.62
King & Queen	55	22	$584,113.30
King William	18	8	$158,306.60
West Point	102	76	$2,165,826.96
Mathews	1637	1179	$20,165,826.96
Middlesex	488	225	$2,943,857.77
Urbanna	20	12	$277,744.64
Totals	4308	3116	$62,972,530.21

Table 26: Repetitive Loss Properties in the Middle Peninsula

County	# of Properties	# of Claims	Total Building Claims	Average Claim
Essex	32	82	$1,855,068.89	$22,622.79
Mathews	169	417	$8,252,285.42	$19,789.65
Gloucester	146	384	$3,310,607.84	$21,642.21
Middlesex	35	78	$1,084,995.57	$13,910.20
Town of Urbanna	2	4	$120,595.91	$30,148.98
Town of Tappahannock	2	4	$66,220.74	$16555.19
Town of West Point	9	21	$644,314.91	$30,681.66

According to the Virginia Hazards Mitigation Plan repetitive loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling ten-year period, since 1978 (Table 26). In 2004 the National Flood Insurance Reform Act recognized repetitive loss as a significant and problem and defined severe repetitive loss (SRL) as: "a single family property (consisting of 1 to 4 residences) that is covered under flood insurance by the NFIP and has incurred flood-related damage for which 4 or more separate claims payments have been paid under flood insurance coverage, with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least 2 separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property. Table 27 show the number of SRL properties within the Middle Peninsula region.

Table 27: Severe Repetitive Loss Properties in the Middle Peninsula.

County	# of Properties	# of Claims	Total Building Payments	Average Pay
Essex	2	9	$142,973.31	$22,884.81
Mathews	11	49	$1,288.909.58	$34,179.62
Gloucester	13	63	$1,857,182.84	$33,028.95
Middlesex	2	6	$157,821.97	$37,271.90

4.4.5. Summer Storms

Summer Storms are weather systems accompanied by strong winds, lightning, heavy rain, and possibly hail and tornadoes. They can occur at any time in the Middle Peninsula of Virginia, although they are most frequent during the warm spring and summer months from April through September. The most common summer storm is the thunderstorm, with the severe thunderstorm with the most potential to cause damage. The potential thunderstorm threat is often measured by the number of "thunderstorm days" – defined as days in which thunderstorms are observed.

Thunderstorms form when a shallow layer of warm, moist air is overrun by a deeper layer of cool, dry air. Cumulonimbus clouds, frequently called "thunderheads," are formed in these conditions. These clouds are often enormous (up to six miles or more across and 40,000 to 50,000 feet high) and may contain tremendous amounts of water and energy. That energy is often released in the form of high winds, excessive rains, lightning, and possibly hail and tornadoes.

Thunderstorms are typically short-lived (often lasting no more than 30-40 minutes) and fast moving (30-50 miles per hour). Strong frontal systems, however, may spawn one squall line after another, composed of many individual thunderstorm cells. Severe thunderstorms may also cause severe flood problems because of the torrential rains that they may bring to an area. Thunderstorms sometimes move very slowly, and can thus dump a tremendous amount of precipitation onto a location. Flooding can result, including flash floods, "urban flooding," and river flooding.

4.5. Locality Specific Critical Facilities and Public Utilities

4.5.1. King and Queen County Critical Facilities and Public Utilities

The County's Courthouse Complex is located in the central portion of the county along the Route 14 ridgeline, which runs in a southeasterly/northwesterly direction. This Complex is the center of county government and contains all county offices. The law enforcement and public safety functions are located in the new courts/administration building, which has a generator that serves these areas of the building during a power outage. This complex is located outside of the 500-year floodplain.

Additional properties that the County owns include 4 solid waste facilities located at 4 different locations in the county and the property that the regional library is located on. All 5 of these properties lie outside of the 500-year floodplain.

There are 4 volunteer fire departments (VFD) and 2 volunteer rescue squads (VRS) located at scattered positions throughout the county. All of these emergency response facilities are located outside the 500-year floodplain.

The County's 3 school sites are all located along the high and dry Route 14/721 corridor. Central High School, located in the King and Queen Courthouse area in the middle portion of the county, is the County's designated shelter due to flooding or any other type of natural disaster.

The Middle Peninsula Regional Airport is located in the southern portion of the county and is owned and operated by a regional authority. The Airport Authority is made up of 4 local governments including King and Queen, King William and Gloucester Counties as well as the Town of West Point. Life-Evac, a medical transport helicopter service, is located at the airport. The airport terminal and runway are located outside the 500-year floodplain.

There are no public water or sewer facilities anywhere in the County - all properties in the County are served by individual wells and septic systems.

Repetitive and Severe Repetitive Loss Residential Structures in King and Queen County
According to FEMA's records, King and Queen County has no Repetitive Loss residential properties or Severe Repetitive Losses as of 5/31/15.

According to VDOT and County officials, flood prone roads in King and Queen County include the following in Table 28.

Table 28: King and Queen County Flood Prone Roads

Route	Road Name	Location of Flooding
749	Kays Lane	At Root Swamp
721	Newtown Road	near Bradley Farm Road
721	Newtown Road	near Level Green Road
721	Newtown Road	near Glebe Road
623	Indian Neck Road	near Rappahannock Cultural Center
625	Poplar Hill Road	near Spring Cottage Road
628	Spring Cottage Road	near Eastern View Road
628	Todds Bridge Road	near Gunsmoke Lane
628	Pattie Swamp Road	at swamp
631	Fleets Mill Road	at Fleets Millpond
631	Norwood Road	at Dickeys Swamp
636	Minter Lane	at Walkerton Creek
620	Powcan Road	at Poor House Lane
620	Duck Pond Road	at Garnetts Creek
634	Mt. Elba Road	at flat areas
633	Mantua Road	at Garnetts Creek
617	Exol Road	at Exol Swamp
614	Devils Three Jump Road	Devils Three Jump Road
14	The Trail	at Truhart

613	Dabney Road	At Little Tastine Swamp
611	Tastine Road	At Little Tastine Swamp
603	Lombardy Road	At Little Tastine Swamp
608	Clancie Road	At Bugan Villa Drive
601	Stratton Major Road	Near Union Prospect Baptist Church
601	Stratton Major Road	Near Union Road
644	Jonestown Road	At Meadow Swamp
605	Plain View Lane	At Guthrie Creek
601	Cheery Row Lane	At Guthrie Creek and swamp
666	Tuckers Road	Entire road including Tuckers R.P.
667	Wrights Dock Road	Entire road
640	Lyneville Road	At 36" cross-pipes
625	Bryds Mill	At cross-pipes
615	Union Hope Road	At Exol Swamp
604	Bryds Bridge Road	At Bryds Bridge
612	Lilly Pond Rod	At Dragons Swamp Bridge
610	Dragonville Rod	At Timber Brook Swamp
614	Rock Springs Road	At bridge
14	Buena Vista Road	at K&Q/ Gloucester County line

Public Boat Ramps
There are 2 public boats ramps in the county along the Mattaponi River that are operated/maintained by the Virginia Department of Game and Inland Fisheries (VDGIF):

Water Body	Access Area	Barrier Free	Type	Ramps	Latitude	Longitude
Mattaponi River	Melrose	Yes	Concrete Ramp	1	37° 38' 14" N 37.6372145	76° 51' 18"W -76.8549627
Directions: From King & Queen Courthouse, Rt. 14 South (2.8 miles); Right onto Rt 602 (1.2 miles) to Ramp						
Mattaponi River	Waterfence	Yes	Concrete Ramp	1	37° 35' 31" N 37.5920552	76° 47' 55"W -76.7987125
Directions: From West Point, Rt 33 East, turn Left onto SR 14 (5 miles), turn Left onto SC 611 to end						
Virginia Department of Game an Inland Fisheries, 2015						

In addition to the VDGIF sites, there is a water access site to the Mattaponi River in Walkerton. Located at the base of the bridge off Route 629, this site is privately owned; however the owner allows public access upon receipt of a donation for use.

Due to the low velocity of the flood waters along this section of the Mattaponi River, none of these boat landings sustain damage from flood waters.

Properties in the 100-year Floodplain by Census Block Groups
The following series of maps show the location of structures in King and Queen County that are either in Flood Zone A or Flood Zone AE in the100-year flood plain. The map also shows structures in the 500-year plain that are labeled: "0.2% annual chance flood hazard". The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 34:

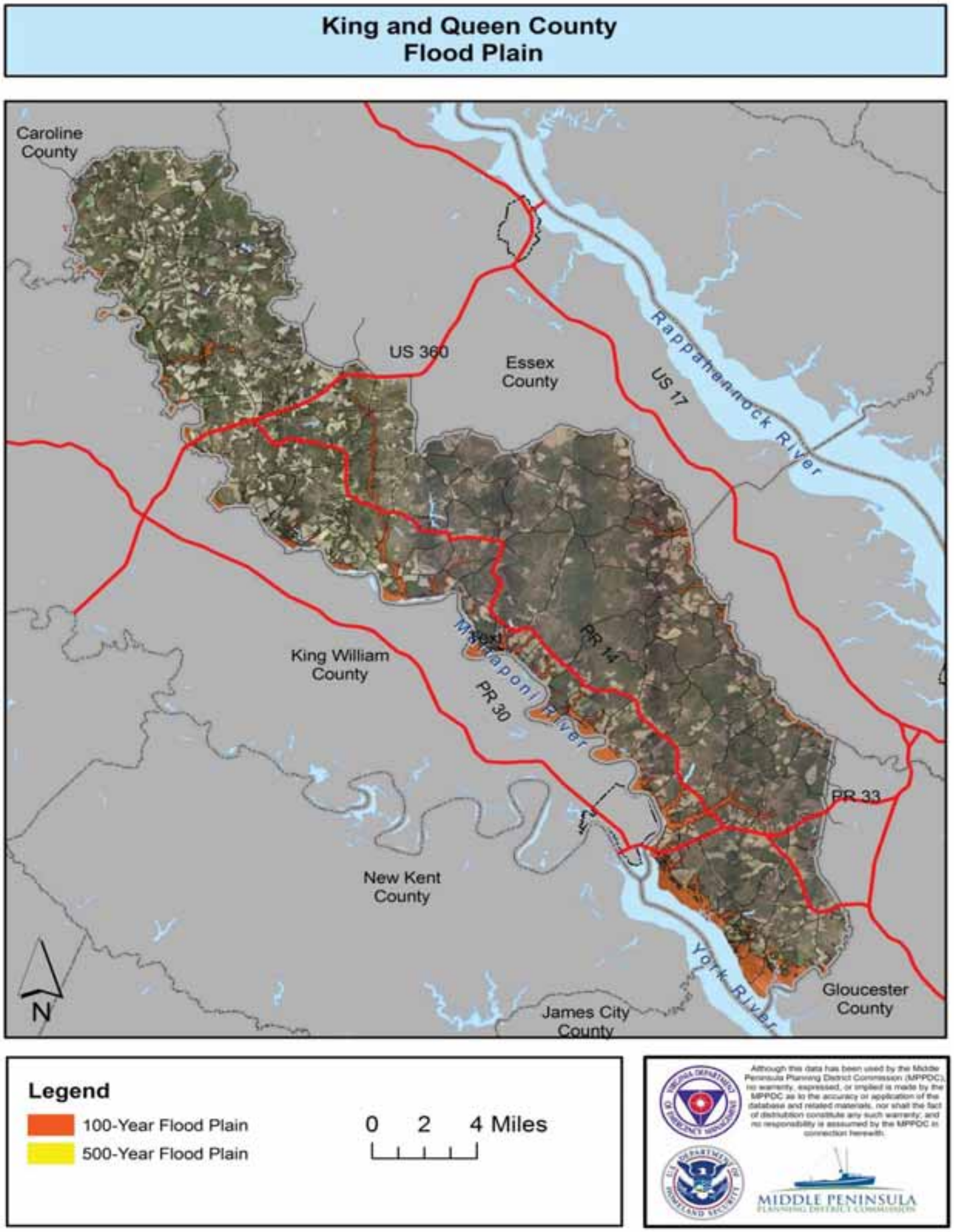

King and Queen County
Flood Plain
Caroline County
US 360
Essex County
Rappahannock River
US 17
King William County
Mattaponi River
PR 14
PR 30
PR 33
New Kent County
York River
Gloucester County
James City County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
0 2 4 Miles
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 35:

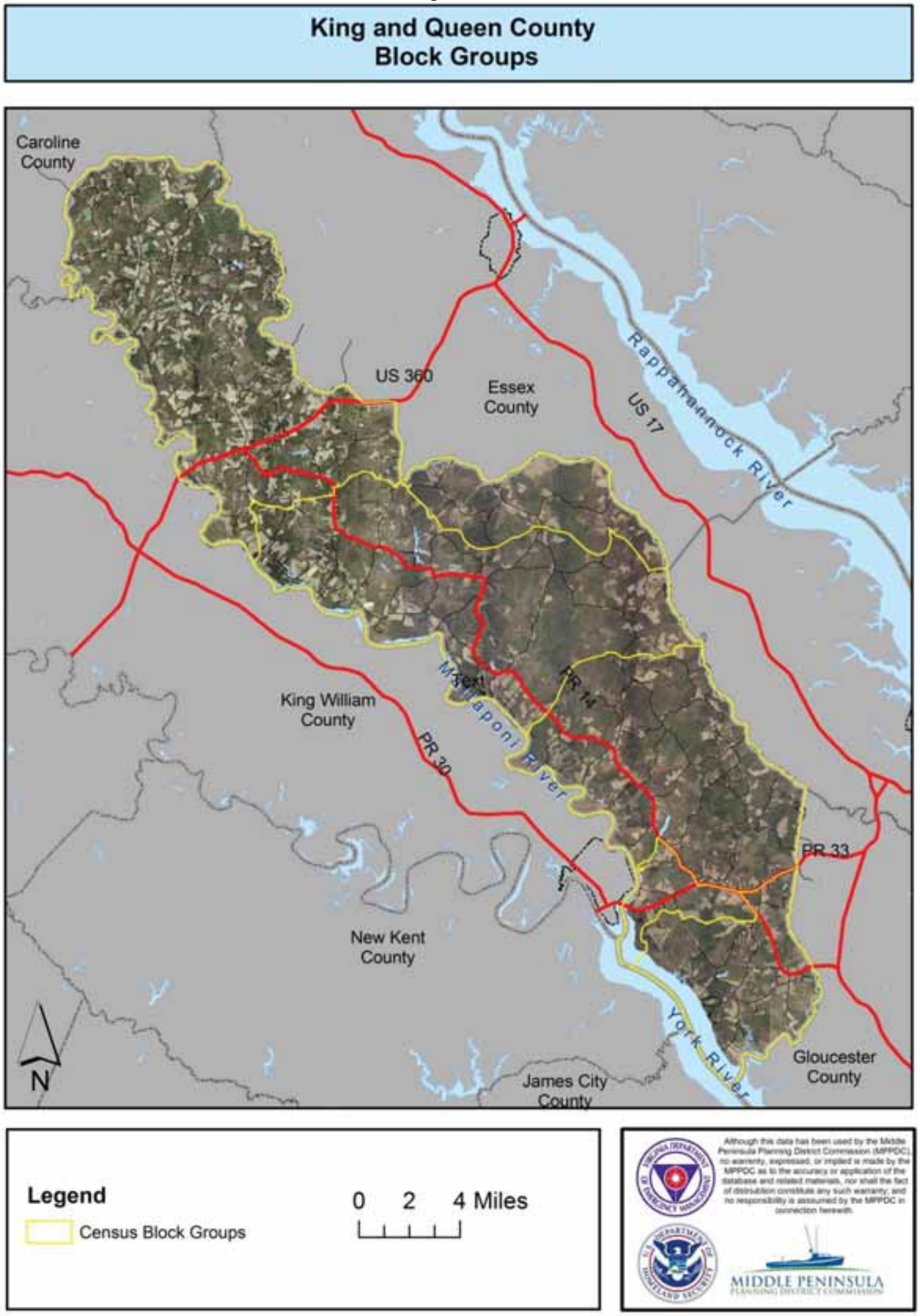

King and Queen County
Block Groups
Caroline County
US 360
Essex County
Rappahannock River
US 17
King William County
Text
PR 14
Mattaponi River
PR 30
PR 33
New Kent County
York River
Gloucester County
James City County
N
Legend
Census Block Groups
0 2 4 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA

Figure 36:

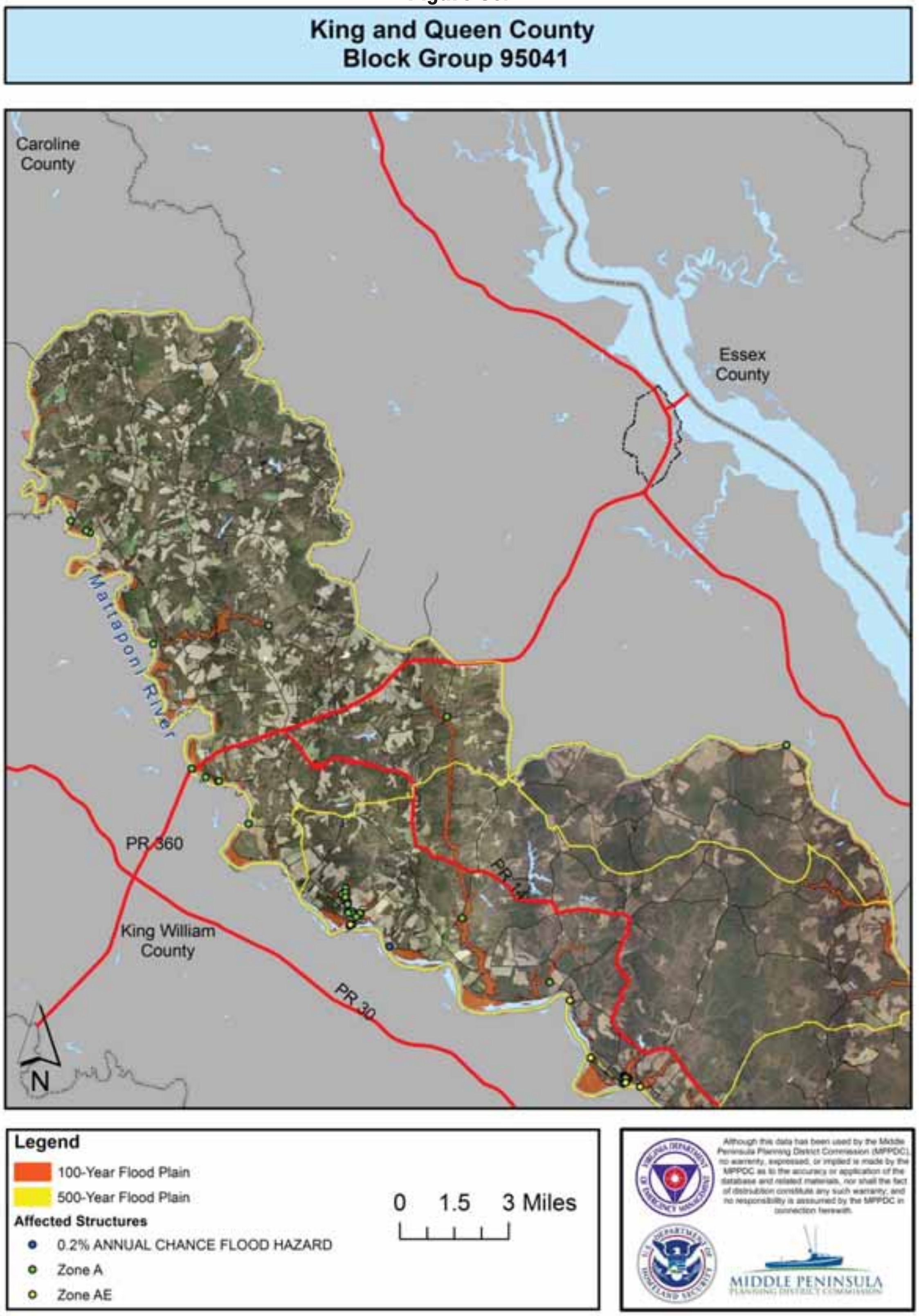

King and Queen County
Block Group 95041
Caroline County
Essex County
Mattaponi River
PR 360
PR 14
PR 30
King William County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 1.5 3 Miles
MIDDLE PENINSULA

Figure 37:

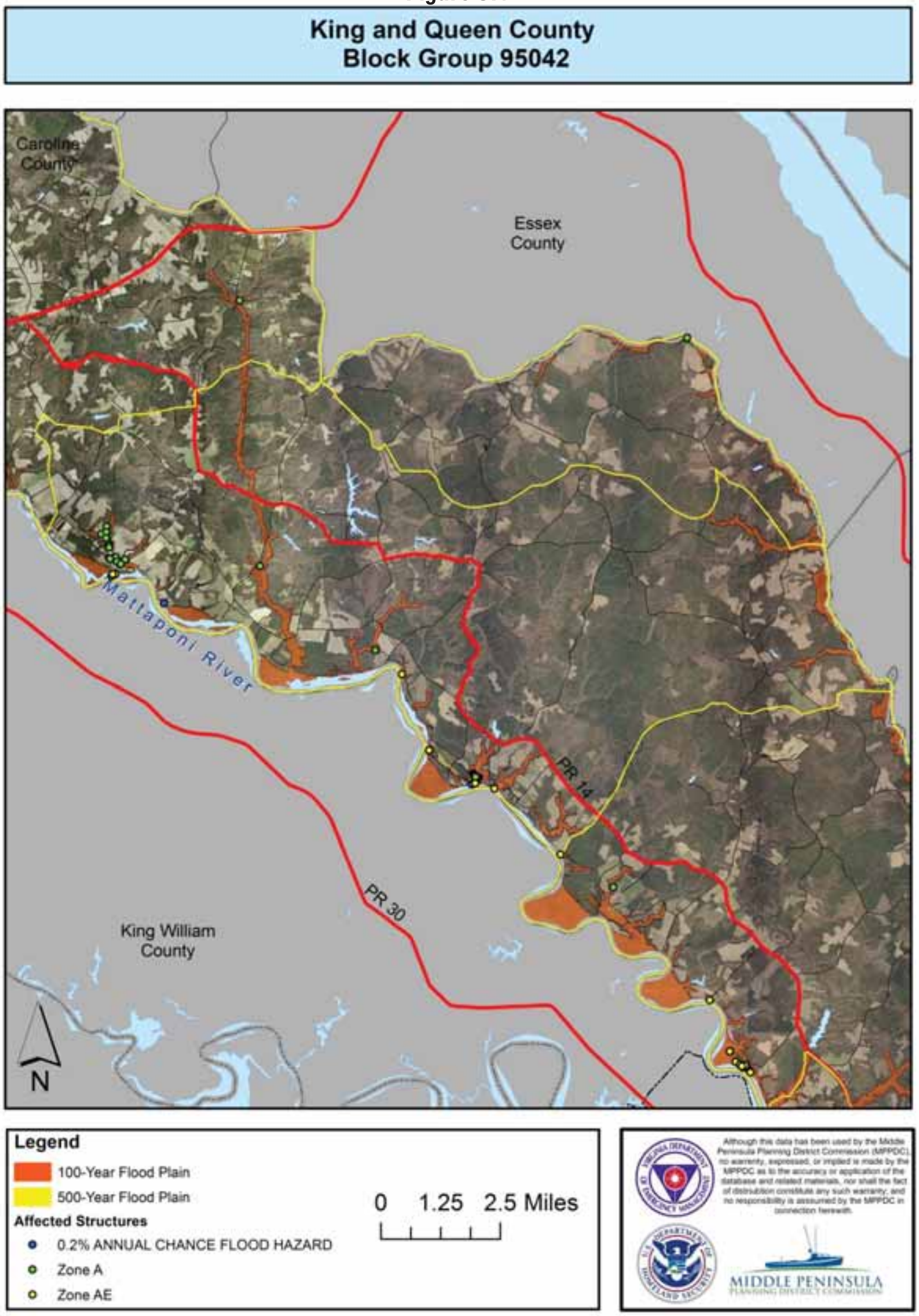

King and Queen County
Block Group 95042
Caroline County
Essex County
King William County
Mattaponi River
PR 14
PR 30
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 1.25 2.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 38:

King and Queen County
Block Group 95051

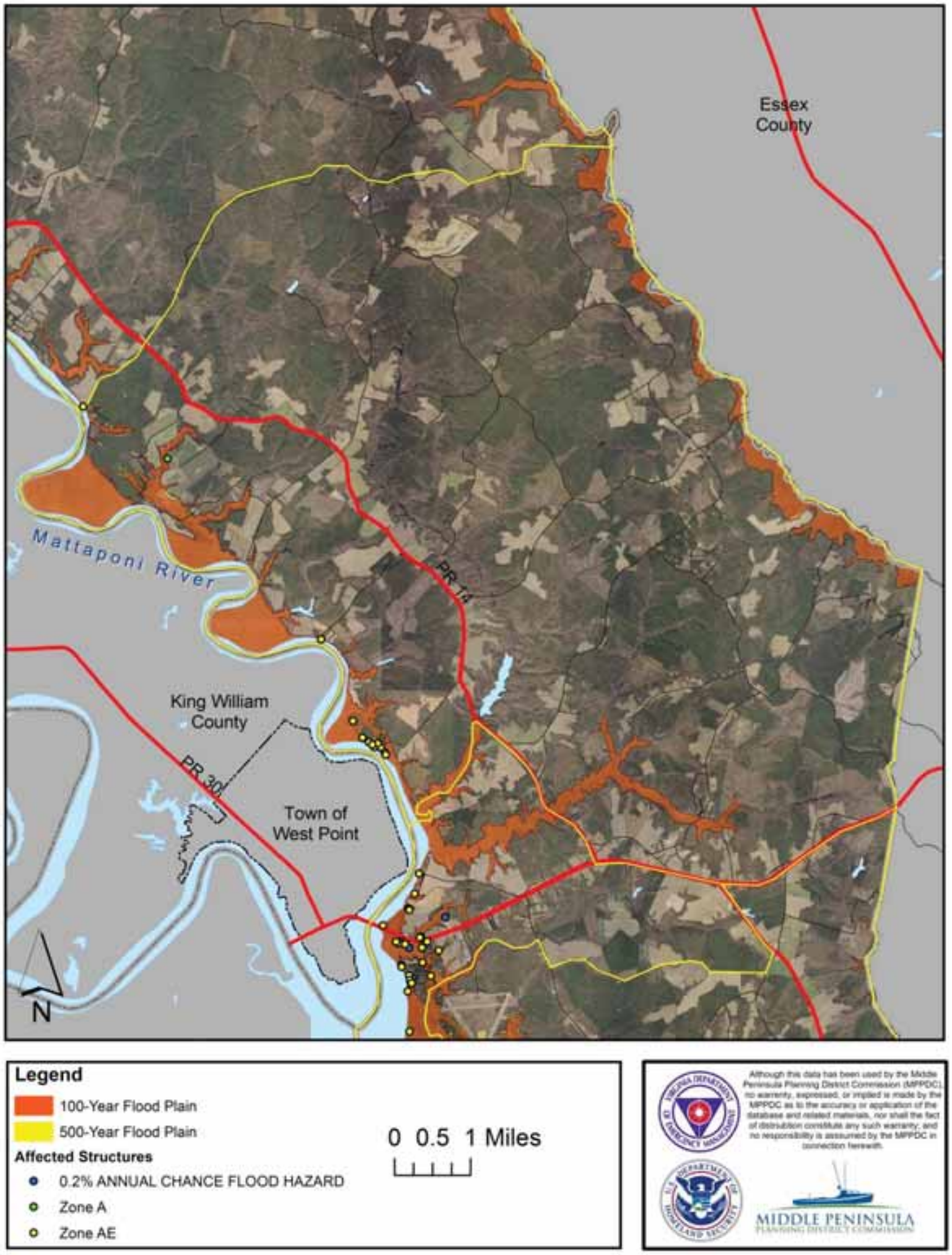


Figure 39:

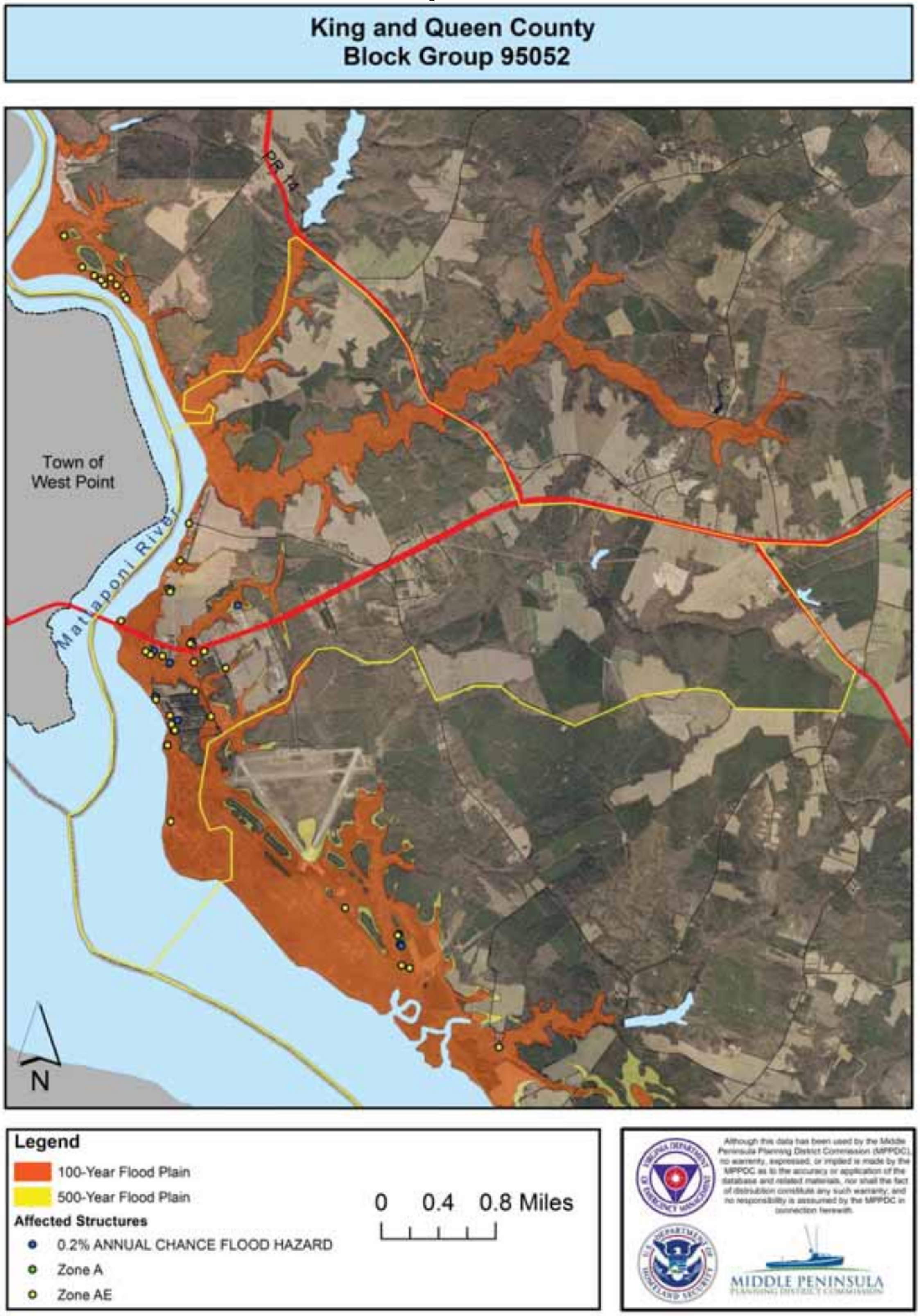
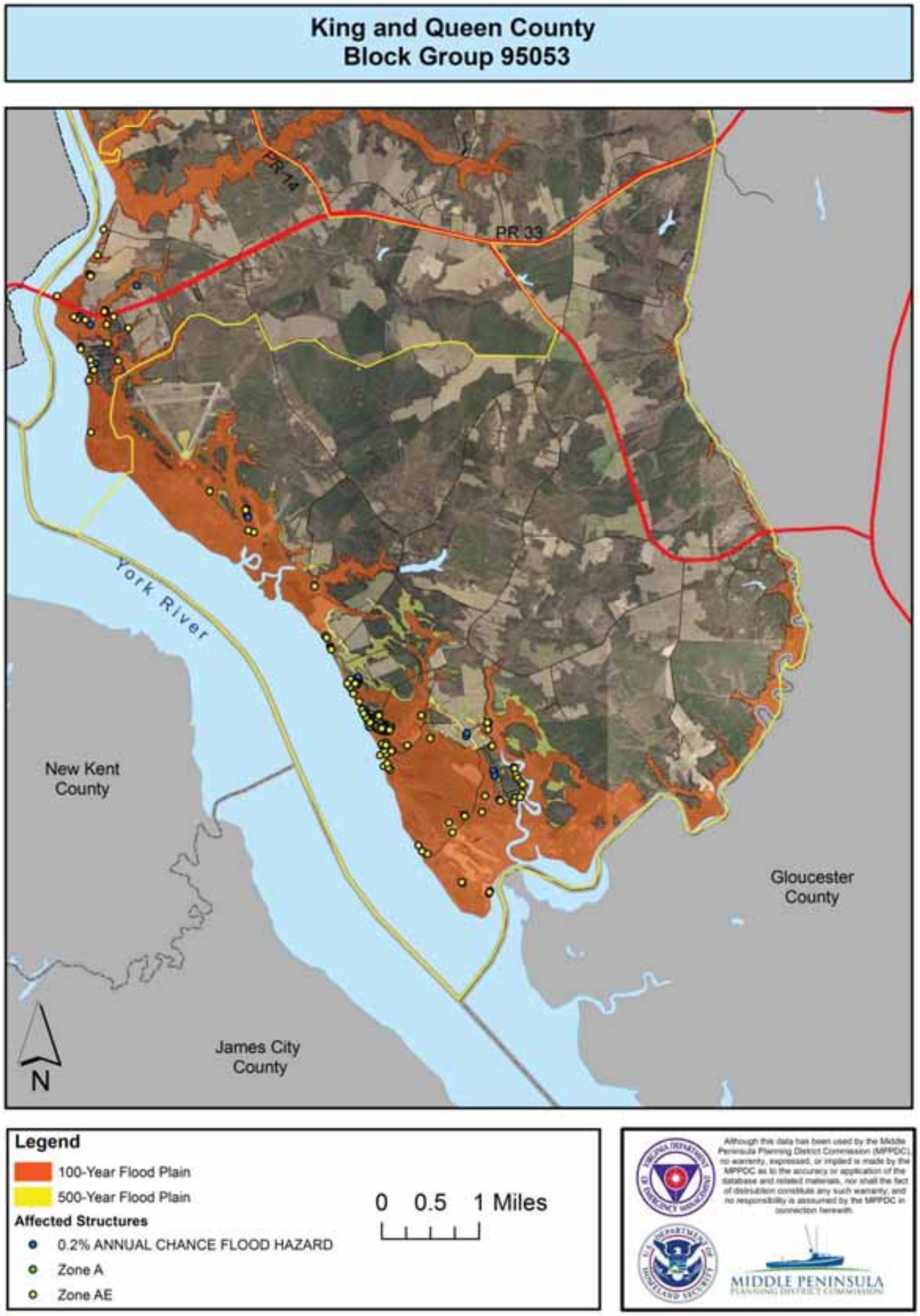

King and Queen County
Block Group 95052
PR 14
Town of
West Point
Mattaponi River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 0.4 0.8 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 40:


King and Queen County
Block Group 95053
PR 14
PR 33
York River
New Kent County
Gloucester County
James City County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
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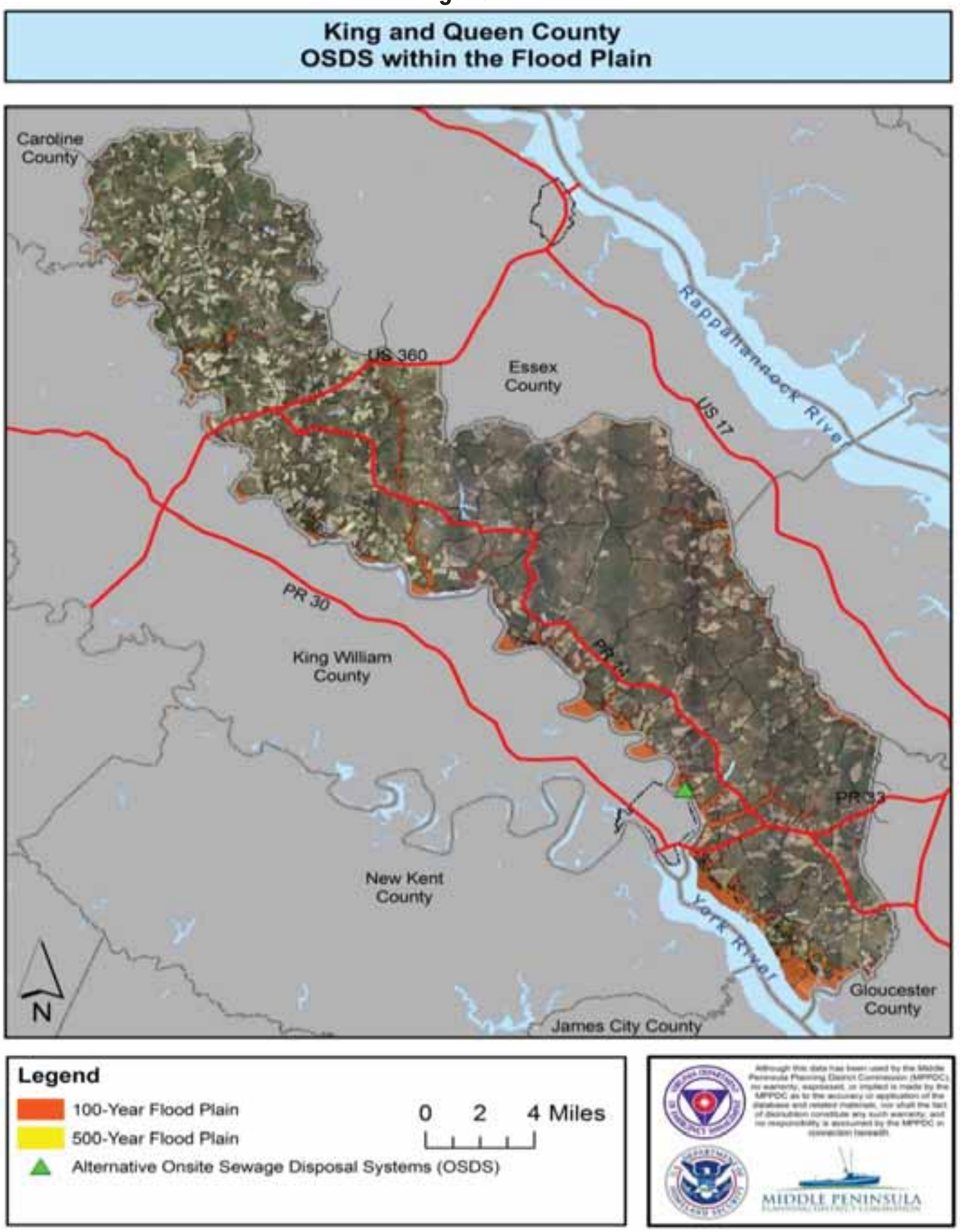
Alternative On-site Sewage Disposal Systems (OSDS)

The Virginia Department of Health (VDH) regulations have changed dramatically in recent years to keep pace with improvements in technology. Now, there are a number of "alternative on-site sewage disposal systems" that are allowed to be constructed where poor soils and/or a high water table prevented the construction of a conventional septic system on the property. As of 2009, there were 1,208 OSDSs permitted and installed in the Middle Peninsula. There are an additional 2,006 OSDSs permitted by the health department, but not yet installed (Figure 41).

Many of these are located in the 100-year floodplain, some of which could suffer damage during flooding events since most of the systems have essential mechanical and other components at-grade or slightly above grade.

Figure 41:



4.5.2. Essex County Critical Facilities and Public Utilities

The County's Offices are located within the Town of Tappahannock, which is centrally located mid-county along the Route 17 corridor. The County Offices are located in a handful of buildings in downtown Tappahannock in an area that is outside of the 500-year floodplain. There are emergency generators at the County Administration Building and at the Sheriff's Office/Dispatch Center.

Additional properties that the County owns includes 2 solid waste facilities located at Center Cross and Bray's Fork, the county library, the elementary school/school board offices and the middle school/high school complex. All of these properties are located outside of the 500-year floodplain. The new middle school has an emergency generator.

The county/town is served by 1 volunteer fire department that has 3 fire stations. One station is located in Tappahannock along Airport Road, another is located at the northern end of the county along Route 17 at Loretto and the third station is located at the southern end of the County near Center Cross. The Tappahannock Volunteer Rescue Squad is located in downtown Tappahannock and it serves town residents as well as all county residents. All of these emergency response facilities are located outside of the 500-year floodplain. The fire department on Airport Road and the EMS facility downtown have emergency generators.

The new Tappahannock-Essex County Community Airport is located off of Route 360 at Paul's Crossroads. The airport is located on a high ridge-line, which is obviously outside of the 500-year floodplain.

The new animal shelter that serves the town and county is located at the town's former maintenance facility along Airport Road, which does not flood.

Repetitive and Severe Repetitive Loss Residential Structures in Essex County

According to FEMA's records, Essex County has 32 Single-Family Repetitive Loss properties and 2 Single-Family Severe Repetitive Losses as of 5/31/15.

According to VDOT officials, flood prone roads in the Essex County/Tappahannock area include the following:

Table 29: Essex/Tappahannock Flood Prone Roads

Route	Road Name	Location
17	Church Lane	Tickners Creek at June Parker Marina
617	Island Farm Road	Piscataway Creek
646	Fort Lowery Lane	Rappahannock River
680	River Place	Rappahannock River

Route 17 is the main south/north road serving the county. This primary road has been designated as a hurricane evacuation route by the Commonwealth of Virginia for some Tidewater residents evacuating northward during a Category 2 or stronger hurricane. However, a portion of Route 17 on the north side of Tappahannock (near the June Parker Marina) floods on a regular basis during storms of minor to moderate intensity. As Essex County and Town of Tappahannock developed plans and proposed them to VDOT in 2014 VDOT began construction on this section of the highway. VDOT will elevate the road and install a bridge to reduce the occurrence of flooring on Route 17, a hurricane evacuation route, from just north Marsh Street to just south of Airport Road. Construction work will began in January 2014 and will conclude by May 2016.

Also according to town officials, all roads that dead end at the Rappahannock River flood, but sustain little damage since flood velocities are low along this section of the river through Tappahannock.

Properties in the 100-year Floodplain by Census Block Groups

The following series of maps show the location of structures in Essex County that are either in the Flood Zone A or in Flood Zone AE in the 100-year flood plain. The map also shows structures in the 500-year plain that are labeled: "0.2% annual chance flood hazard". The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 42:

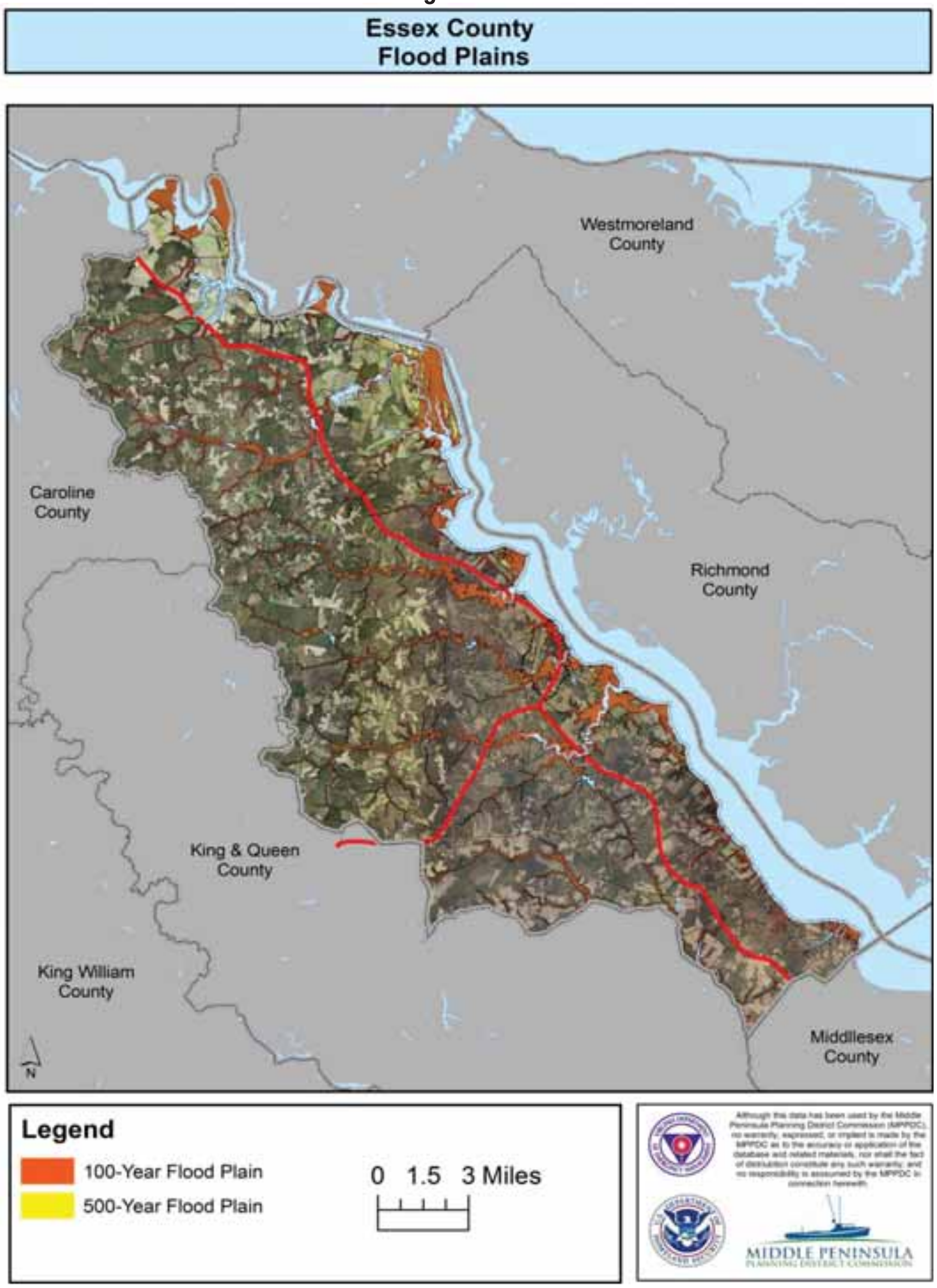
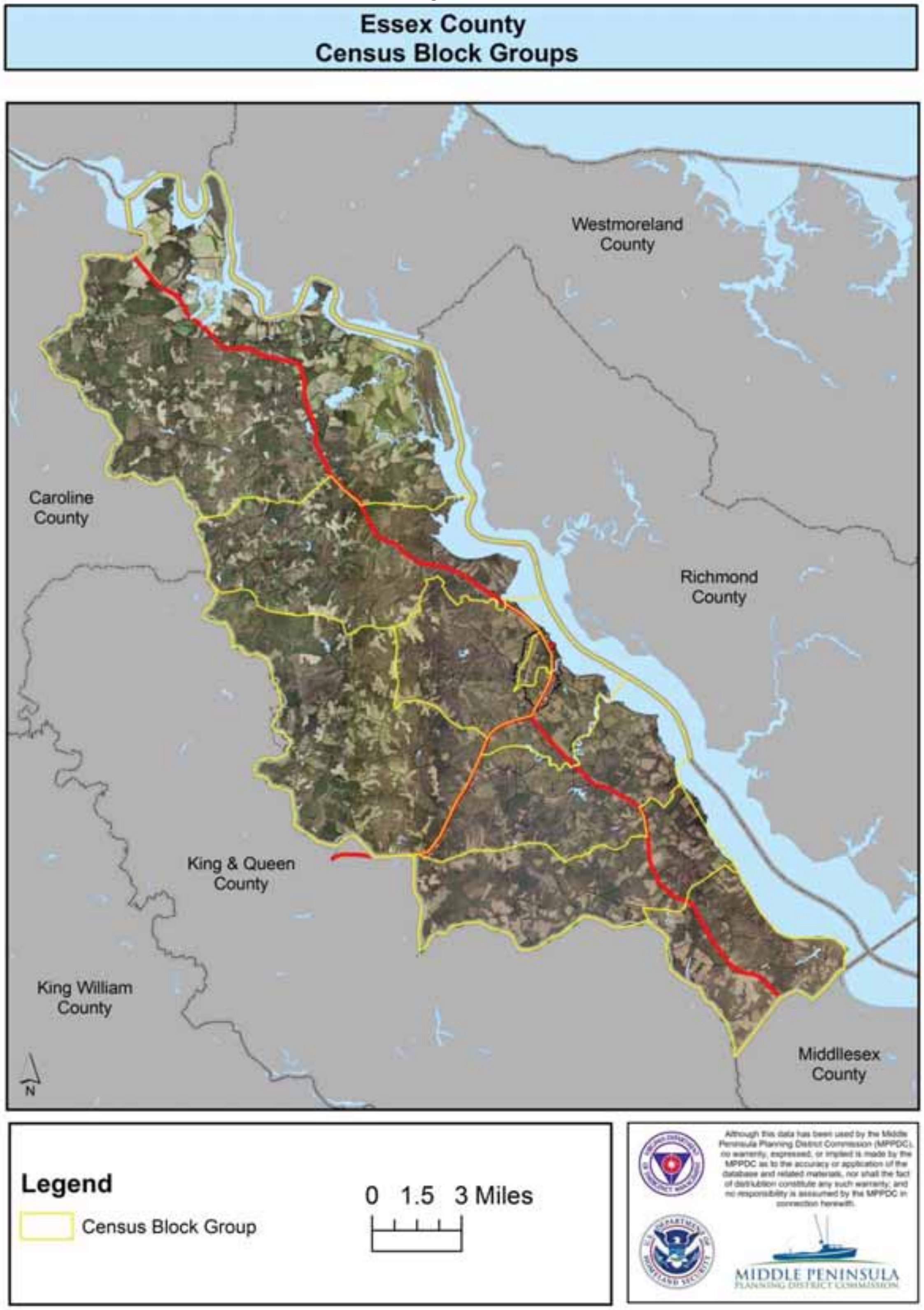


Figure 43:



Essex County
Census Block Groups
Westmoreland County
Caroline County
Richmond County
King & Queen County
King William County
Middlesex County
N
Legend
Census Block Group
0 1.5 3 Miles
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 44:

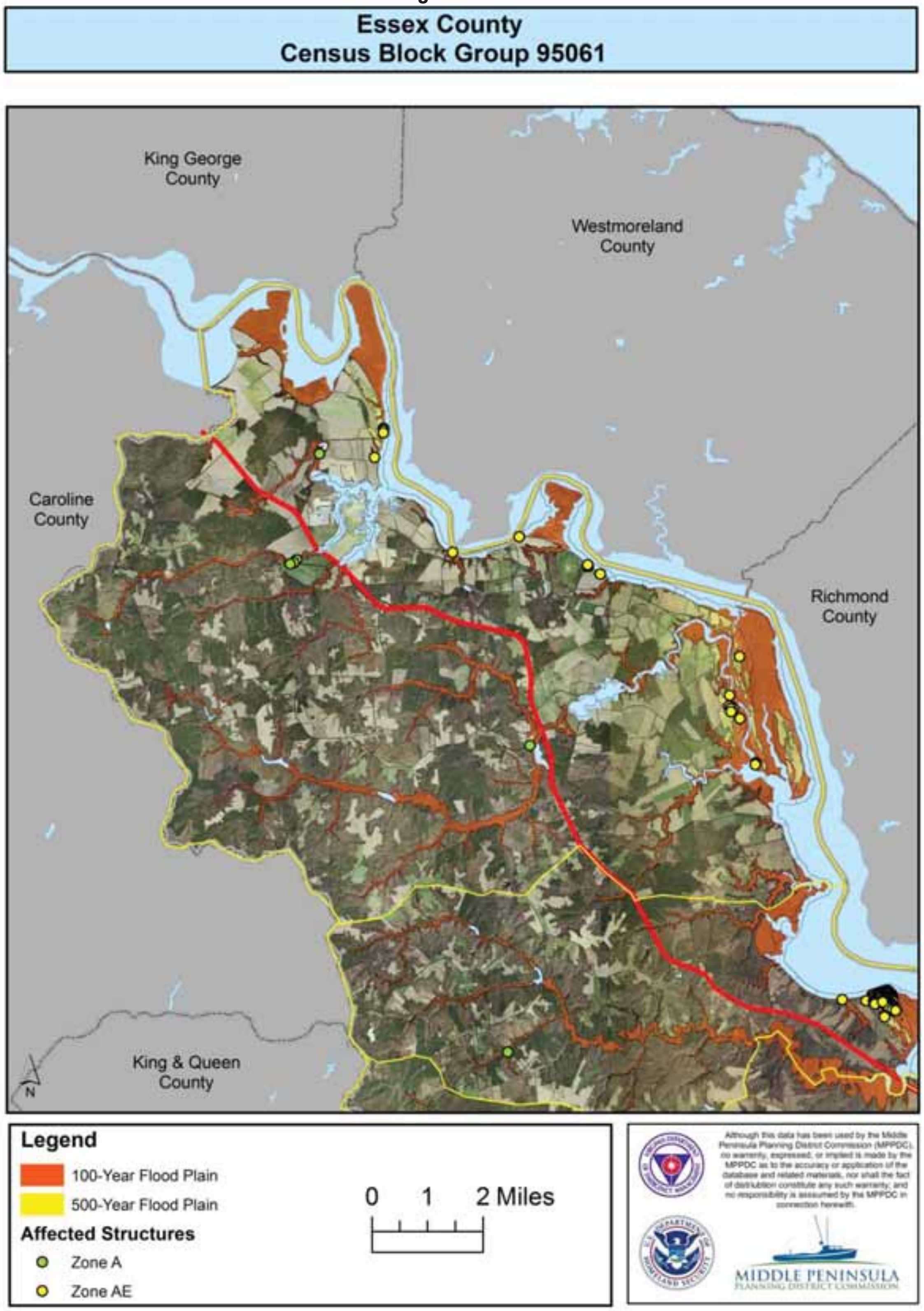

Essex County
Census Block Group 95061
King George County
Westmoreland County
Caroline County
Richmond County
King & Queen County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
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Figure 45:

Essex County
Census Block Group 95062

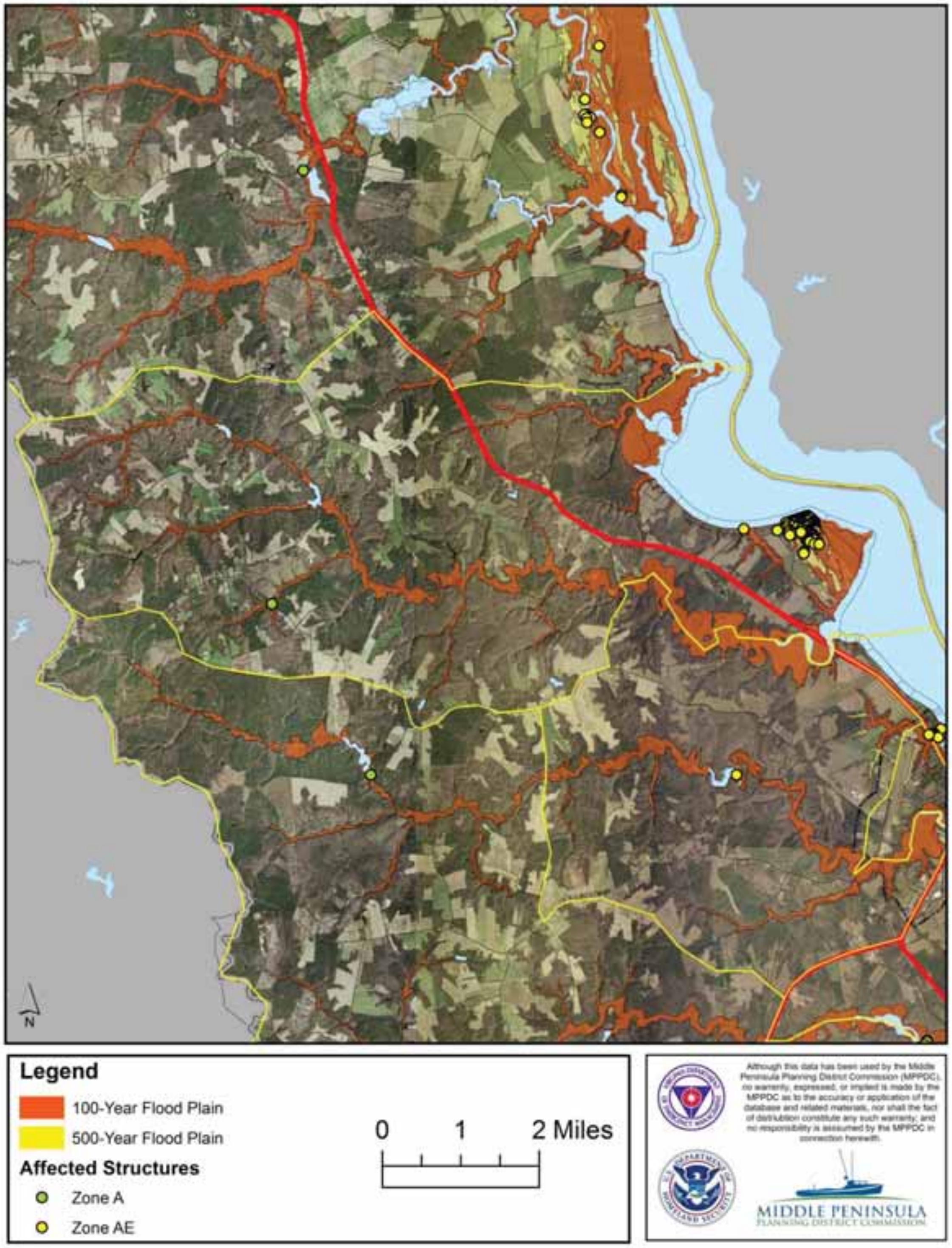
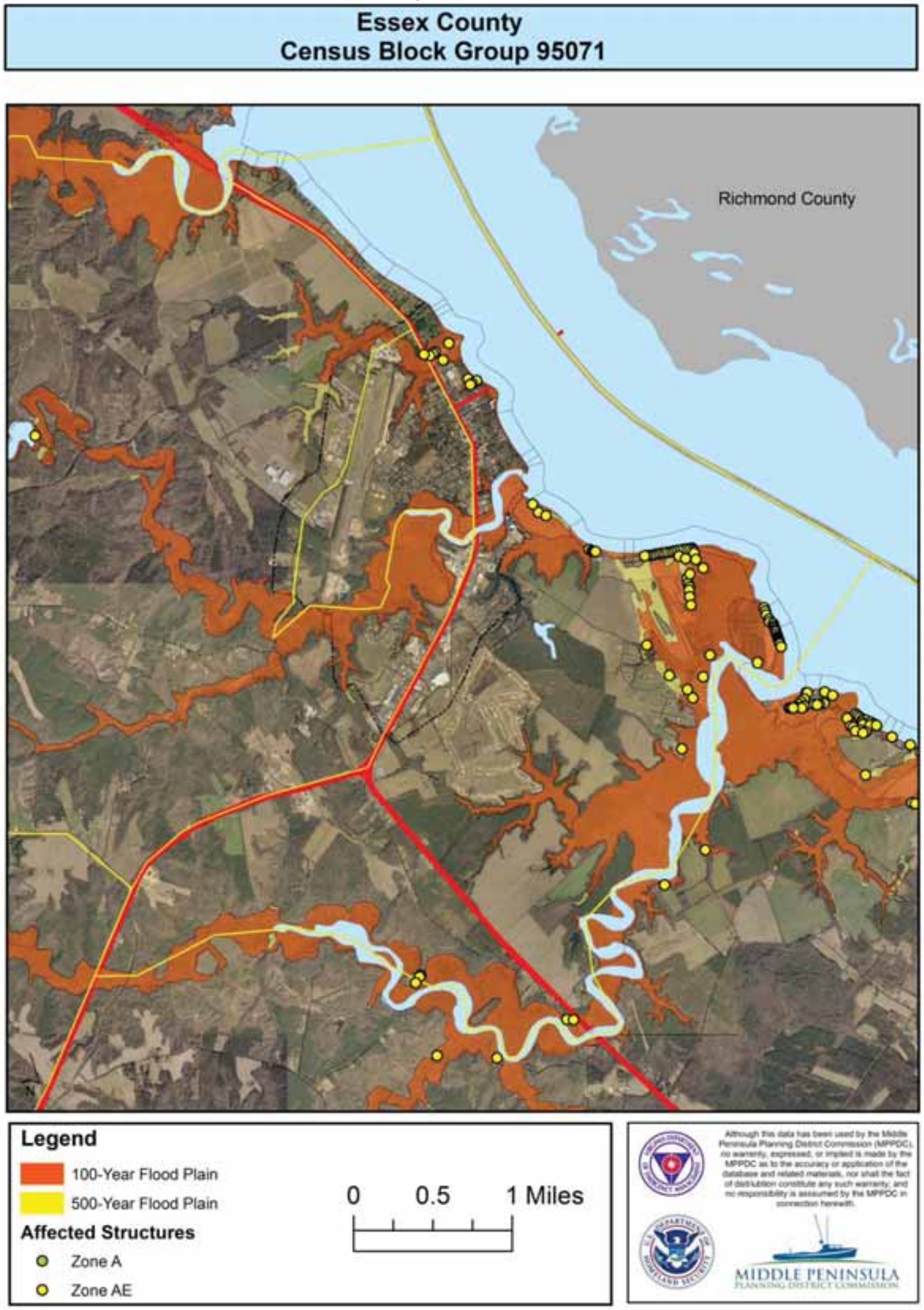


Figure 46:

Essex County
Census Block Group 95063

Figure 47:


Essex County
Census Block Group 95071
Richmond County
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
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PLANNING DISTRICT COMMISSION

Figure 48:


Essex County
Census Block Group 95072
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.45 0.9 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 49:

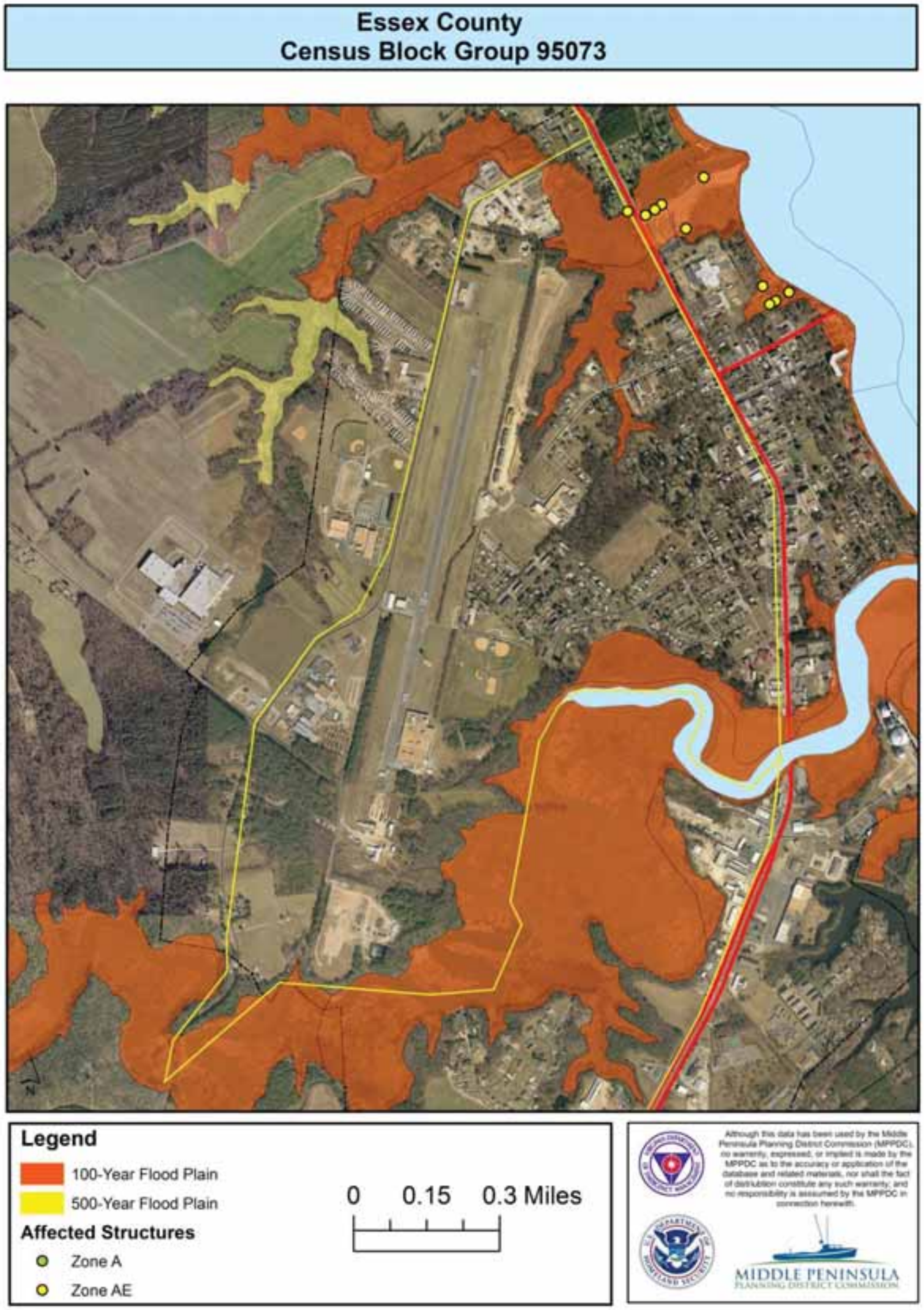

Essex County
Census Block Group 95073
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0
0.15
0.3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA

Figure 50:

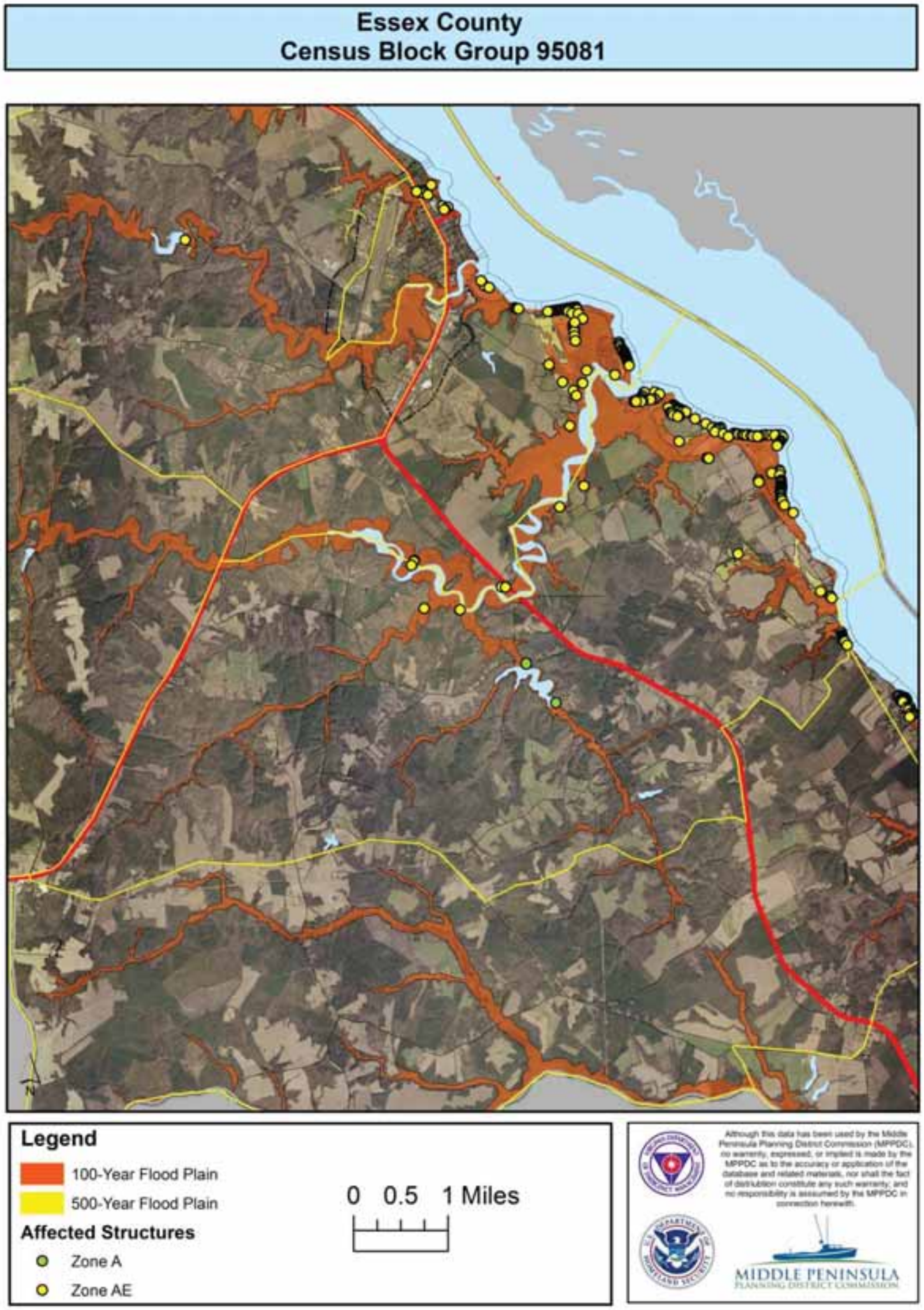

Essex County
Census Block Group 95081
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA

Figure 51:

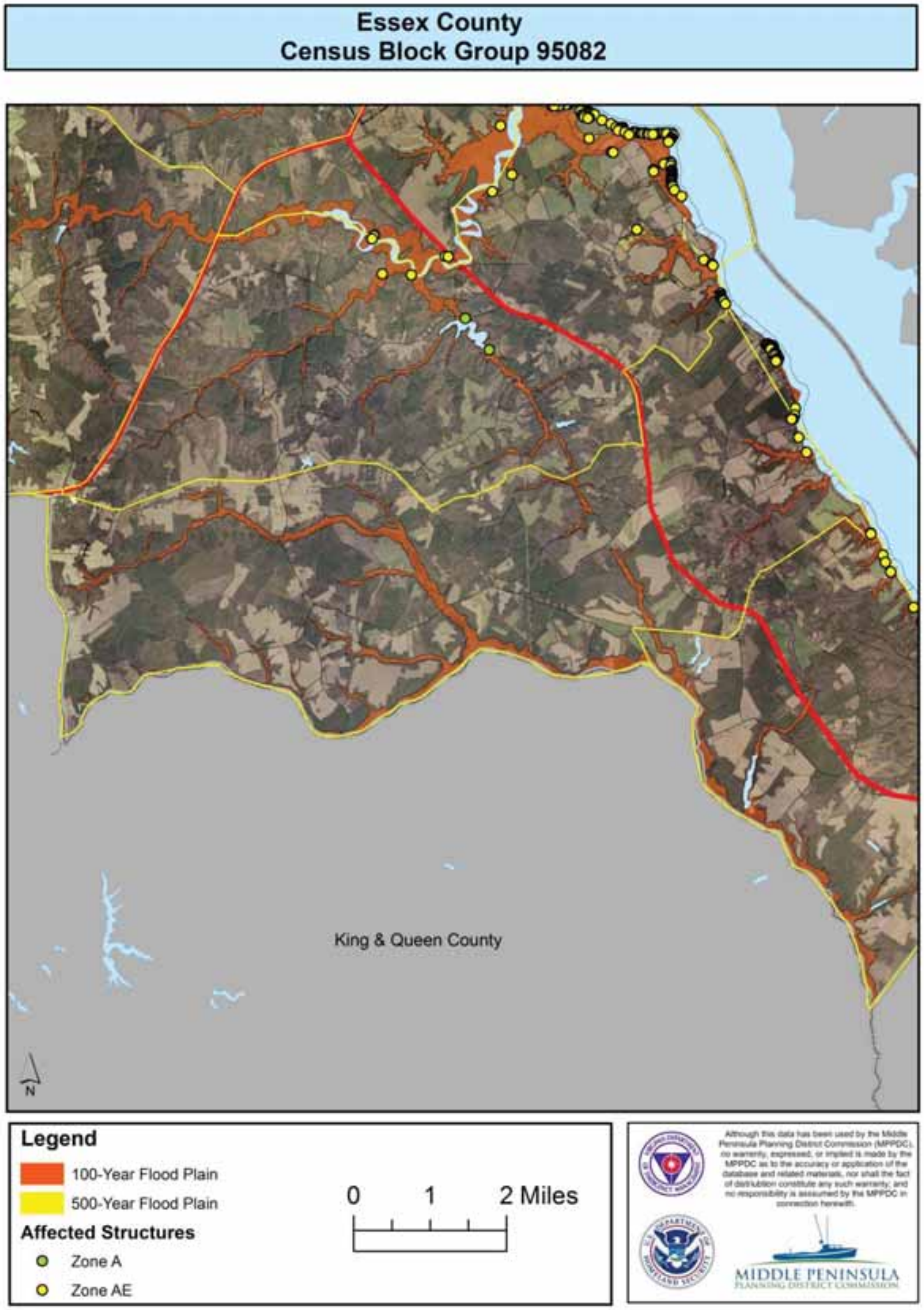
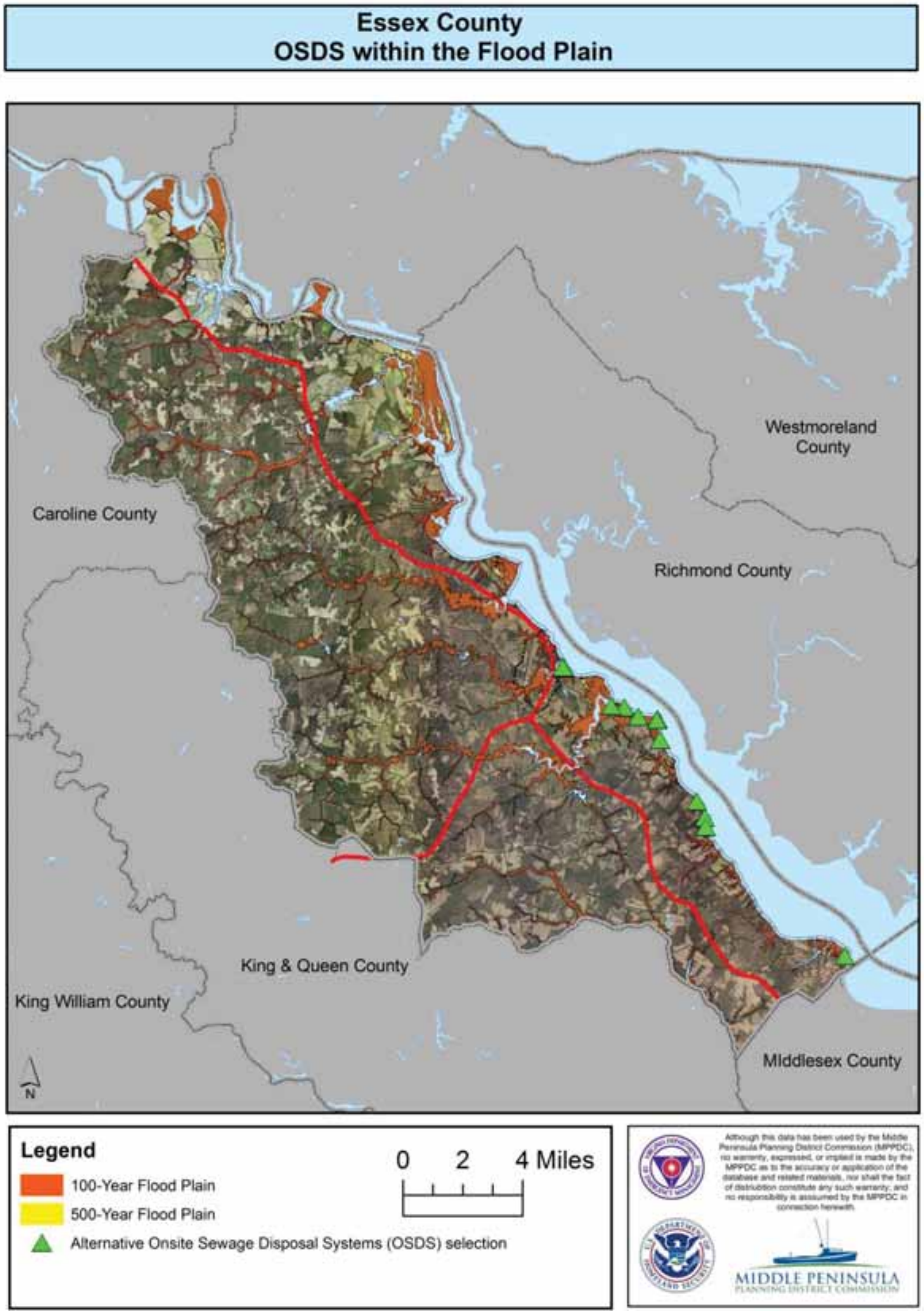

Essex County
Census Block Group 95082
King & Queen County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 52:


Essex County
Census Block Group 95083
King & Queen County
Middlesex County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA

Alternative On-site Sewage Disposal Systems (OSDS). The following map (Figure 53) show the location of the OSDS systems constructed in the 100-year and 500-year floodplain in Essex County:

Figure 53:



Tappahannock Critical Facilities and Public Utilities

The Town of Tappahannock provides public water and sewer services to its citizens. The water system does not sustain damage during floods.

The wastewater treatment plant is located along Hoskins Creek on the west side of Route 17. The wastewater treatment plant does not suffer damage during severe flooding events. In the last plan there was mention that there was one sewerage pump station located along Newbill Drive that received flood damage during hurricane strength storms. During Hurricane Isabel in 2003, the electrical controls needed to be repaired since there was flood damage. However since the last plan the Newbill Drive electrical controls have been raised to above the flood line of Hurricane Isabel in hopes to avoid future issues.

Public Boat Landings

There is one public boat ramp in the Town of Tappahannock along Hoskin's Creek that is operated/maintained by the VDGIF:

Water Body	Access Area	Barrier Free	Type	Ramps	Latitude	Longitude
Hoskin's Creek	Hoskin's Creek	No	Concrete Ramp	1	35° 55' 12" N 37.9200873	76° 51' 26"W -76.8571004
Directions: Town of Tappahannock, Rt. T-1002 (Dock Street)						
Virginia Department of Game an Inland Fisheries, 2015						

In addition to Hoskin's Creek, there is public access at the Prince Street road ending which is owned by the Middle Peninsula Chesapeake Bay Public Access Authority. While Prince Street may suffer minor damage during severe storm events, Dock Street does not sustain damage from flood waters according to town officials.

Repetitive and Severe Repetitive Loss Residential Structures in the Town of Tappahannock

According to FEMA's records, the Town of Tappahannock has 2 Single Family Repetitive Loss properties and no Severe Repetitive Losses as of 5/31/15.

4.5.3. King William County Critical Facilities and Public Utilities

Public water and sewerage systems serve portions of the Route 360 growth corridor in Central Garage. A package wastewater treatment plant discharges sewer effluent into an unnamed tributary that leads into Moncuin Creek, which then flows into the Pamunkey River. Floodwaters do not adversely impact the wastewater treatment plant.

The public water system serves the relatively high and dry Central Garage area. Therefore, this Route 360/30 area water system does not sustain damage from flooding events.

According to VDOT officials, flood prone roads in the King William County/West Point area include the following:

Table 30: King William County/West Point Flood Prone Roads		
Route	**Road Name**	**Location**
30	King William Road	Cypress Swamp at Olson's Pond
636	VFW Road	Cypress Swamp
632	Mt. Olive- Cohoke Road	Intersection of Route 633
609	Smokey Road	Herring Creek
628	Dorrel Road	Herring Creek
1006	Thompson Ave	West Point Creek
1003	Chelsea Road	West Point Creek to dead end
1130	Glass Island Road	Mattaponi River
1107	Kirby Street	1st to 7th Streets
n/a	1st to 7th Streets	Between Kirby St. and Pamunkey River
n/a	2nd to 5th Streets	Between Lee St. and Mattaponi River

Public Boat Landings

There are 2 public boat ramps in King William County that is owned and maintained by VDGIF:

Water Body	Access Area	Barrier Free	Type	Ramps	Latitude	Longitude
Mattaponi River	Aylett	Yes	Concrete Ramp	1	37° 47' 8" N 37.7855806	77° 6' 11"W -77.1030150
Directions: Aylett, Rt 360 East, Right onto Rt 600						
Pamunkey River	Lestor Manor	Yes	Concrete Ramp	1	37° 35' 10" N 37.5861120	76° 59' 4"W -76.9845725
Directions: From King William Courthouse, Rt 30 South (.7 miles); Right on Rt 633 (7.4 miles); Left on Rt 672 (.4 miles)						
Virginia Department of Game an Inland Fisheries, 2015						

Additionally there is a very small canoe/kayak launce at Zoar State Forest located a few miles north of Route 360.

Due to the low velocity of the flood waters along these upper reaches of the Mattaponi River, neither of these boat landings sustain damage from flood waters.

Repetitive and Severe Repetitive Loss Residential Structures in King William County

According to FEMA's records, King William County has no Repetitive Loss residential properties or Severe Repetitive Loss as of 5/31/15.

Properties in 100-year Floodplain by Census Block Group

The following series of maps show the location of structures in King William County that are either in the Flood Zone A or in Flood Zone AE in the 100-year flood plain. The map also shows structures in the 500-year plain that are labeled: "0.2% annual chance flood hazard". The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 54:

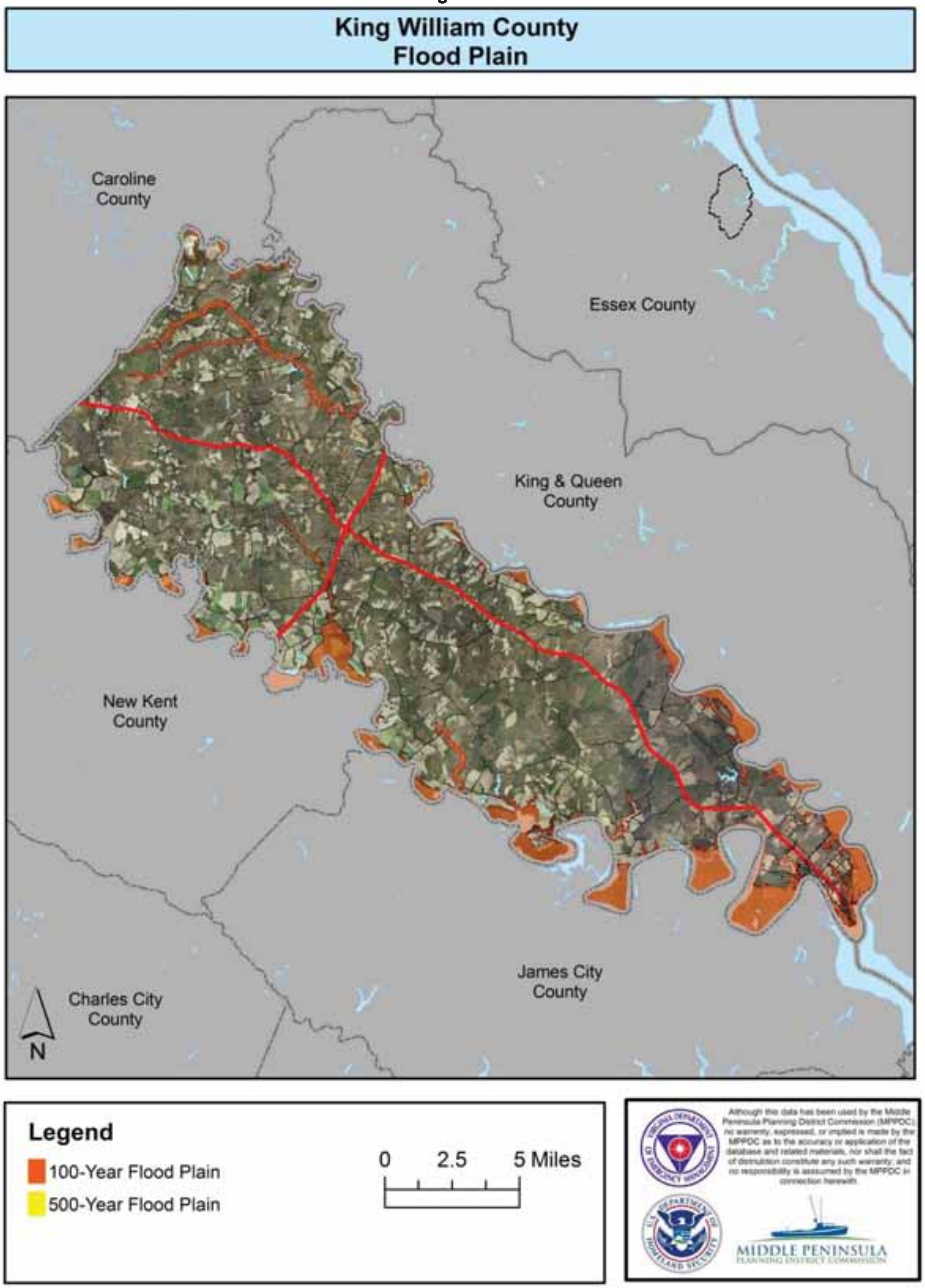

King William County
Flood Plain
Caroline County
Essex County
King & Queen County
New Kent County
James City County
Charles City County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
0 2.5 5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC) no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 55:

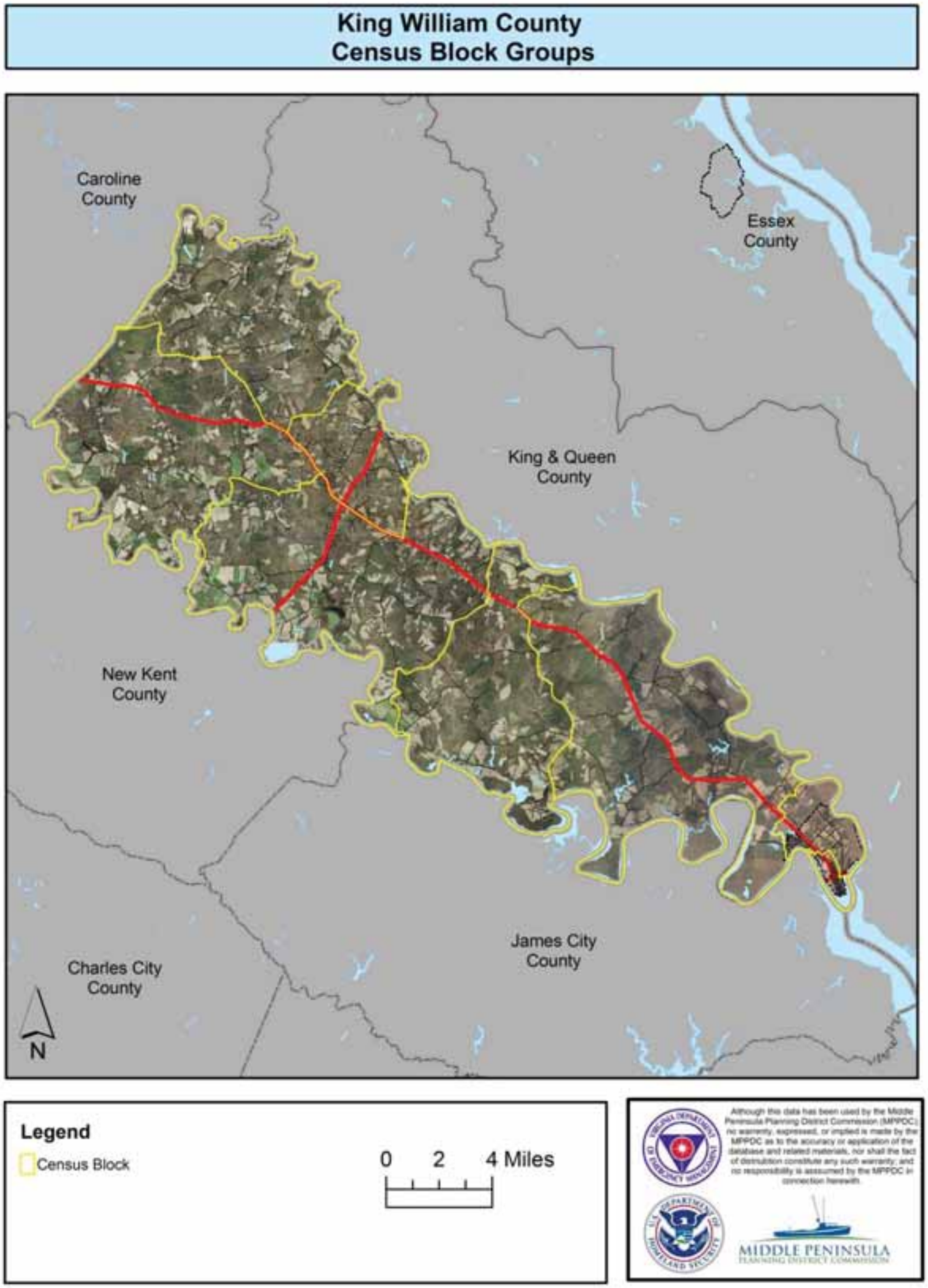

King William County
Census Block Groups
Caroline County
Essex County
King & Queen County
New Kent County
James City County
Charles City County
N
Legend
Census Block
0 2 4 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC) no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
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Figure 56:

King William County
Census Block Group 95011

Figure 57:


KIng William County
Census Block Group 95012
Caroline County
Hanover County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC) no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
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Figure 58:

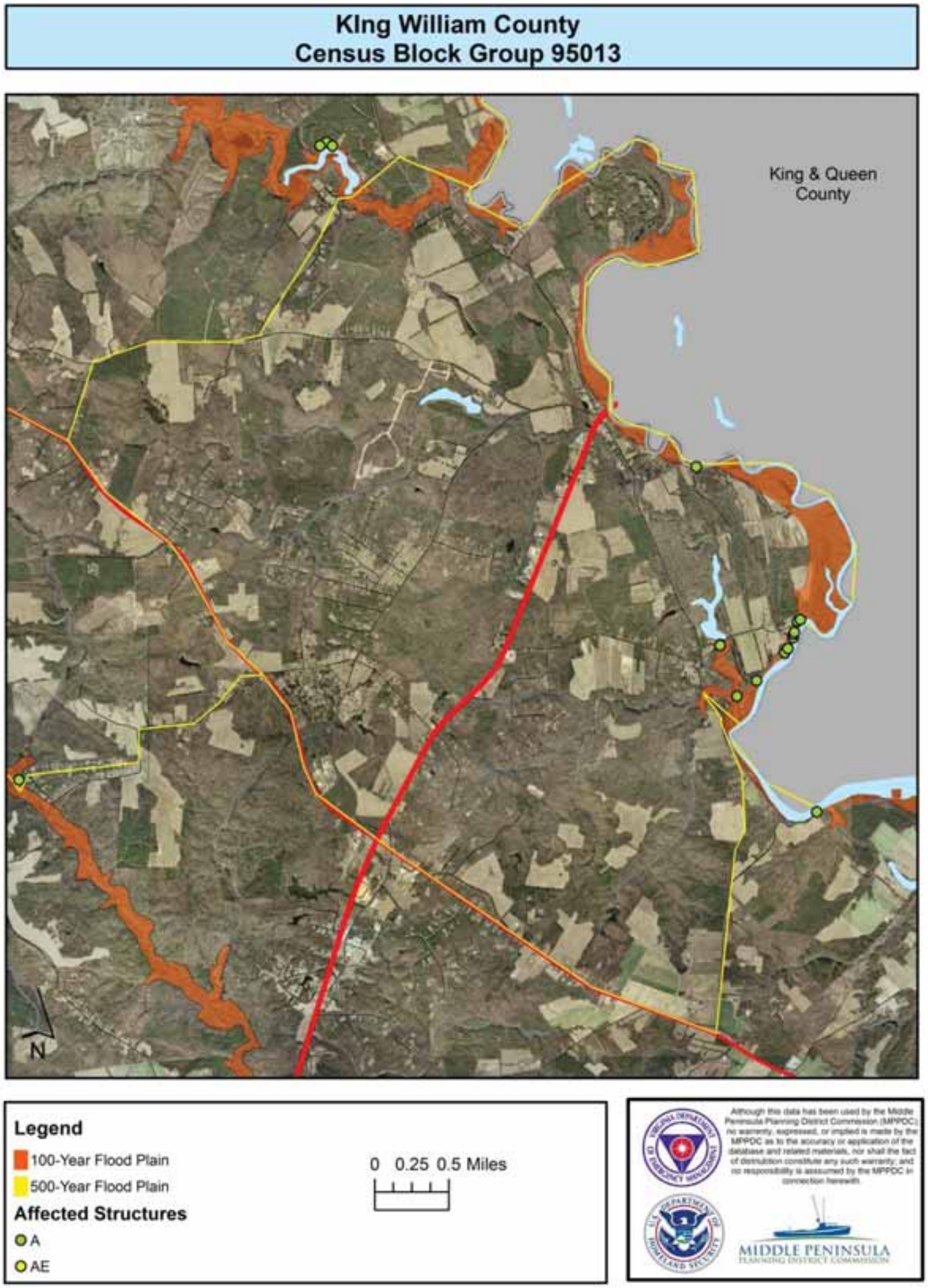
KIng William County
Census Block Group 95013
King & Queen County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC) no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
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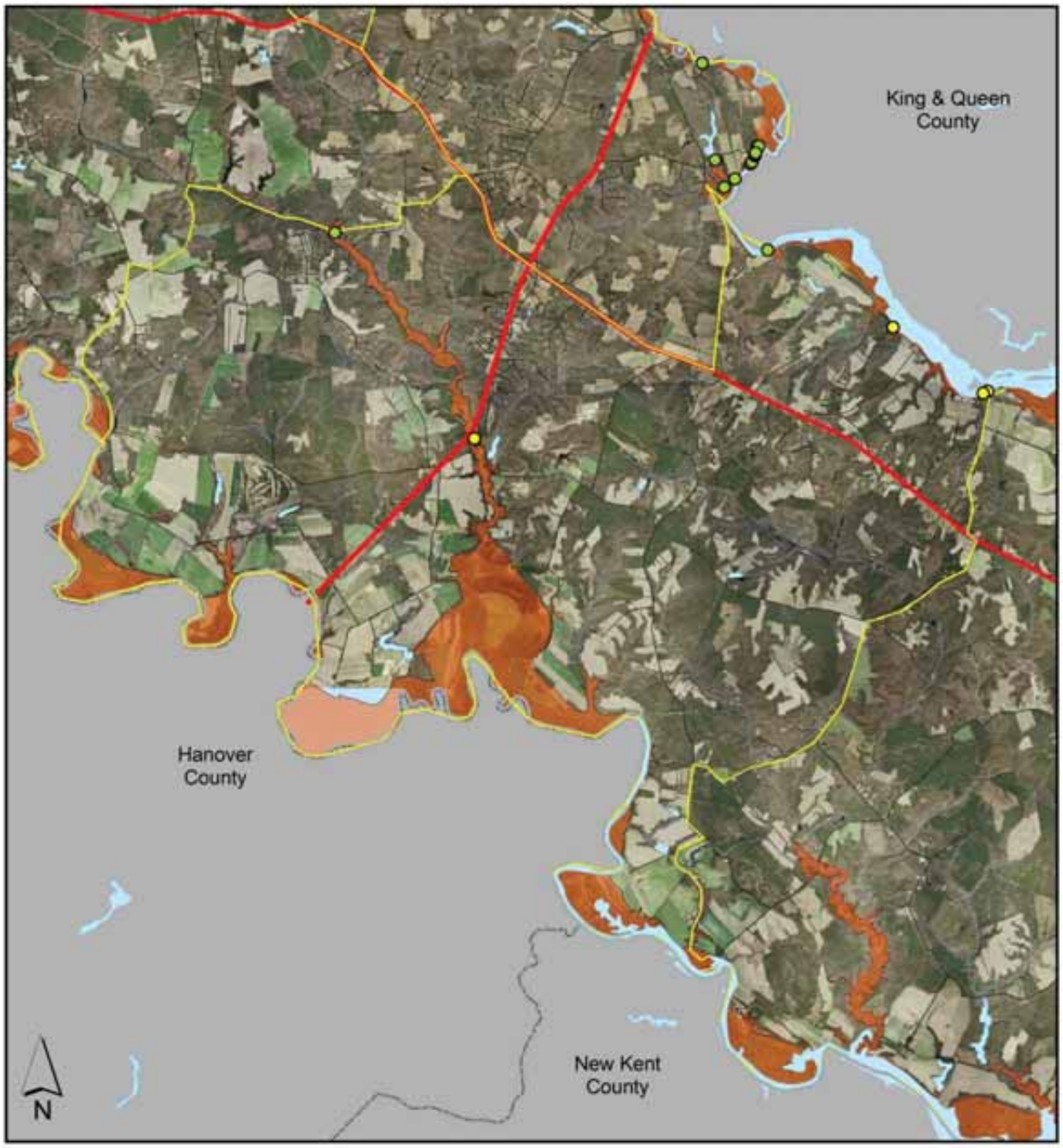
Figure 59:

KIng William County
Census Block Group 95014



Legend

100-Year Flood Plain

500-Year Flood Plain

Affected Structures

A

AE

0 0.5 1 Miles

Figure 60:

KIng William County
Census Block Group 95021

Figure 61:

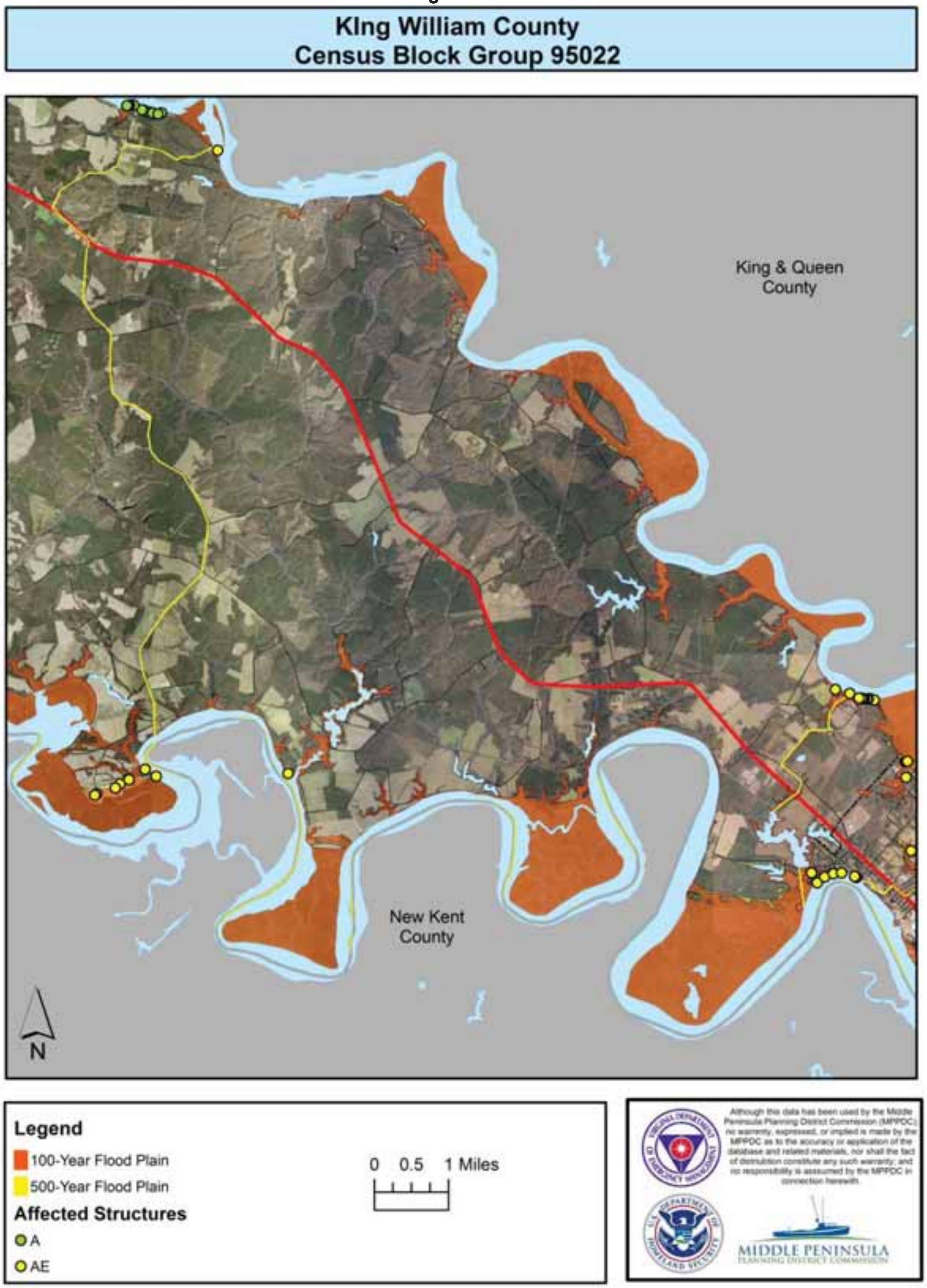

KIng William County
Census Block Group 95022
King & Queen County
New Kent County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC) no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA

Figure 62:

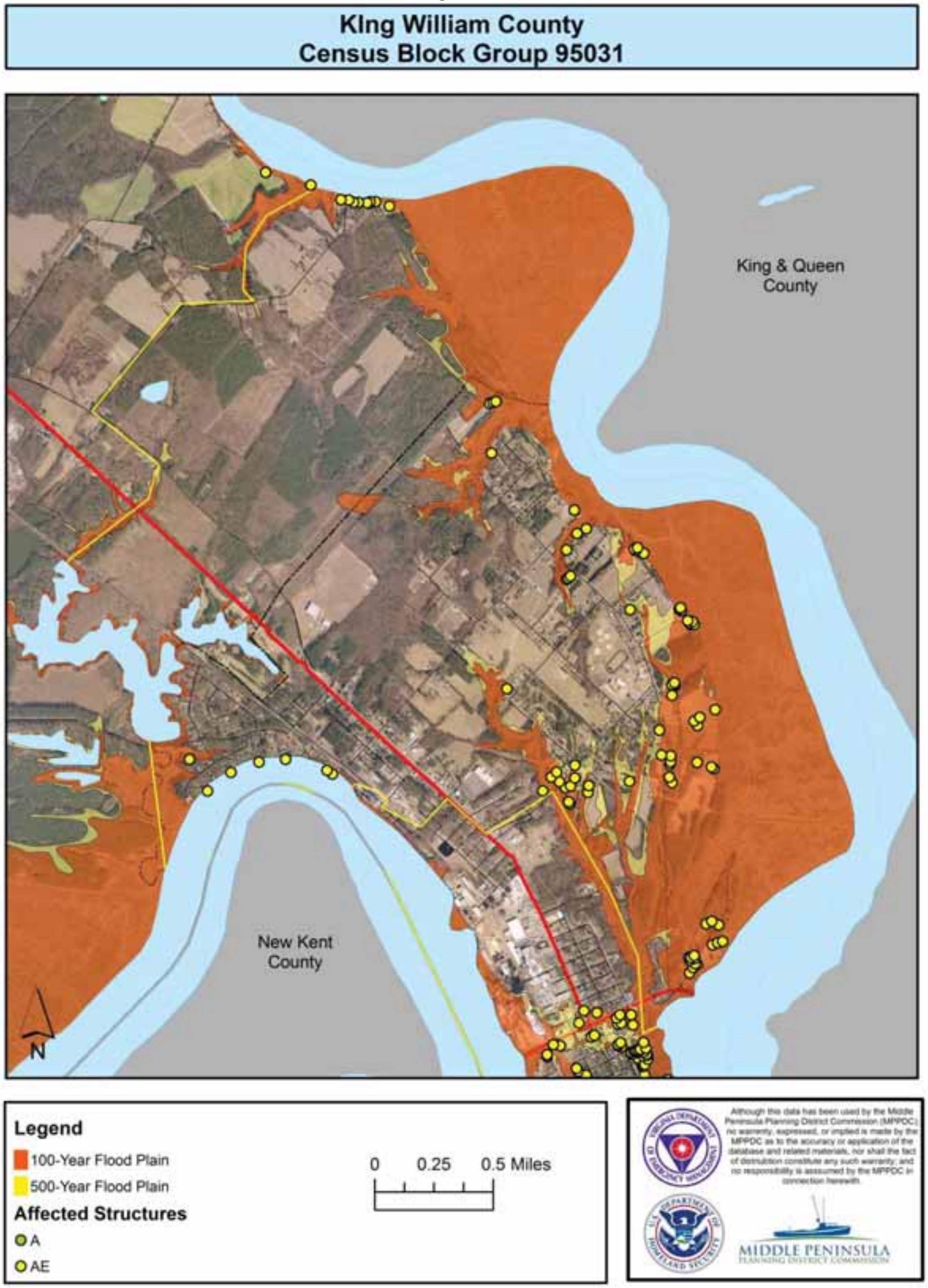
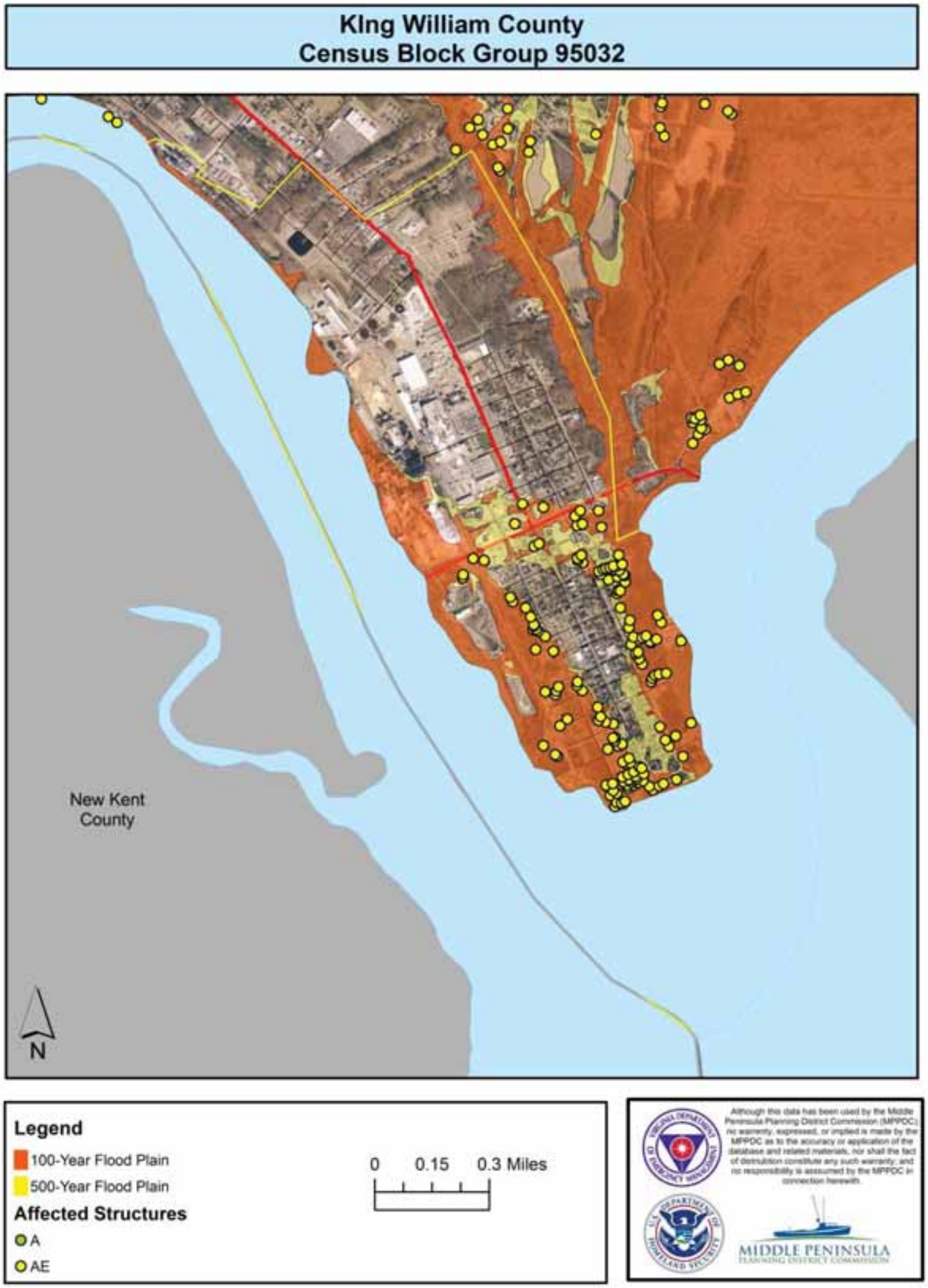

King William County
Census Block Group 95031
King & Queen
County
New Kent
County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC) no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distribution constitute any such warranty; and no responsibility is assumed by the MPPDC in connection herewith.
MIDDLE PENINSULA

Figure 63:


KIng William County
Census Block Group 95032
New Kent
County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.15 0.3 Miles
MIDDLE PENINSULA

Alternative On-site Sewage Disposal Systems (OSDS)

The map (Figure 64) below shows the locations of the installed OSDS facilities constructed in the 100-year floodplain in King William County.

Figure 64: