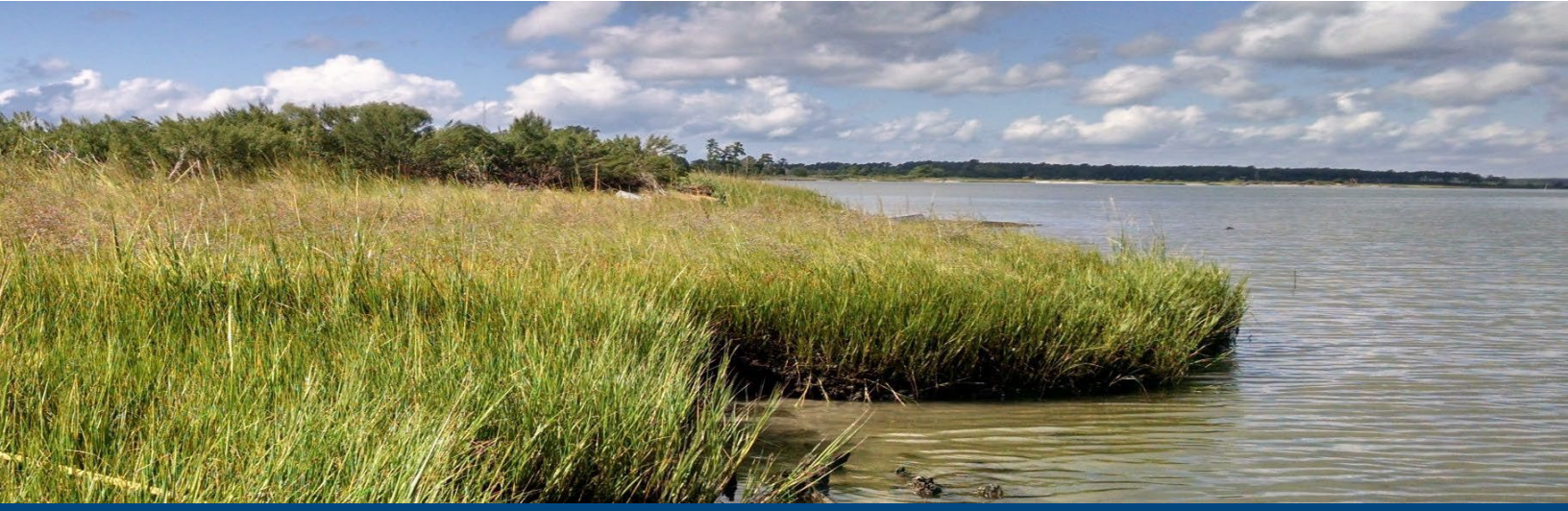


VIRGINIA TRANSPORTATION PLANNING FOR SEA LEVEL RISE

January 15, 2022

VDOT INTERIM REPORT

Introduction

This Report is offered in response to Item 446 (F) of Chapter 552 of the 2021 Special Session I Acts of Assembly, which directed the Virginia Department of Transportation (VDOT), with the assistance of the Virginia Institute of Marine Science (VIMS), to provide "an annual update on the status of the Coastal Virginia Transportation Infrastructure Inundation Study." VDOT entered into an agreement with VIMS in 2019 for a study to develop a strategy for understanding and addressing sea level rise, land subsidence, and recurrent flooding impacts on road infrastructure. In accordance with the agreement and pursuant to Item 446 (F), this report has been developed, is current through December 1, 2021, and provides/summarizes VIMS' progress pursuant to its scope of work for its study/project on "Developing a Strategy for Understanding and Addressing Sea Level Rise, Land Subsidence and Recurrent Flooding Impacts on Road Infrastructure" as requested by VDOT's Virginia Transportation Research Council from the Center for Coastal Resources Management.

This project represents a partnership between VIMS and VDOT to develop a proactive strategy for understanding and addressing sea level rise, land subsidence and recurrent flooding impacts on existing and planned road infrastructure and to assess how that infrastructure will impact natural ecosystems in Virginia's coastal zone as the climate changes. Virginia's coastal zone is defined in the Code of Virginia as "Tidewater Virginia" and includes 44 localities: the Counties of Accomack, Arlington, Caroline, Charles City, Chesterfield, Essex, Fairfax, Gloucester, Hanover, Henrico, Isle of Wight, James City, King and Queen, King George, King William, Lancaster, Mathews, Middlesex, New Kent, Northampton, Northumberland, Prince George, Prince William, Richmond, Spotsylvania, Stafford, Surry, Westmoreland, and York, and the Cities of Alexandria, Chesapeake, Colonial Heights, Fairfax, Falls Church, Fredericksburg, Hampton, Hopewell, Newport News, Norfolk, Petersburg, Poquoson, Portsmouth, Richmond, Suffolk, Virginia Beach, and Williamsburg. Certain elements under this project were subsequently expanded to include remaining areas of Northern Virginia Planning District 8 (Loudon County, City of Manassas, and Manassas Park).

The project incorporates three fundamental elements that any major public service agency must address when considering climate change impacts: science, management and policy. Over five years, the project partners will coordinate a series of products that can be loosely divided into two major areas of focus: 1) climate adaptation of transportation infrastructure and 2) ecosystem impacts of transportation infrastructure.

Three key tasks with the following outcomes are contemplated: Task 1 is to develop a tool to identify management strategies for transportation infrastructure subject to current or future flooding by tidal waters between 2020 and 2080. The outcome of Task 2 is to forecast impacts and mitigation options for transportation infrastructure interaction with coastal ecosystems. There is also a Task 3, Legal and Policy Analysis, to identify policy and regulatory issues implicated in developing one or more strategies to address sea level rise, land subsidence and recurrent flooding impacts on existing and planned road infrastructure, as well as how that infrastructure will impact natural ecosystems in Virginia's coastal zone as the climate changes.

To ensure the goals and objectives of VDOT are met, three workgroups representing VDOT's technical, environmental, and policy professionals, respectively, will be formed. To ensure the interests of the

larger stakeholder communities are considered, a stakeholder committee comprised of select members from local governments, state agencies, and regional planning organizations will be organized.

This interim report summarizes cumulative progress and any significant findings between Dec 2020 and Dec 2021 and is organized into four major sections: General Project, Task 1, Task 2, and Task 3. Unless otherwise indicated, the data and information set forth in this report is not final and is subject to future update and/or revision.

Tasks and Accomplishments

General Accomplishments

Through a series of meetings and conference calls, the Secretary of Natural Resources (the Commonwealth's Chief Resilience Officer), VDOT and VIMS/CCRM (Center for Coastal Resources Management) successfully coordinated the required Memorandum of Understanding and Scope of Work for the contract to begin. Principal investigators at VIMS worked to address as many elements of interest as possible to both VDOT, the Virginia Transportation Research Council, the office of the Secretary of Natural Resources, and legislators; accounting for availability of existing data, models, and funding limits. A contractual arrangement between VIMS and VDOT was put in place in October 2019. The schedule of products for years 1-3 of the 5-year project is summarized in Appendix A, Tentative Schedule of Tasks.

Moving forward, the project team has started coordination of three workgroups comprised of VDOT and CCRM staff: the Environmental Workgroup, the Infrastructure Risk Workgroup, and the Legal Policy Workgroup. The purpose of these groups is to assist with access to data, prioritize VDOT information needs, develop reasonable strategies, and generate products within frameworks and formats most useful to the end- users.

The Infrastructure Workgroup met twice in 2020 and three times in 2021 to focus on project elements that include data access, product formats, and troubleshooting. Two additional meetings with the workgroup and the VIMS team have brought in external stakeholders working to address difficult technical data issues. The Environmental Workgroup met four times in 2020 and five times in 2021 to focus on project elements that range from data access and compilation, methodological processes, focal species determination, product formats, and future habitat.

The Legal Policy Workgroup met four times in 2020 and twice in 2021 to discuss potential policy and regulatory issues.

The VIMS team has briefed leaders of various units within state, local, and regional government on the project goals including the Coastal Flooding Joint Subcommittee on January 12, 2021.

A stakeholder advisory committee is also under consideration. VDOT and CCRM agreed that members should represent both urban and rural communities in the coastal zone where road networks and infrastructure are already known to be vulnerable. Along with a representative from the office of the Governor, state agencies including the Department of Conservation and Recreation (DCR), Virginia Department of Emergency Management, and the Department of Wildlife Resources (DWR) are contemplated along with federal representatives from the United States Army Corps of Engineers and the Federal Highway Administration. Regional planning entities from Hampton Roads to the Eastern Shore have been suggested as well.

Task 1. Climate adaptation of transportation infrastructure

The goals of task one are to develop a tool to identify management strategies for road segments subject to current or future flooding by tidal waters between 2020 and 2080. Four independent products have been outlined with each one contributing critical data to improve our capacity to develop guidance for VDOT:

Product 1.1: Assessment of VDOT and local roads and transportation within Federal Emergency Management Agency (FEMA) Flood Hazard Zones;

Product 1.2: Road network and recurrent flood frequency analysis to evaluate vulnerability of major roads and community infrastructure to flooding into the future;

Product 1.3: Locality-based flood frequency maps to assess current road flooding frequency due to tidal, wind, and precipitation events; and

Product 1.4: Interactive planning portal for VDOT.

This reporting period focuses on elements of all four products.

Product 1.1 Assessment of VDOT and Local Roads within FEMA Flood Hazard Zones

FEMA has designated flood hazard zones that reflect the chance that an area or place will be flooded. The most commonly known 100-year and 500-year flood plains represent zones with flood events that have a 1% chance annually of being equaled or exceeded, and 0.2% chance annually of being equaled or exceeded, respectively. While these zones are most frequently used to assess flood insurance rates or the need for flood insurance coverage, they also provide valuable information for future planning of development and infrastructure with respect to flooding. These zones have been mapped at national scales by FEMA and are displayed in the Virginia Flood Risk Information System (VFRIS) (http://cmap2.vims.edu/VaFloodRisk/vfris2.html) developed by VIMS in cooperation with the Department of Conservation and Recreation; the Commonwealth's designated floodplain management agency.

This project uses these zones for a level one (general) assessment of flood risk to public roads and associated infrastructure such as signage, roadside ditches, right of way, wharfs, docks, etc. FEMA designates these zones based on models that consider elevation and exposure to high velocity wave events that may be tidal, wind, or precipitation driven. The assessment adequately incorporates all VDOT and locally maintained roads but does not adequately account for bridges since these structures are naturally elevated above the flood zone. In addition, the specific location of features such as ditches, signage, and right-of-way designations are not accounted for but presumed to be within close proximity of the mapped roadway. Product 1.2 will address all roads and bridges more accurately, and account for flooding in ditches, since it will model for elevation of these surfaces relative to actual water levels using LiDAR (light detecting and radar) data.

Approach

GIS was used to superposition FEMA flood zones with road centerline data to assess baseline vulnerability of road networks to flooding. The results quantify the road miles and location of roads on a locality by locality basis that are coincident with high-risk flood zones.

The assessment used the OpenStreetMap (OSM) road network as the base road network. Using OSM allowed for roads not maintained by VDOT to be included in the analysis. VDOT road classifications were transferred to the base road network by applying an 8-meter buffer to the VDOT road network and transferring all VDOT codes to the OSM data. Any VDOT roads not covered by the designated buffers (typically smaller roads) were assigned classifications based on the best match of OSM codes to VDOT codes. All layers were projected in Lambert Conformal Conic Virginia and calculations were performed in meters and converted to miles. Bike trails and pedestrian paths were eliminated from the analysis. Table 1 describes how the OSM and the VDOT road classifications were merged in the analysis.

Assigning road segments with ownership, road type, and flood zone information is not straightforward, because each of the road layers used are slightly different (i.e., road segments often do not exactly overlay each other). To match information for road segments as best as possible, centerpoints were created for each road segment, attributes matched, and then transferred back to the road layer based on an ID field.

The analysis calculated miles of roadways by road class that fell within four designated FEMA Flood Hazard Zones: 1% Annual Chance (all A and V zones), the 0.2% Annual Chance, Area of Minimal Flood Hazard, and Area of Undetermined Flood Hazard (zone D). The data were clipped for each locality in the coastal zone of Virginia. Beginning in 2020, the analysis was expanded to include the jurisdictions located in Northern Virginia Planning District 8. Some of these localities lie outside of the coastal zone of Virginia. Also, the data tables were produced with updated VDOT road classes and with the addition of Falls Church as described below.

Category 1: Grouped Based on Road Ownership
Ownership groupings were chosen based on feedback from working group on March 9, 2021.
Data Source: VDOT Linear Referencing System (LRS)
Dataset: VDOT_LRS201_453C8B78-7A25-4251-B6F2-51F969DB9381
Layer: LRS_Route\SDE_VDOT_RESPONSIBILITY_MSTR_RTE
Field: RIM_OWNERSHIP_CATEGORY_DSC
Groupings:

- VDOT roadways include:
  - 01-State Hwy Agency (1,2)
- Locality roadways include:
  - 02-County Hwy Agency (3)
  - 03-Town or Twnship Hwy Agency
  - 04-Municipal or City Hwy Agency
  - 12-Local Park, Forest, or Reservation Agency
- Federal roadways include:
  - 60-Other Federal Agency (A)
  - 66-National Park Service (D)
  - 70-Corps of Engineers (F)
  - 74-Army
- Other roadways include:
  - Private roadways
  - Other: Local Toll Authority
  - Other Public Instrumentality (e.g., Airport, School/University)
  - OSM network roads not included in the LRS

Category 2: Assigning Road Type
Road types were determined using a combination of data. For VDOT owned roads, the functional classification was used. For locality roadways, a combination of VGIN Road Centerline (RCL) Segments, and, when RCL categories were unavailable, OSM categories mapped to be those most similar to the RCL categories.

VDOT Roadways road types:
Data Sources:

Datasets:

- FC_2014_FHWA_Submittal1 - 2014 Functional Classification (LRS Based)
- FC_2014_FHWA_Submittal1 - 2014 Functional Classification (Non-Prime)Direction FC_2014_ FHWA_Submittal1 - 2014 Functional Class (Non-LRS Based)
- Fields: State_FUNCT_CLASS_DESC; FUNCTIONAL_CLASS_ID; TMPD_FC

VDOT Road Categories:

- Interstate
- Interstate Ramp
- Major Collector
- Minor Arterial
- Minor Arterial Ramp
- Minor Collector
- Other Freeway or Expressway
- Other Freeway or Expressway Ramp
- Other Principal Arterial
- Other Principal Arterial Ramp
- Not classified = All VDOT road segments without functional classification available

Locality Roadways Road Types:

Data Sources:

- Virginia Road Centerline shapefile (published quarterly, latest update utilized shapefile downloaded March of 2021)
- When RCL categories were unavailable: OSM categories mapped to be those most similar to the RCL categories.

Fields:

- MTFCC (MAF/TIGER Feature Class Code), OSM highway (descriptions available here: https://wiki.openstreetmap.org/wiki/Key:highway#Highway)

When RCL class was not available for a road segment, the OSM highway class was used. OSM classes were statistically analyzed to determine the best match to RCL categories as shown in the table below.

Locality Road Type	Includes	
	RCL MTFCC	*Open Street Map Class*
US and VA Primary Highways	S1200PRI: US and VA Primary Highways	Primary Trunk
Limited Access Highway	S1100: Limited Access Highway S1640: Limited Access Highway Frontage	Motorway
Local Main Arteries	S1200LOC: Local Main Arteries	Secondary
Local Secondaries	S1200: Secondary S1400: Local Secondaries	Residential Service Living Street Tertiary Unclassified
Parking Lot Roads	S1780 Parking Lot Roads	
HOV Lanes	S1100HOV: HOV Lanes	
Ramps	S1630: Ramp	Motorway Link Primary Link Secondary Link Tertiary Link Trunk Link
Other	C3061: Cul-de-sac G5020: Census Tract (Gloucester only) S1740: Private roads for service vehicles S9999: Driveways	

Federal and Other Roadways
Road type information was not presented for these roads.

Category 3: Adding Flood Zone information

Data Source:

- Dataset: FEMA National Flood Hazard Layer FEMA_NFHL_VA_20190619\NFHL_51_20190619.gdb Field: S_Fld_Haz_Ar

Categories:

- Minimal Flood Risk = D, X: AREA OF MINIMAL FLOOD HAZARD, X: AREA WITH MINIMAL FLOOD HAZARD, X: AREA WITH REDUCED FLOOD RISK DUE TO LEVEE, X: 1 PCT DRAINAGE AREA LESS THAN 1 SQUARE MILE
- Moderate Flood Risk: 0.2% Annual Chance = X: 0.2 PCT ANNUAL CHANCE FLOOD HAZARD
- High Flood Risk: 1% Annual Chance = A, A99: AREA WITH REDUCED FLOOD RISK DUE TO LEVEE, AE, AE
- FLOODWAY, AH, AO, VE
- Area of Undetermined Flood Risk = AREA NOT INCLUDED

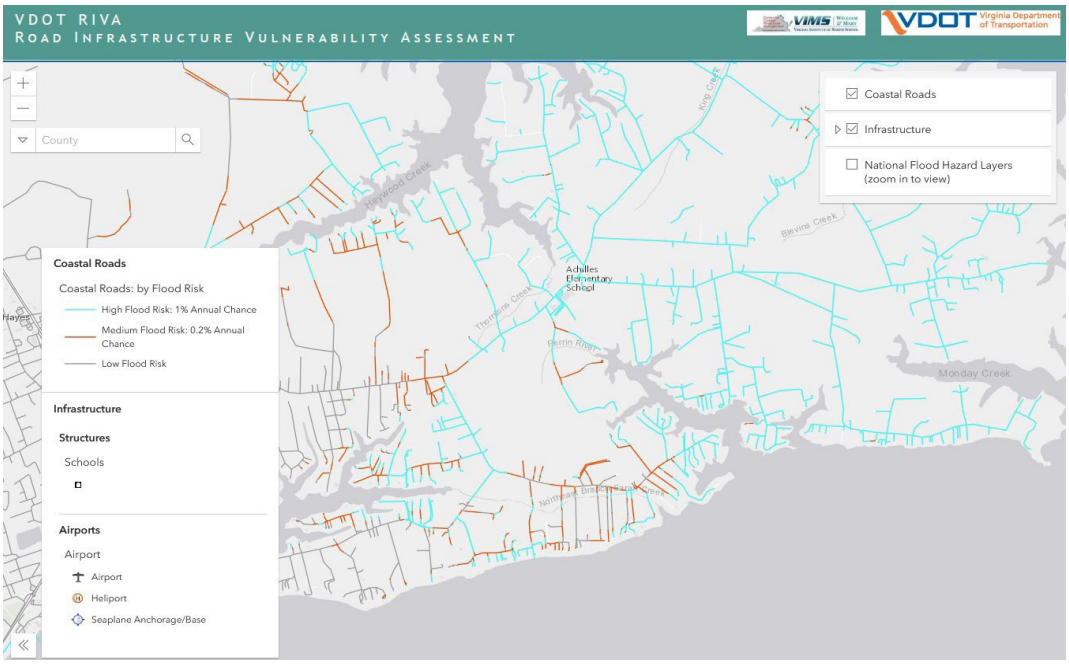
Results

Approximately 64,593 miles of roadway were assessed in Virginia. This includes the coastal zone and localities within District 8. Although the data has not yet been finalized, initial estimates indicate that: the majority of the network is currently within the Area of Minimal Flood Hazard zone; five percent falls within the most vulnerable flood hazard zone (1% annual chance of flooding); and 2.5 percent falls within the flood hazard zone with a 0.2% annual chance of flooding. Fifty miles of roadway fall within the zone designated by FEMA as an Area of Undetermined Flood Hazard. The analysis included all road classes that are listed in Table 1. The results are summarized in Appendix B by locality. An interim map tool has been generated to enable users to view the road vulnerability assessed here. By following this link, the user can zoom to a specific locality and visually observe the location, length, and vulnerability class of each road evaluated: http://cmap2.vims.edu/RIVA/index.html

Road Class	Merging	
	VGIN/VDOT MTFCC	*Open Street Map Class*
Alleys	S1730: Alleys	
HOV Lanes	S1100HOV: HOV Lanes	
Limited Access Highway	S1100: Limited Access Highway S1640: Limited Access Highway Frontage	Motorway
Local Main Arteries	S1200LOC: Local Main Arteries	Secondary Tertiary Unclassified
Local Secondaries	S1200: Secondary S1400: Local Secondaries	Residential Service Living Street
Other	C3061: Cul-de-Sac G5020: Census Tract (Gloucester Only) S1740: Private Roads for service vehicles	
Parking Lot Roads	S1780: Parking Lot Roads	
Ramp	S1630: Ramp	Motorway Link Primary Link Secondary Link Tertiary Link Trunk Link
US and VA Primary Highways	S1200PRI: US and VA Primary Highways	Primary Trunk

Table 1 Original Road Classification and Merging Protocol

Figure 1. Draft viewer for flood risk zones on roads



Product 1.2 Road Network and Recurrent Flood Frequency Analysis to evaluate vulnerability of major community infrastructure

This locality based analysis focuses on land areas where road closures due to frequency of recurrent flooding increase vulnerability of communities and their critical transportation infrastructure, and the ability of VDOT to provide services to the community. The road network analysis provides critical information VDOT needs to mitigate and adapt to these conditions. The Hampton Roads region was designated as the first focal area for the analysis. This focus shifted to the Peninsula and the Eastern Shore to allow more time to initiate coordination with regional transportation authorities in Hampton Roads. The analysis in 2020 focused on these localities: Accomack County, Northampton County, James City County, City of Poquoson, City of Hampton, City of Williamsburg, and the City of Newport News. The analysis in 2021 focused on Northern Virginia and the Southside.

Approach

The first step in the product is to develop current and projected frequency of water levels at different elevations. Flood frequencies are calculated from NOAA tide gauge data. Mean future sea levels are based on Sea Level Report Card projections (VIMS) until 2050 and the NOAA *et al.* 2017 sea level rise analysis for time periods after 2050. In Hampton Roads, the Sewell's Point Gauge have been used. These data can be tied to road elevations and routing information (e.g., a road network) to assess the impact of road flooding on access to and from target areas. Concurrently, we are building a road network with land elevations (NAVD88) for the analysis. Road networks and road centerline data were acquired from the OSM database. Roads in OSM have information already formatted in a way that makes network building more efficient, compared to VDOT road databases. Elevations will be mapped to the roads using high resolution land use and LiDAR data available through the Virginia Geographic Information Network (VGIN). Community infrastructure data such as public buildings, hospitals, fire and rescue facilities, etc. that are available through various geospatial resources have been acquired where they exist. VDOT facilities and critical infrastructure outside of roadways will still need to be acquired via VDOT. Some facility information is available through the state's real estate database which has been acquired but not yet verified by VDOT partners. In 2021, VDOT provided locations of facilities for use in the Eastern Shore and Southside vulnerability assessments.

The network analysis is run using raster processing and network analysis tools in ArcGIS Desktop 8.0. Roadways and transportation pathways assess how traffic can move to and from a node if a barrier (i.e. a flooded road) is encountered. Nodes can represent critical infrastructure in a community such as fire and rescue stations, hospitals, military bases, and entrances to major arteries or evacuation routes. These data are available through various sources.

Progress Toward Results

Data from NOAA's Sewell's Point tide gauge in Norfolk (Hampton Roads) was used for the localities that comprise the region known as the Peninsula. NOAA's Windmill Point and Kiptopeake (see Figure 2) tide gauges were used for Accomack and Northampton Counties, respectively. Tidal records from a 19-year period (roughly one tidal epoch) were extracted and the data were analyzed for the frequency of water levels at topographic elevation increments of one foot (NAVD88). Originally an approximate 2050 mean sea level of 1.5 ft. and an approximate 2100 mean sea level of 4.2 ft. were added to the tide gauge record to model future flood frequencies. The modeled data was re-analyzed for the frequency of water levels at elevation intervals of one foot (NAVD88).

Following guidelines recently released by the Commonwealth's Chief Resilience Officer, this assessment is scheduled to be revised in 2021 to be consistent with the Commonwealth's recommendation for using NOAA's intermediate-high sea level rise scenario as their planning horizon. This will change the 2050 and 2100 projections to 2.08 ft. and 6.06 ft., respectively. This approach ignores the possibility of increased frequency or intensity of storm surge events, however, there are currently no good predictions for increased likelihood of storms making landfall in Virginia. Therefore, that potential is difficult to adequately account for in modeled data.

Raw LiDAR elevation point clouds were downloaded for the localities of interest and elevation rasters were created from them. From the elevation rasters, the flooded areas were determined for varying flood levels derived from the tide gauge data. These flooding area polygons were used as polygon barrier inputs in the road network analysis. The use of the raw LiDAR data point clouds reconciled problems associated with overpasses and bridged yielding incorrect elevation profiles from data generated using bare earth raster data.

The road network analysis was completed using road network datasets in the OSM format as the source road data. First, the source point locations (county seats) were imported into the network analysis layer. Then, for each flood level, the flood area polygons were imported as a polygon barrier layer. Finally, the network analysis was solved to determine accessible and inaccessible roads for that flood level.

Progress toward completion of the road network analysis requires the construction of a "service area" within which movement through the network can be assessed. The service area for the selected localities were initially constructed from a locality specific point of origin (seat of government). There are critical VDOT infrastructure for which access should be assessed. In the coming year, the VDOT technical infrastructure working group will help determine primary VDOT target areas for analysis in each locality. These might include such things as VDOT properties, access to the HRBT and MMBT for commuters and evacuation travel. Additional geographic areas will be added.

In 2021, the road networks were completed for the entire coastal plain of Virginia. In addition, service areas were determined for VDOT supplied locations in the Eastern Shore and Southside Virginia. At this time, road networks are still being considered regionally and all analyses are being run as starting at the location of interest and running out to all points within the road network (see Figure 3). This approach continues to evolve based on feedback from the working group to result in the analyses that are most informative to VDOT's planning needs.

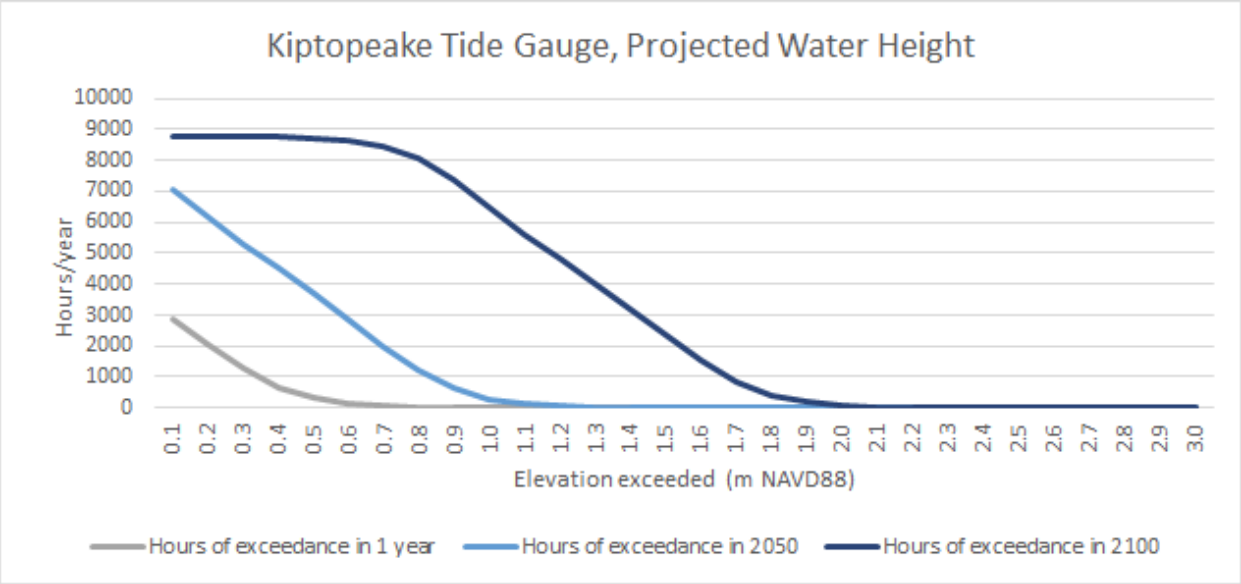


Figure 2. Example of water exceedances for different flood levels for flood frequency analysis

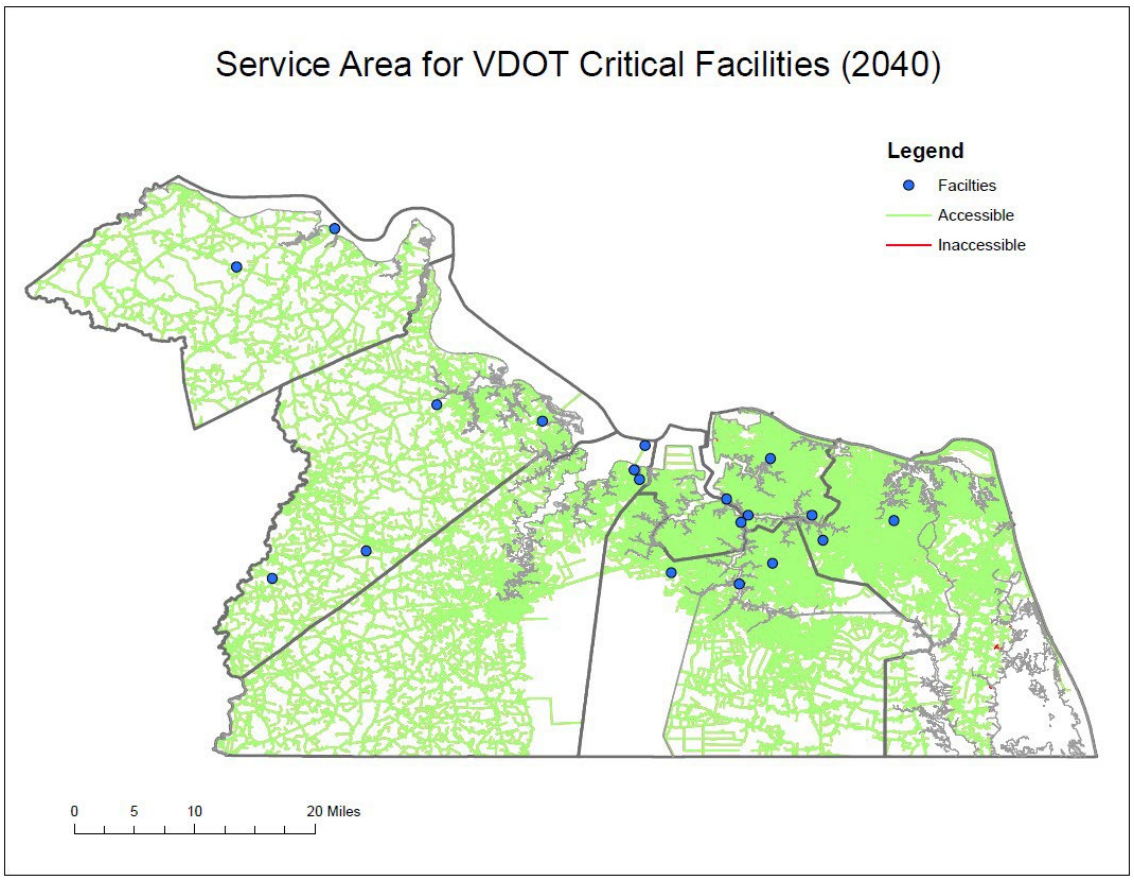


Figure 3. Current service areas for VDOT selected critical facilities

Product 1.3. Locality-based flood frequency maps to assess current road flooding frequency due to tidal, wind, and precipitation events

In 2013, VIMS analyzed data from the VDOT 511 database to assess the frequency of road closures in localities over a four-year period of record (Mitchell *et al.* 2013). The data that goes into VDOT's 511 originates from a variety of sources including VDOT patrol and construction crews, traffic cameras, state police, pavement sensors and citizens (https://www.virginiadot.org/travel/511_virginia_faqs.asp). While this database may not be comprehensive in nature, and may not consider locally maintained roads it does provide an indicator of the current state of the flooding problem by assessing the number of reported incidences and times that roads were closed due to flooding. The data also provide a way to validate model output in this study, and to decipher areas that flood due to large precipitation events rather than tidal flooding.

In 2020, data collected as part of the 511 program since 2013 was acquired and maps were updated. Following a meeting of the Infrastructure Risk Workgroup in April, 2020, WAZE data was suggested by VDOT partners as a possible source for recurrent flood data for areas not covered in the 511 database (e.g. City of Norfolk). These data cover three years of record. In April, a small subset of that database was provided for review, but the larger dataset has not been delivered. At this time, the maps have not yet been updated to reflect this new data source.

Examination of the WAZE data suggested it was problematic to include in this type of analysis. Other options are being explored for augmenting flood data on City-owned streets. Some additional data was obtained from VDOT including the high-water locations and flood related road closures from Fairfax County and Prince William County. This information is compiled by VDOT Maintenance personnel in NOVA, and separate from the 511 data. This data was geocoded, mapped and the resulting locations were coded by whether they fell in the floodplain or not.

Product 1.4. Interactive planning portal for VDOT

This product aims to develop a final landing site for the project which can serve both VDOT and the community at large. CCRM's AdaptVA portal has been discussed during the 2020 project year as a logical home site for the data and products developed for this project. AdaptVA is an information gateway on climate change adaptation for a broad audience in Virginia. It has evolved over many years, in partnership with other programs, to serve state and local agencies. We propose to host a home-site for the VDOT products with AdaptVA (http://adaptva.com/).

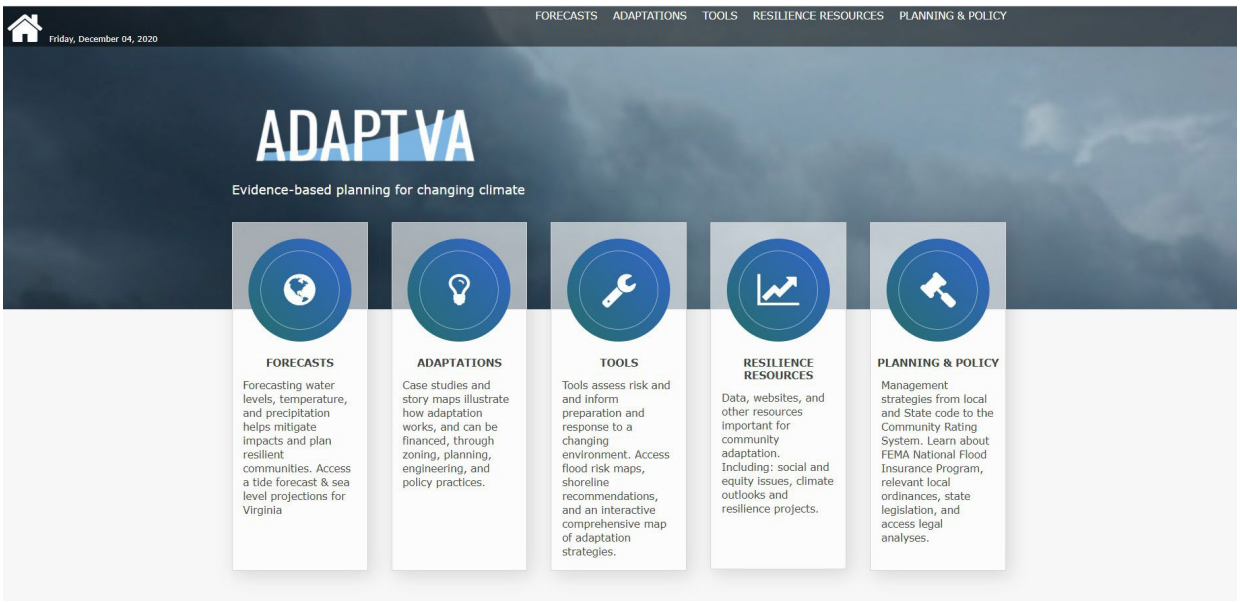


Figure 5. ADAPTVA is a gateway to resources, tools, and water level forecasts for Virginia

Within the home site the interactive tool will be accessible. During 2020, several designs and draft tools (Figure 4a and 4b) have been developed, and have been shared with VDOT personnel. We used the community based road network analyses that have been completed thus far as well as the FEMA flood zone analysis from Product 1.1 above to populate the draft site: https://experience.arcgis.com/experience/4cd067b4be764ac88897784288f48610/.

Task 2. Ecosystem impacts of transportation infrastructure

The goals of Task 2 are to evaluate the extent of the recurrent and future flood impacts on Rare, Threatened and Endangered (RTE) species and the essential habitats they occupy. VIMS will undertake several independent analyses which will contribute critical data and improve our capacity to guide VDOT on appropriate management strategies to mitigate future use conflicts. Under Task 2, VIMS intends to generate the following products over the course of the project:

Product 2.1: Compiled information on species habitat in collaboration with state partners.

Product 2.2: High Resolution species distribution models depicting current RTE species distribution and habitat areas within the Tidewater area.

Product 2.3: Forecast possible future locations of migratory birds and RTE species habitats.

Product 2.4: Assess the potential for existing and planned local land use changes and transportation infrastructure to come into conflict with future RTE species habitats by virtue of changing proximities between 2020 and 2080.

Product 2.5: Identify site-specific, proactive mitigation/compensation strategies against impacts in 2.4.

This reporting period has focused on Products 2.1, 2.2, and 2.3.

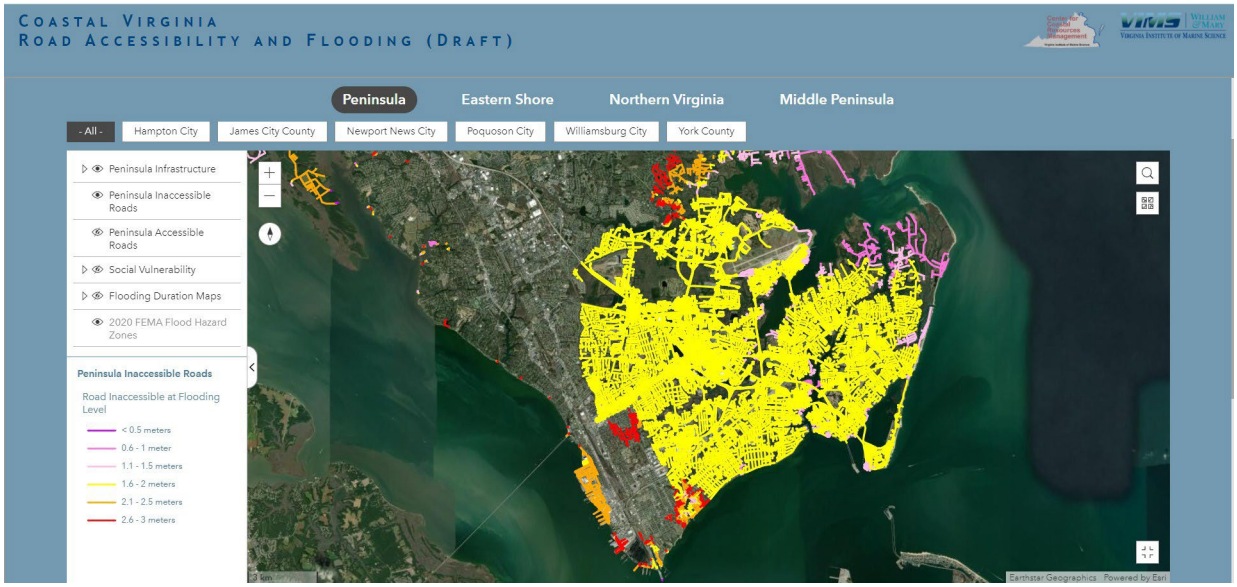


Figure 4a. The road network analysis classifies road network accessibility to the point of origin based on flood level barriers generated using water level data and LiDAR.

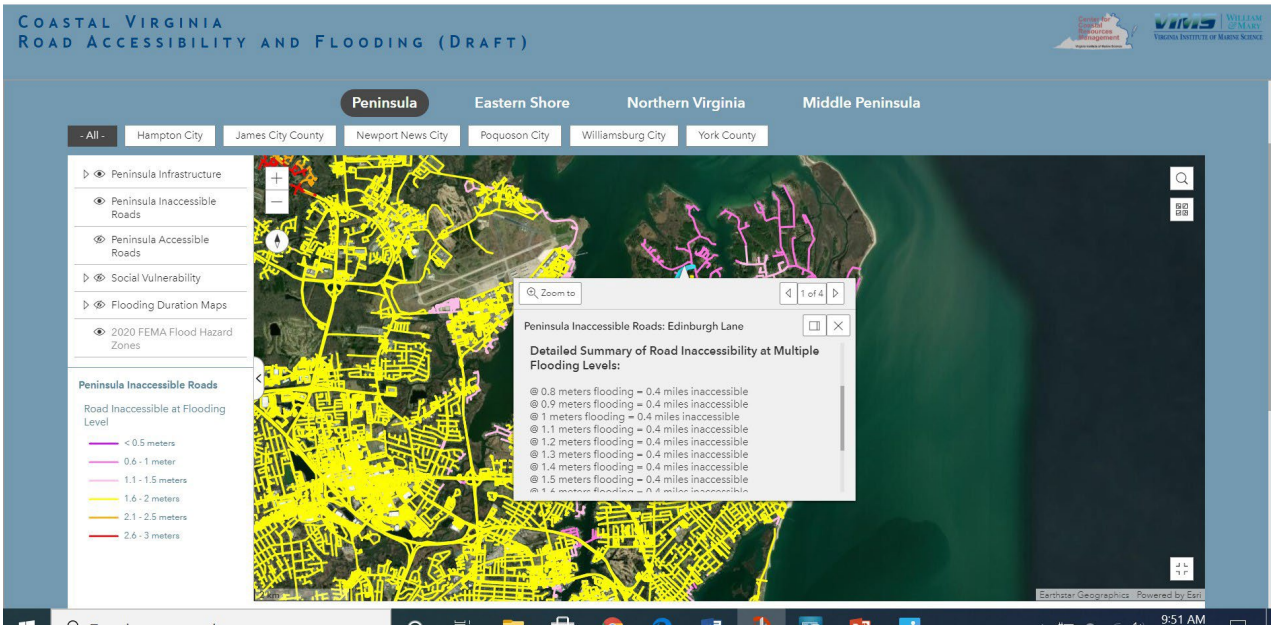


Figure 4b. Any road can be selected to see the amount of roadway inaccessible at specific flood water levels.

Product 2.1 Compile information on species habitat in collaboration with state partners

Approach

A first step in evaluating current and future species habitat distributions is the acquisition, evaluation, and synthesis of relevant data and modeling on vulnerable species (RTE and habitat specialists), habitat features (e.g., marsh extent, elevation), and environmental variables (e.g. sea levels, temperature). In collaboration with DCR, DWR, and U.S. Fish and Wildlife Service (USFWS), we have compiled available information and models depicting current habitat areas of rare, threatened and endangered coastal species and migratory birds found in the Tidewater area. Key data sources and tools include: Natural Heritage Data Explorer (NHDE), Virginia Coastal Geospatial and Education Mapping System, and DWR Wildlife Environmental Review Map Service (WERMS). These data sets have been compiled in ArcGIS. We have also begun compiling information on salt-marsh-associated birds with primary habitats at risk from sea level rise, in collaboration with Dr. Bryan Watts (W&M, Center for Conservation Biology), for inclusion in species habitat modeling.

Progress Toward Results

We have compiled and developed spatial habitat variables that are relevant to the species of interest. We have collected land cover data (LCD; WorldView Solutions, Inc), digital elevation models from the United States Geological Survey (USGS), soil properties (NRCS), shoreline modifications (CCRM), tidal marsh extent and community composition (CCRM), precipitation (Abatzoglou & Hegewisch 2014), temperature (Weather Underground), non-tidal wetlands (USFWS), and sea level rise (Mean future sea levels are based on Sea Level Report Card projections (VIMS) until 2050 and the NOAA *et al.* 2017 sea level rise analysis for time periods after 2050. We are utilizing the NOAA Intermediate-High scenario for consistency with the Virginia's Coastal Resilience Master Plan and the other components of this project. We have created derivatives of the various spatial layers to focus on species-specific habitat requirements, such as distance from water, or proportion of land cover. These variables have been incorporated into habitat models developed for Product 2.2.

Data on Alewife, American Shad, Blueback Herring, and Hickory Shad were obtained from Alan Weaver with DWR. These data represent electroshock catch records from DWR surveys dating back to 1994. Records are from multiple stations in seven tributaries, including the Appomattox, Chickahominy, James, Mattaponi, North Anna, Rappahannock, and South Anna Rivers.

Product 2.2 High Resolution species distribution models depicting current RTE species distribution and habitat areas within the Tidewater area

Approach

We have evaluated multiple spatial and statistical techniques to determine the best approach for developing high-resolution species habitat models. Our approach provides a robust, general method that can be nuanced to meet the various aspects that are unique to each species. We are using a random forest algorithm to generate predictions of current suitable habitat for each species based on the results of preliminary efforts to identify which algorithms provide the best predictive output. Across species and sample sizes, random forest models consistently outperformed other popular algorithms, including maximum entropy, boosted regression trees, and artificial neural networks. Numerous steps

and precautions have been taken to reduce the chances of producing highly predictive but biologically irrelevant models while simultaneously increasing our ability to accurately assess the predictive power of the models. All species models and their aggregate output will be provided in the online tool reference in Product 1.4 upon their completion.

Progress Toward Results

We have developed spatial and statistical protocols for mapping all terrestrial (i.e., non-fish) species in the study. For each species, potential habitats are derived from the LCD based on their specific habitat requirements obtained during the literature review. We use the potential habitat to eliminate the areas where we know the species cannot exist and the inclusion of which would result in inaccurately inflated estimates of model predictive power. For example, we do not need to include the middle of the Chesapeake Bay as a possible habitat for amphibians when we know that they cannot be there. The model algorithms would correctly identify that no presence points occur in the middle of the Bay, and would then report that it's doing a really good job of identifying a huge area where the species does not occur. Once the potential habitat layer has been generated, presence locations are placed within the boundaries of the DWR/DCR occurrence polygons (Figure 5). The number of points is determined by the size of the areas identified by DWR/DCR, divided by 900 (30 m x 30 m resolution), with a maximum number of points capped at 1,000. An equal number of background (pseudo-absence) points are placed in the potential habitat areas outside of known locations. The values for all relevant spatial habitat variables (e.g., proportion of forested land cover within 500 m) are then joined to each of the presence and background points, and exported for statistical analysis.

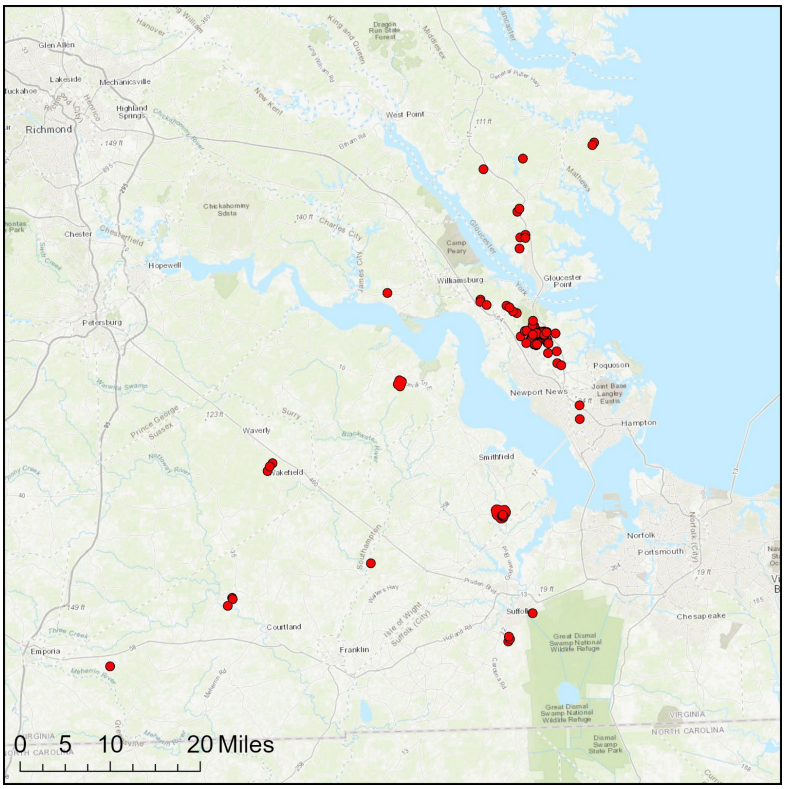


Figure 5 - DWR occurrence records are provided as polygons with variable buffer distances around a centroid. Each circle represents one recorded observation of a Mabee's salamander in the last 30 years. Polygons were further refined to reflect only the areas that overlapped potential suitable habitat.

Statistical analysis occurs in two primary stages: 1) variable selection and 2) distribution modeling. All analyses are conducted in the R statistical environment. We use variable selection to pare down the list of potential variables thereby minimizing the effects of overfitting in the final output. This, combined with limiting the potential pool of variables to those with ecologically defensible effects on the species, contributes to a robust species distribution modeling approach. Variable selection relies on running univariate logistic regressions (function glm from the base 'stats' package) for each variable in the dataset for each species. Variables are selected for inclusion in the final model if they receive a lower sample-size corrected Akaike's Information Criterion (AICc) value than the null model, indicating that they have effectively explained some of the variation in the data. When multiple spatial scales of a single variable (e.g., 100 m, 500 m, 1,000 m) all receive lower AICc values than the null model, only the scale with the lowest AICc value is selected for the final model. With the pared down list of variables for the final model, we extract the associated spatial layers, and feed all of the data into a random forest algorithm executed by the 'biomod2' package. To address the underlying spatial uncertainty contained within the various records from DWR and DCR, each presence point is weighted in the model based on the size of the buffer around each point provided by DWR and DCR. The most precise observation receives a weight of 1, with a linear decrease in weight to 0.75 for the least accurate observation. For the birds that are being modeled, eBird point observations are also included with a uniform weight of 0.75 given the absence of any spatial precision in the records. The random forest algorithm is run ten times using a cross validation approach. Each run randomly splits the data into a training set (80% of the observations) and a testing set (20% of the observations). The model is developed on the training set and then its predictive abilities are checked against the testing set. This step is designed to eliminate the impact of overly influential observations or clusters of observations, and ultimately improves our ability to assess the predictive power of the model. For each of the ten iterations, a True Skill Statistic (TSS) is generated, which integrates the true positive and true negative rates. The higher the TSS value, the better the model.

After running the random forest models, a spatially explicit predictive surface is generated for each model. To combine each surface into a single estimate for habitat suitability, a weighted average is employed using the proportion of the cumulative TSS score as the layer's weight in the final output. This ensures that models with a higher predictive power receive a greater weight in the final product than models with lower predictive power. The final output provides the habitat suitability estimate on a continuous scale from 0 to 1, with 1 being the most suitable predicted habitat (Figure 6). For ease of application by members of the VDOT Environmental Workgroup, the predictive surfaces were further classified into presence/absence based on occurrence thresholds identified using the sensitivity/specificity cutoff included in the `'biomod2'` package.

To date, we have generated predictive models for all 28 non-fish species. These models have been reviewed by State biologists for accuracy and their feedback is currently being incorporated into the classified outputs.

Due to a paucity of subaqueous habitat data, we utilized a different approach for anadromous fish models. Rather than habitat models that identify where a species is likely to be, we have developed models that identify *when* a species is most likely to be in a given stretch of river. Essentially all of the rivers in coastal VA are essential anadromous fish habitat, but time-of-year restrictions are in place to minimize potential impacts to annual upstream spawning migrations. The timing of fish migrations is largely tied to water temperatures, which means that as climate change continues and the region continues to warm, we expect the window for fish migration to also shift in response. To address the link between temperature and fish occurrence, we have developed hierarchical Bayesian models to fit a

quadratic relationship between catch (count) and temperature within each river for each species. These models can then be used to predict when each species is likely to arrive and peak for future scenarios using predicted water temperatures.

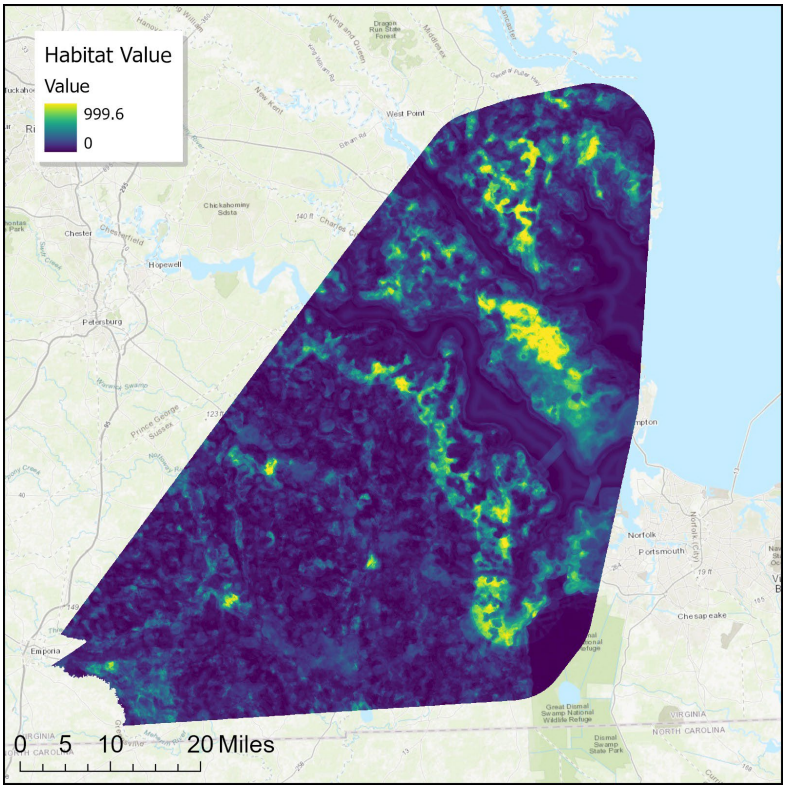


Figure 6 - Aggregated predictive surface of suitable habitat for the Mabee's salamander. Areas that are most likely to provide suitable habitat for Mabee's salamander are shown in yellow, while areas that would unlikely be able to support the species are shown in blue. The scale has been converted from 0-1 to 0-1,000, where a value of 1,000 would indicate the most suitable habitat. The area surrounding the Grafton Ponds on the Middle Peninsula, an area known to be a bastion for the species, is accurately identified by the modeling procedure as being a highly suitable area.

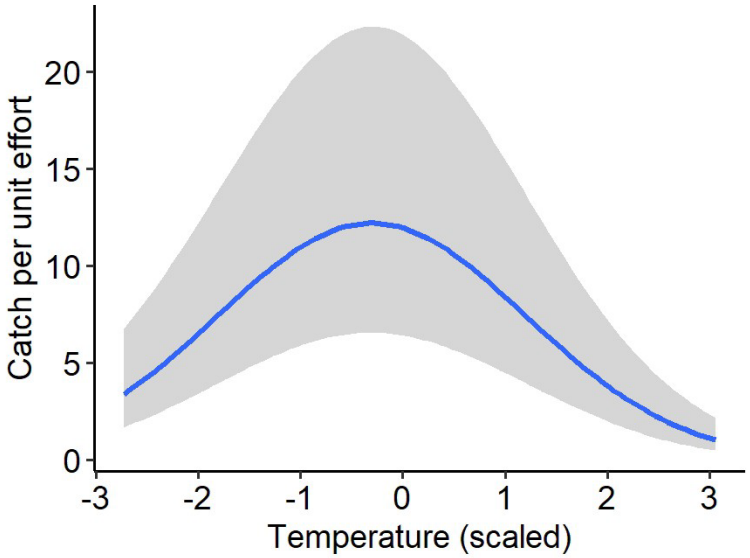


Figure 7 – Conditional effects plot of catch per unit effort of American Shad by water temperature. Temperature has been centered to the mean and scaled by the standard deviation. Actual temperatures ranged from 3.3 °C to 28.3 °C.

Product 2.3 Forecast possible future locations of migratory birds and RTE species habitats

Approach

We can forecast future habitat for migratory birds and RTE species by incorporating our predicted current distributions with spatially explicit estimates of future sea level, land cover, and climate. Sea level rise estimates will be based on projected water levels using the NOAA Intermediate-high curve, in accordance with Virginia's Coastal Resilience Master Plan. A high-resolution topographic-bathymetric LiDAR- derived digital elevation model from USGS will provide the underlying elevation surface to identify areas that are expected to be submerged, intertidal, and riparian in the target years 2040 and 2080. Future predictions of nearshore land cover for this project will be primarily driven by the anticipated changes in sea-level. Areas that are expected to drop lower than mean water (the typically lowest elevation for *Spartina alterniflora* marshes) will be assumed lost. Formerly upland areas that become intertidal will be assumed to convert to marsh given that the surface is pervious (i.e., no pavement or buildings). Climate data will inform the future windows for anadromous fish migration.

Progress toward results

We are in the process of obtaining the data to model future scenarios. The future intertidal areas will be mapped in-house at CCRM, and identification of marsh migration potential will follow the methods previously published by Isdell *et al.* 2020 (DOI: 10.1007/s13157-020-01384-4). We are attempting to track down future predictions of water temperature in the tributaries for the fish models. Recent work by another group at VIMS (DOI: 10.1111/1752-1688.12916) provides the most promising source of this data. If the data cannot be obtained at an adequate resolution for our future scenarios, we will attempt to develop a regression model linking air temperature from climate models to water temperature.

We anticipate that the greatest challenge in forecasting future habitat will be for sand/shell dependent nesting birds such as the terns and gulls. The highly dynamic nature of these habitats makes spatially explicit forecasts tenuous. Several of these species have already been locally extirpated from large swaths of their historic range in Virginia as a result of sea level rise (Bryan Watts, pers. comm.). Much of the future potential habitat in Virginia for these species is likely going to arise through management actions to either elevate some natural habitats, or to create new habitat with projects like those currently underway for the expansion of the Hampton Roads Bridge Tunnel. Our models should, however, be able to inform efforts by VDOT and partner agencies to identify areas that may be most beneficial for target species while also minimizing potential impacts on other species.

Task 3. Legal and Policy Analysis

This task involves coordination among VIMS, the Chief Resilience Officer of the Commonwealth of Virginia and VDOT to develop one or more strategies for understanding and addressing sea level rise, land subsidence and recurrent flooding impacts on existing and planned road infrastructure as well as how that infrastructure will impact natural ecosystems in Virginia's coastal zone as the climate changes.

Beginning in the fall of 2019, the Virginia Coastal Policy Center (VCPC) began preliminary research to identify key policy and regulatory issues that may be implicated in developing strategies to address sea level rise, land subsidence and recurrent flooding.

The Legal Policy Workgroup, composed of VIMS and VDOT personnel, was established, met four times in 2020 and two times in 2021, and will continue to meet as necessary to examine and further develop these issues.

Appendix A. Tentative Schedule of Tasks

Task 1	2020							2021												2022				
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
1.1			X	X	X	X	X																	
1.2				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1.3			X	X	X	X	X	X	X	X														
1.4																								→

Product 1.1: Assessment of VDOT and Local Roads within FEMA Flood Hazard Zones
Product 1.2: Road Network and Recurrent Flood Frequency Analysis
Product 1.3: VDOT 511 Flood Frequency Maps
Product 1.4: Interactive Planning Portal for VDOT

Task 2	2020							2021												2022				
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
2.1			X	X	X	X	X	X	X															
2.2										X	X	X	X	X	X	X	X	X	X					
2.3																				X	X	X	X	X
2.4																								→
2.5																								→

Product 2.1: Compile information on species habitat in collaboration with state partners
Product 2.2: Update and map species distributions
Product 2.3: Forecast possible future locations of migratory birds and RTE species habitats
Product 2.4: Assess detrimental impact on RTE habitat due transportation infrastructure (2020-2080)
Product 2.5: Identify site-specific, proactive mitigation/compensation strategies against impacts in 2.3

APPENDIX B: ASSESSMENT OF ROAD NETWORKS WITHIN FEMA FLOOD ZONES

Center for Coastal Resources Management
Virginia Institute of Marine Science

All road lengths are rounded to the nearest integer. Cells with "-" indicate no roads in that category.

			Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	
Summary		All Coastal Roads	64,593	3,107	1,524	59,962	
		All Coastal VDOT Roads	20,375	708	203	19,464	

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Accomack County	VDOT Roadway	Major Collector	137	18	7	112	<1
		Minor Arterial	32	5	1	25	<1
		Minor Arterial Ramp	4	<1	<1	2	1
		Minor Collector	45	9	4	32	-
		Other Principal Arterial	69	-	-	69	<1
		Not classified	409	103	30	276	<1
	Locality Roadway	Local Main Arteries	7	7	<1	-	-
		Local Secondaries	8	5	2	<1	-
	Federal Roadway		7	7	<1	-	-
	Other Roadway		820	224	67	529	<1
			1,537	379	111	1,045	2

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Alexandria City	VDOT Roadway	Interstate	17	3	2	12	<1
		Interstate Ramp	13	3	2	8	<1
		Major Collector	<1	-	<1	<1	-
		Minor Arterial	<1	<1	<1	<1	-
		Other Principal Arterial	1	<1	<1	<1	-
		Not classified	2	<1	<1	1	<1
	Locality Roadway	US and VA Primary Highways	32	<1	<1	31	<1
		Local Main Arteries	43	2	3	38	<1
		Local Secondaries	16	<1	<1	15	<1
		Parking Lot Roads	<1	-	<1	<1	-
		HOV Lanes	1	-	-	<1	-
		Ramps	3	<1	<1	3	-
	Federal Roadway		4	2	<1	2	-
	Other Roadway		413	15	19	378	<1
			545	27	27	491	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Arlington County	VDOT Roadway	Interstate	27	<1	1	26	<1
		Interstate Ramp	18	<1	<1	17	<1
		Major Collector	2	-	<1	2	<1
		Minor Arterial	11	<1	<1	10	<1
		Minor Arterial Ramp	3	-	<1	2	-
		Minor Collector	1	<1	<1	<1	-
		Other Freeway or Expressway	8	-	<1	7	<1
		Other Freeway or Expressway Ramp	3	-	<1	3	<1
		Other Principal Arterial	42	<1	2	39	<1
		Not classified	5	<1	<1	5	<1
	Locality Roadway	US and VA Primary Highways	5	<1	<1	5	<1
		Local Main Arteries	61	<1	2	58	<1
		Local Secondaries	30	<1	<1	29	-
		Ramps	<1	<1	-	<1	-
	Federal Roadway		28	4	4	19	<1
	Other Roadway		562	9	19	493	40
			807	16	32	717	42

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Caroline County	VDOT Roadway	Interstate	31	1	-	30	<1
		Interstate Ramp	3	-	-	3	-
		Major Collector	92	4	-	88	<1
		Minor Arterial	45	3	-	42	<1
		Minor Arterial Ramp	15	2	-	13	<1
		Minor Collector	39	2	-	38	-
		Other Principal Arterial	85	5	-	80	<1
		Not classified	335	12	-	324	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		<1	-	-	<1	-
	Other Roadway		1,267	49	-	1,218	<1
			1,913	76	-	1,837	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Charles City County	VDOT Roadway	Major Collector	40	<1	-	40	-
		Minor Arterial	45	1	-	44	<1
		Minor Arterial Ramp	3	<1	-	3	-
		Minor Collector	22	-	-	22	-
		Not classified	76	1	<1	74	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		341	13	2	325	<1
			526	16	3	508	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Chesapeake City	VDOT Roadway	Interstate	57	3	1	52	-
		Interstate Ramp	31	<1	<1	31	-
		Other Freeway or Expressway	6	-	<1	6	-
		Other Freeway or Expressway Ramp	1	-	-	1	-
		Other Principal Arterial	1	-	-	<1	-
		Not classified	4	<1	<1	4	-
	Locality Roadway	US and VA Primary Highways	137	6	6	124	<1
		Limited Access Highway	21	5	1	15	-
		Local Main Arteries	108	6	3	98	<1
		Local Secondaries	89	10	7	72	-
		Ramps	12	1	<1	10	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		1,846	148	90	1,608	<1
			2,312	180	110	2,023	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Chesterfield County	VDOT Roadway	Interstate	34	3	1	30	<1
		Interstate Ramp	15	3	<1	11	<1
		Major Collector	223	6	<1	216	<1
		Minor Arterial	180	5	<1	173	-
		Minor Arterial Ramp	7	<1	<1	6	-
		Minor Collector	16	<1	<1	15	-
		Other Freeway or Expressway	82	3	<1	78	<1
		Other Freeway or Expressway Ramp	40	<1	<1	40	-
		Other Principal Arterial	130	4	<1	126	-
		Not classified	1,388	10	2	1,377	<1
	Locality Roadway	US and VA Primary Highways	3	<1	<1	2	<1
		Limited Access Highway	<1	-	-	<1	-
		Local Main Arteries	2	<1	<1	2	-
		Local Secondaries	1	-	-	1	<1
	Federal Roadway		-	-	-	-	-
	Other Roadway		1,690	28	6	1,656	<1
			3,811	64	13	3,733	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Colonial Heights City	VDOT Roadway	Interstate	7	<1	<1	7	-
		Interstate Ramp	2	<1	-	2	-
		Minor Collector	<1	-	-	<1	-
		Not classified	<1	-	-	<1	<1
	Locality Roadway	US and VA Primary Highways	5	<1	<1	5	<1
		Local Main Arteries	4	-	-	4	-
		Local Secondaries	7	<1	<1	7	<1
	Federal Roadway		-	-	-	-	-
	Other Roadway		131	5	3	124	<1
			157	6	3	149	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Essex County	VDOT Roadway	Major Collector	60	2	<1	58	-
		Minor Arterial Ramp	1	-	-	1	-
		Minor Collector	29	<1	-	29	-
		Other Principal Arterial	87	3	-	84	<1
		Not classified	183	9	2	172	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		641	14	6	621	-
			1,002	28	8	965	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Fairfax City	VDOT Roadway	Interstate Ramp	<1	-	-	<1	<1
		Other Principal Arterial	<1	-	-	<1	<1
		Not classified	1	-	-	<1	<1
	Locality Roadway	US and VA Primary Highways	40	2	<1	18	20
		Local Main Arteries	9	<1	<1	4	4
		Local Secondaries	10	<1	<1	4	5
	Federal Roadway		-	-	-	-	-
	Other Roadway		286	4	2	137	143
			345	7	2	164	172

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Fairfax County	VDOT Roadway	Interstate	155	6	<1	149	<1
		Interstate Ramp	85	3	<1	82	<1
		Major Collector	253	6	<1	247	<1
		Minor Arterial	444	16	<1	428	<1
		Minor Arterial Ramp	32	<1	<1	32	-
		Minor Collector	144	6	<1	138	<1
		Other Freeway or Expressway	37	<1	-	36	-
		Other Freeway or Expressway Ramp	22	<1	-	21	-
		Other Principal Arterial	233	5	<1	228	<1
		Not classified	1,973	18	1	1,954	<1
	Locality Roadway	US and VA Primary Highways	9	<1	<1	9	<1
		Limited Access Highway	<1	-	-	<1	-
		Local Main Arteries	27	<1	<1	26	<1
		Local Secondaries	7	<1	-	6	<1
		Parking Lot Roads	<1	-	-	<1	-
		Ramps	<1	<1	-	<1	-
	Federal Roadway		90	4	<1	86	<1
	Other Roadway		3,579	57	3	3,516	2
			7,091	125	5	6,957	3

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
City of Falls Church	VDOT Roadway	Major Collector	<1	-	-	<1	-
		Other Principal Arterial	<1	-	-	<1	-
		Not classified	<1	<1	-	<1	-
	Locality Roadway	US and VA Primary Highways	5	<1	<1	5	-
		Local Main Arteries	3	<1	<1	3	-
		Local Secondaries	26	<1	<1	24	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		32	<1	<1	32	-
			66	1	<1	64	-

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Fredericksburg City	VDOT Roadway	Interstate	13	<1	-	13	-
		Interstate Ramp	6	-	-	6	-
		Minor Collector	3	<1	-	3	-
		Other Principal Arterial	3	<1	<1	3	<1
		Not classified	<1	-	-	<1	<1
	Locality Roadway	US and VA Primary Highways	40	2	3	16	19
		Local Main Arteries	15	1	<1	10	4
		Local Secondaries	30	<1	3	12	14
		Ramps	4	<1	<1	1	2
	Federal Roadway		2	-	-	1	1
	Other Roadway		351	3	10	239	99
			469	8	17	305	139

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Gloucester County	VDOT Roadway	Major Collector	75	9	2	64	-
		Minor Arterial	27	<1	-	27	<1
		Minor Arterial Ramp	1	-	-	<1	-
		Minor Collector	35	3	2	30	-
		Other Principal Arterial	61	<1	-	60	<1
		Not classified	218	32	20	166	<1
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		743	98	53	592	-
			1,160	144	78	939	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Hampton City	VDOT Roadway	Interstate	32	4	4	22	3
		Interstate Ramp	12	1	<1	10	-
		Other Principal Arterial	<1	<1	<1	<1	-
		Not classified	<1	<1	<1	<1	-
	Locality Roadway	US and VA Primary Highways	74	12	10	53	-
		Local Main Arteries	56	9	8	40	-
		Local Secondaries	24	9	3	12	-
		Ramps	5	<1	<1	5	-
	Federal Roadway		3	3	<1	<1	-
	Other Roadway		886	268	117	486	16
			1,093	305	142	628	18

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Hanover County	VDOT Roadway	Interstate	52	4	<1	47	<1
		Interstate Ramp	24	<1	<1	24	-
		Major Collector	195	7	<1	187	<1
		Minor Arterial	115	3	<1	112	<1
		Minor Arterial Ramp	2	<1	-	2	-
		Minor Collector	108	4	<1	104	<1
		Other Freeway or Expressway	3	-	<1	3	-
		Other Freeway or Expressway Ramp	<1	-	-	<1	-
		Other Principal Arterial	28	2	-	26	<1
		Not classified	517	7	<1	509	<1
	Locality Roadway	US and VA Primary Highways	9	<1	<1	9	-
		Local Main Arteries	5	<1	<1	4	-
		Local Secondaries	6	<1	<1	5	-
	Federal Roadway		2	-	-	2	-
	Other Roadway		1,699	28	3	1,668	<1
			2,764	56	5	2,703	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Henrico County	VDOT Roadway	Interstate	109	3	<1	105	<1
		Interstate Ramp	73	<1	<1	72	<1
		Major Collector	8	<1	<1	8	<1
		Minor Arterial	59	<1	<1	58	<1
		Minor Collector	<1	-	-	<1	-
		Other Freeway or Expressway	16	2	<1	14	<1
		Other Freeway or Expressway Ramp	3	<1	-	3	-
		Other Principal Arterial	75	4	1	70	<1
		Not classified	10	<1	<1	9	<1
	Locality Roadway	US and VA Primary Highways	4	<1	<1	3	<1
		Local Main Arteries	219	6	<1	213	<1
		Local Secondaries	81	1	1	79	<1
		Ramps	<1	-	-	<1	-
	Federal Roadway		8	-	-	8	-
	Other Roadway		2,335	31	12	2,292	<1
			3,000	48	17	2,933	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Hopewell City	VDOT Roadway	Interstate	3	<1	-	3	-
		Interstate Ramp	2	<1	-	1	-
		Major Collector	1	-	-	<1	-
		Minor Arterial	<1	<1	<1	-	-
		Other Principal Arterial	<1	-	-	<1	-
		Not classified	<1	-	-	<1	-
	Locality Roadway	US and VA Primary Highways	16	<1	<1	15	-
		Local Main Arteries	11	<1	-	11	-
		Local Secondaries	8	<1	<1	8	-
	Federal Roadway		<1	-	-	<1	-
	Other Roadway		167	2	<1	165	-
			208	3	<1	204	-

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Isle of Wight County	VDOT Roadway	Major Collector	65	2	<1	62	<1
		Minor Arterial	54	2	<1	52	<1
		Minor Arterial Ramp	1	-	-	<1	-
		Minor Collector	54	2	<1	52	<1
		Other Principal Arterial	37	2	<1	30	4
		Not classified	328	9	2	318	<1
	Locality Roadway	US and VA Primary Highways	<1	<1	-	-	<1
		Local Main Arteries	<1	<1	-	<1	-
		Local Secondaries	3	<1	-	3	<1
	Federal Roadway		-	-	-	-	-
	Other Roadway		644	18	14	612	<1
			1,188	36	17	1,131	4

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
James City County	VDOT Roadway	Interstate	21	-	-	21	<1
		Interstate Ramp	7	-	-	7	-
		Major Collector	25	<1	<1	25	<1
		Minor Arterial	41	1	<1	39	<1
		Minor Arterial Ramp	9	-	-	9	<1
		Minor Collector	13	<1	-	13	-
		Other Freeway or Expressway	21	<1	<1	20	<1
		Other Freeway or Expressway Ramp	4	<1	<1	4	<1
		Other Principal Arterial	36	<1	-	36	<1
		Not classified	280	5	3	273	<1
	Locality Roadway	US and VA Primary Highways	<1	-	-	<1	-
		Local Secondaries	<1	-	-	<1	-
	Federal Roadway		14	5	2	7	-
	Other Roadway		613	10	3	601	<1
			1,084	22	8	1,054	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
King and Queen County	VDOT Roadway	Major Collector	86	1	<1	84	-
		Minor Arterial	35	<1	<1	35	-
		Minor Arterial Ramp	2	-	-	2	-
		Minor Collector	36	<1	-	36	-
		Other Principal Arterial	32	1	<1	30	-
		Not classified	175	6	3	166	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		415	12	9	394	-
			780	21	12	747	-

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
King George County	VDOT Roadway	Major Collector	32	<1	-	32	-
		Minor Arterial	40	<1	<1	39	<1
		Minor Arterial Ramp	<1	-	-	<1	-
		Minor Collector	13	<1	-	13	-
		Other Principal Arterial	59	<1	-	58	<1
		Not classified	135	<1	<1	134	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		386	4	<1	382	-
			665	5	<1	659	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
King William County	VDOT Roadway	Major Collector	78	3	2	73	<1
		Minor Arterial	37	<1	<1	36	-
		Minor Arterial Ramp	3	<1	<1	2	-
		Minor Collector	30	<1	-	30	-
		Other Principal Arterial	18	<1	<1	17	-
		Not classified	165	5	5	156	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		530	10	6	514	-
			861	19	14	828	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Lancaster County	VDOT Roadway	Major Collector	72	5	<1	67	<1
		Minor Arterial	38	<1	-	36	1
		Minor Arterial Ramp	<1	-	-	<1	-
		Minor Collector	17	<1	<1	16	<1
		Not classified	160	6	3	151	<1
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		409	28	11	371	<1
			697	41	14	640	1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Loudon County	VDOT Roadway	Major Collector	215	5	1	205	3
		Minor Arterial	162	3	2	156	1
		Minor Arterial Ramp	7	-	-	7	<1
		Minor Collector	114	6	<1	105	2
		Other Freeway or Expressway	43	<1	<1	42	<1
		Other Freeway or Expressway Ramp	16	<1	<1	16	<1
		Other Principal Arterial	54	2	<1	52	<1
		Not classified	990	20	3	958	10
	Locality Roadway	US and VA Primary Highways	14	<1	<1	13	-
		Limited Access Highway	<1	-	-	<1	-
		Local Main Arteries	16	<1	<1	16	-
		Local Secondaries	21	<1	<1	20	<1
		Ramps	1	<1	<1	<1	-
	Federal Roadway		18	<1	-	17	-
	Other Roadway		2,723	43	7	2,649	25
			4,394	81	14	4,256	42

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Manassas City	VDOT Roadway	Major Collector	<1	-	-	<1	-
		Minor Arterial	<1	<1	<1	<1	-
		Minor Arterial Ramp	<1	-	-	<1	-
		Minor Collector	<1	<1	<1	<1	-
		Other Freeway or Expressway	1	-	-	<1	-
		Other Freeway or Expressway Ramp	2	<1	<1	2	-
		Other Principal Arterial	<1	-	-	<1	-
		Not classified	<1	<1	<1	<1	-
	Locality Roadway	US and VA Primary Highways	12	<1	<1	11	-
		Local Main Arteries	26	<1	-	25	-
		Local Secondaries	8	<1	<1	8	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		216	3	2	212	<1
			267	4	3	260	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Manassas Park City	VDOT Roadway	Major Collector	<1	-	-	<1	-
		Minor Arterial	<1	-	-	<1	-
		Other Principal Arterial	1	-	-	<1	-
		Not classified	<1	-	-	<1	-
	Locality Roadway	US and VA Primary Highways	2	<1	<1	2	-
		Local Main Arteries	2	<1	-	2	-
		Local Secondaries	4	<1	-	3	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		49	<1	<1	48	-
			57	<1	<1	57	-

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Mathews County	VDOT Roadway	Major Collector	32	6	3	24	-
		Minor Arterial	30	2	2	26	<1
		Minor Arterial Ramp	4	3	<1	<1	-
		Minor Collector	16	4	2	10	-
		Not classified	100	36	12	52	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		314	101	48	165	<1
			497	153	66	278	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Middlesex County	VDOT Roadway	Major Collector	41	1	<1	40	-
		Minor Arterial	35	<1	<1	34	<1
		Minor Collector	9	<1	-	9	-
		Other Principal Arterial	29	<1	-	29	-
		Not classified	132	2	1	129	-
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		388	10	4	374	<1
			635	15	6	613	1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
New Kent County	VDOT Roadway	Interstate	40	<1	-	40	-
		Interstate Ramp	6	-	-	6	-
		Major Collector	35	<1	<1	33	-
		Minor Arterial	38	<1	-	38	-
		Minor Collector	30	<1	-	29	<1
		Other Principal Arterial	50	2	<1	48	<1
		Not classified	151	2	2	147	<1
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		481	7	4	468	2
			830	13	7	809	2

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Newport News City	VDOT Roadway	Interstate	40	1	<1	34	5
		Interstate Ramp	19	<1	<1	18	-
		Minor Collector	<1	-	-	<1	-
		Other Principal Arterial	5	<1	-	<1	4
		Not classified	<1	-	-	<1	<1
	Locality Roadway	US and VA Primary Highways	102	2	<1	99	<1
		Local Main Arteries	28	<1	<1	27	<1
		Local Secondaries	39	2	<1	36	-
		Ramps	4	<1	-	4	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		1,136	46	22	1,062	7
			1,373	53	24	1,280	16

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Norfolk City	VDOT Roadway	Interstate	58	7	<1	50	-
		Interstate Ramp	30	2	<1	27	-
		Major Collector	<1	<1	<1	-	-
		Minor Arterial	<1	<1	<1	<1	-
		Minor Collector	<1	-	-	<1	-
		Other Freeway or Expressway	1	<1	<1	<1	-
		Other Freeway or Expressway Ramp	1	<1	<1	<1	-
		Other Principal Arterial	2	<1	<1	2	-
		Not classified	3	1	<1	2	-
	Locality Roadway	US and VA Primary Highways	137	22	20	95	<1
		Limited Access Highway	1	-	-	<1	-
		Local Main Arteries	39	7	8	25	-
		Local Secondaries	88	21	22	45	<1
		Ramps	2	<1	<1	1	-
		Other	-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		1,203	203	244	757	<1
			1,566	266	296	1,004	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Northampton County	VDOT Roadway	Major Collector	52	<1	<1	50	<1
		Minor Arterial	2	-	-	2	-
		Minor Collector	37	<1	1	36	-
		Other Principal Arterial	64	-	<1	64	-
		Not classified	179	10	6	162	<1
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		482	31	9	428	14
			815	42	17	741	15

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Northumberland County	VDOT Roadway	Major Collector	62	2	<1	58	<1
		Minor Arterial	14	<1	-	13	<1
		Minor Arterial Ramp	2	<1	<1	2	<1
		Minor Collector	35	<1	-	34	<1
		Other Principal Arterial	31	<1	-	31	<1
		Not classified	278	5	2	270	<1
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		623	19	4	600	<1
			1,044	27	6	1,009	2

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Petersburg City	VDOT Roadway	Interstate	20	1	<1	19	-
		Interstate Ramp	10	<1	<1	10	-
		Major Collector	2	-	-	2	-
		Minor Arterial	<1	-	-	<1	-
		Minor Arterial Ramp	<1	-	-	<1	-
		Minor Collector	1	-	-	1	-
		Other Principal Arterial	2	<1	<1	2	-
		Not classified	<1	<1	<1	<1	-
	Locality Roadway	US and VA Primary Highways	27	2	<1	25	<1
		Local Main Arteries	27	2	<1	24	<1
		Local Secondaries	15	<1	<1	14	<1
		Ramps	<1	-	-	<1	-
	Federal Roadway		3	-	-	<1	3
	Other Roadway		227	8	2	216	1
			335	13	4	314	4

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Poquoson City	VDOT Roadway	Major Collector	<1	<1	-	-	-
	Locality Roadway	US and VA Primary Highways	8	6	2	<1	-
		Local Main Arteries	3	2	<1	-	-
		Local Secondaries	1	1	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		87	64	20	3	<1
			99	73	23	3	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Portsmouth City	VDOT Roadway	Interstate	12	<1	<1	11	-
		Interstate Ramp	8	<1	<1	7	-
		Other Freeway or Expressway	16	3	<1	12	<1
		Other Freeway or Expressway Ramp	3	<1	<1	2	-
		Not classified	2	<1	<1	2	-
	Locality Roadway	US and VA Primary Highways	45	9	7	28	<1
		Limited Access Highway	1	-	-	<1	-
		Local Main Arteries	28	4	3	21	<1
		Local Secondaries	45	10	12	23	-
		Ramps	3	-	<1	3	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		600	136	108	356	<1
			762	165	132	465	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Prince George County	VDOT Roadway	Interstate	49	2	<1	46	-
		Interstate Ramp	10	-	-	10	-
		Major Collector	72	2	<1	70	-
		Minor Arterial	53	3	<1	50	<1
		Minor Arterial Ramp	10	<1	<1	9	-
		Minor Collector	41	1	-	39	<1
		Other Principal Arterial	20	<1	<1	19	-
		Not classified	204	5	<1	199	<1
	Locality Roadway	US and VA Primary Highways	1	<1	-	<1	-
		Local Main Arteries	<1	-	-	<1	-
	Federal Roadway		2	-	-	<1	2
	Other Roadway		644	8	2	634	<1
			1,106	23	3	1,078	2

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Prince William County	VDOT Roadway	Interstate	66	2	<1	64	<1
		Interstate Ramp	32	<1	-	32	-
		Major Collector	199	7	1	191	<1
		Minor Arterial	127	3	<1	122	<1
		Minor Arterial Ramp	7	<1	<1	7	-
		Minor Collector	76	3	<1	73	<1
		Other Freeway or Expressway	30	<1	<1	29	-
		Other Freeway or Expressway Ramp	2	<1	<1	2	-
		Other Principal Arterial	95	3	<1	91	<1
		Not classified	863	10	2	852	<1
	Locality Roadway	US and VA Primary Highways	<1	-	-	<1	-
		Local Main Arteries	<1	-	-	<1	-
		Local Secondaries	1	-	-	<1	-
	Federal Roadway		21	<1	-	21	-
	Other Roadway		2,072	30	10	2,032	<1
			3,591	58	15	3,517	1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Richmond City	VDOT Roadway	Interstate	34	3	2	28	<1
		Interstate Ramp	16	1	<1	14	<1
		Major Collector	1	-	-	1	-
		Minor Arterial	<1	-	<1	<1	-
		Minor Collector	<1	-	-	<1	-
		Other Freeway or Expressway	5	<1	<1	5	<1
		Other Freeway or Expressway Ramp	5	<1	<1	5	-
		Other Principal Arterial	<1	-	<1	<1	-
		Not classified	2	-	<1	2	<1
	Locality Roadway	US and VA Primary Highways	113	4	2	105	1
		Limited Access Highway	5	-	-	5	-
		Local Main Arteries	102	1	3	97	1
		Local Secondaries	92	5	1	86	<1
		Ramps	5	<1	<1	5	-
	Other Roadway		1,153	26	16	1,100	11
			1,535	42	25	1,453	15

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Richmond County	VDOT Roadway	Major Collector	46	<1	-	46	<1
		Minor Arterial	26	<1	-	26	-
		Minor Collector	18	<1	<1	17	<1
		Other Principal Arterial	25	<1	<1	24	<1
		Not classified	152	2	1	148	<1
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		252	6	3	243	<1
			519	9	5	504	1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Spotsylvania County	VDOT Roadway	Interstate	25	<1	-	24	<1
		Interstate Ramp	3	-	-	3	-
		Major Collector	153	4	-	150	<1
		Minor Arterial	63	1	-	62	<1
		Minor Arterial Ramp	4	<1	-	4	-
		Minor Collector	51	2	-	49	<1
		Other Principal Arterial	46	<1	-	46	<1
		Not classified	564	4	-	560	<1
	Locality Roadway	US and VA Primary Highways	<1	-	-	<1	<1
		Local Secondaries	<1	-	-	<1	-
	Federal Roadway		22	<1	-	22	<1
	Other Roadway		1,327	22	-	1,305	<1
			2,259	34	-	2,224	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Stafford County	VDOT Roadway	Interstate	37	<1	<1	36	<1
		Interstate Ramp	9	-	-	9	-
		Major Collector	135	5	<1	130	-
		Minor Arterial	11	<1	<1	11	-
		Minor Arterial Ramp	1	-	-	<1	-
		Minor Collector	57	2	<1	54	<1
		Other Principal Arterial	48	3	<1	45	<1
		Not classified	507	6	<1	500	-
	Locality Roadway	US and VA Primary Highways	<1	<1	-	-	<1
	Federal Roadway		<1	<1	<1	<1	-
	Other Roadway		986	15	3	968	<1
			1,792	32	6	1,754	1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Suffolk City	VDOT Roadway	Interstate	11	<1	-	7	4
		Interstate Ramp	6	-	-	6	-
		Major Collector	<1	-	-	<1	<1
		Minor Arterial	<1	<1	<1	<1	<1
		Minor Collector	5	-	-	5	-
		Other Freeway or Expressway	6	-	<1	6	<1
		Other Freeway or Expressway Ramp	<1	-	-	<1	-
		Other Principal Arterial	<1	-	-	<1	<1
		Not classified	7	<1	<1	6	<1
	Locality Roadway	US and VA Primary Highways	140	2	<1	137	<1
		Limited Access Highway	26	<1	<1	25	<1
		Local Main Arteries	179	3	<1	175	<1
		Local Secondaries	397	4	1	391	<1
		Ramps	9	-	<1	9	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		957	32	4	921	<1
			1,743	43	6	1,689	5

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Surry County	VDOT Roadway	Major Collector	7	<1	-	7	-
		Minor Arterial	49	2	-	46	<1
		Minor Arterial Ramp	9	<1	-	9	-
		Minor Collector	46	1	-	45	-
		Other Principal Arterial	<1	-	-	<1	-
		Not classified	191	5	<1	186	<1
	Locality Roadway		-	-	-	-	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		365	6	<1	360	<1
			668	14	<1	654	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Virginia Beach City	VDOT Roadway	Interstate	29	<1	<1	29	-
		Interstate Ramp	13	-	<1	13	-
		Other Principal Arterial	1	-	<1	<1	-
		Not classified	8	2	1	5	-
	Locality Roadway	US and VA Primary Highways	142	11	9	122	<1
		Local Main Arteries	220	15	9	196	<1
		Local Secondaries	149	18	8	123	<1
		Ramps	3	<1	<1	3	-
	Federal Roadway		-	-	-	-	-
	Other Roadway		2,475	182	154	2,138	<1
			3,042	229	182	2,630	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Westmoreland County	VDOT Roadway	Major Collector	80	<1	<1	79	-
		Minor Arterial	61	2	<1	59	-
		Minor Collector	23	<1	-	22	-
		Not classified	236	5	<1	231	<1
	Locality Roadway	Local Main Arteries	4	<1	<1	3	-
		Local Secondaries	22	2	<1	20	-
	Federal Roadway		2	-	<1	1	-
	Other Roadway		454	10	2	443	<1
			881	19	3	858	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
Williamsburg City	VDOT Roadway	Major Collector	<1	-	-	<1	-
		Minor Arterial	2	-	-	2	-
		Other Freeway or Expressway	<1	-	-	<1	-
		Other Principal Arterial	<1	<1	-	<1	-
		Not classified	4	-	-	4	-
	Locality Roadway	US and VA Primary Highways	14	<1	-	14	<1
		Local Main Arteries	4	-	-	4	-
		Local Secondaries	1	-	-	1	-
	Federal Roadway		4	<1	-	4	-
	Other Roadway		111	<1	<1	111	<1
			141	<1	<1	141	<1

	Road Ownership	Road Type	Total Road Length (miles)	1% Annual Chance Flood Hazard (all A and V zones) (miles)	0.2% Annual Chance Flood Hazard (miles)	Area of Minimal Flood Hazard (miles)	Areas of Undetermined Flood Hazards (miles)
York County	VDOT Roadway	Interstate	23	<1	-	22	<1
		Interstate Ramp	10	<1	-	10	-
		Major Collector	51	5	2	44	<1
		Minor Arterial	12	<1	-	12	-
		Minor Arterial Ramp	1	-	-	1	-
		Minor Collector	4	<1	-	4	-
		Other Freeway or Expressway	8	-	-	8	<1
		Other Freeway or Expressway Ramp	2	-	-	2	-
		Other Principal Arterial	42	1	<1	41	<1
		Not classified	265	26	20	219	<1
	Locality Roadway	US and VA Primary Highways	6	<1	<1	6	-
		Local Main Arteries	<1	<1	<1	<1	<1
		Local Secondaries	<1	-	-	<1	-
	Federal Roadway		23	<1	<1	23	<1
	Other Roadway		569	29	18	518	4
			1,018	62	40	911	5