Appendix A: Application Form for Grant Requests for All Categories

Virginia Department of Conservation and Recreation
Virginia Community Flood Preparedness Fund Grant Program

Name of Local Government:
City of Richmond

Category of Grant Being Applied for (check one):

X **Capacity Building/Planning**

_____ **Project**

_____ **Study**

NFIP/DCR Community Identification Number (CID) 510129

If a state or federally recognized Indian tribe, Name of tribe N/A

Name of Authorized Official: Surani Olsen PE
Program and Operations Manager Water Resources, Richmond DPU

Signature of Authorized Official: ______________________________

Mailing Address (1): 730 E. Broad Street

Mailing Address (2): ______________________________

City: Richmond **State:** Virginia **Zip:** 23219

Telephone Number: (804) 646-7674 **Cell Phone Number:** (____) N/A

Email Address: surani.olsen@richmondgov.com

Contact Person (If different from authorized official):

Mailing Address (1): ___________________

Mailing Address (2): ____

City: _____________________________ **State:** __ __________ **Zip:** __ __________

Telephone Number: ___ **Cell Phone Number:** (_ _____

Email Address: ____

Is the proposal in this application intended to benefit a low-income geographic area as defined in the Part 1 Definitions? Yes ____ No _X__

Categories (select applicable project):

Project Grants (Check All that Apply)

- ☐ Acquisition of property (or interests therein) and/or structures for purposes of allowing floodwater inundation, strategic retreat of existing land uses from areas vulnerable to flooding; the conservation or enhancement of natural flood resilience resources; or acquisition of structures, provided the acquired property will be protected in perpetuity from further development.
- ☐ Wetland restoration.
- ☐ Floodplain restoration.
- ☐ Construction of swales and settling ponds.
- ☐ Living shorelines and vegetated buffers.
- ☐ Structural floodwalls, levees, berms, flood gates, structural conveyances.
- ☐ Storm water system upgrades.
- ☐ Medium and large scale Low Impact Development (LID) in urban areas.
- ☐ Permanent conservation of undeveloped lands identified as having flood resilience value by *ConserveVirginia* Floodplain and Flooding Resilience layer or a similar data driven analytic tool.
- ☐ Dam restoration or removal.
- ☐ Stream bank restoration or stabilization.
- ☐ Restoration of floodplains to natural and beneficial function.
- ☐ Developing flood warning and response systems, which may include gauge installation, to notify residents of potential emergency flooding events.

Study Grants (Check All that Apply)

- ☐ Studies to aid in updating floodplain ordinances to maintain compliance with the NFIP or to incorporate higher standards that may reduce the risk of flood damage. This must include establishing processes for implementing the ordinance, including but not limited to, permitting, record retention, violations, and variances. This may include revising a floodplain ordinance when the community is getting new Flood Insurance Rate Maps (FIRMs), updating a floodplain ordinance to include floodplain setbacks or freeboard, or correcting issues identified in a Corrective Action Plan.
- ☐ Revising other land use ordinances to incorporate flood protection and mitigation goals, standards and practices.
- ☐ Conducting hydrologic and hydraulic studies of floodplains. Applicants who create new maps must apply for a Letter of Map Revision or a Physical Map Revision through the Federal Emergency Management Agency (FEMA). For example, a local government might conduct a hydrologic and hydraulic study for an area that had not been studied because the watershed is less than one square mile. Modeling the floodplain in an area that has numerous letters of map change that suggest the current map might not be fully accurate or doing a detailed flood study for an A Zone is another example.
- ☐ Studies and Data Collection of Statewide and Regional Significance.
- ☐ Revisions to existing resilience plans and modifications to existing comprehensive and hazard.
- ☐ Other relevant flood prevention and protection project or study.

<u>Capacity Building and Planning Grants</u>

- x Floodplain Staff Capacity.
- ☐ Resilience Plan Development
  - ☐ Revisions to existing resilience plans and modifications to existing comprehensive and hazard mitigation plans.
  - ☐ Resource assessments, planning, strategies and development.
    - o Policy management and/or development.
    - o Stakeholder engagement and strategies.

Location of Project (Include Maps): _ City of Richmond

NFIP Community Identification Number (CID#):(See appendix F 510129 **______________________**

Is Project Located in an NFIP Participating Community? ☒ Yes ☐ No

Is Project Located in a Special Flood Hazard Area? X Yes ☐ No

Flood Zone(s) (If Applicable): Floodway

Flood Insurance Rate Map Number(s) (If Applicable):

Total Cost of Project: $ 30,870.00 ____

Total Amount Requested $ 23152.5

Supporting Reference Information

Links to Supporting Documentation

a. City of Richmond Current Floodplain Ordinance
    i. Municode City of Richmond Chapter 14 Floodplain Ordinance
b. Crater Hazard Mitigation Plan
    i. Attached in this package. Previously submitted in part of Resilience Plan compliance.

B. Scope of Work Narrative – Capacity Building and Planning

City of Richmond's (OWNER) has areas that are located in the floodway and one of the City' Floodplain Ordinance requirements for the proposed developments in these areas is a no rise certification that is supported by a hydrology and hydraulic analysis report and civil plans. Water Resources Division currently performs the review of development plans before a construction permit can be issued including reviews of hydrology and hydraulic analysis (HHA) model and no rise certifications for proposed projects that are located in the floodway. The purpose of this application is to apply for funding to outsource the review of HHA and no rise certification to a third party consultant so the City's engineer can learn from the reviews and develop Water Resources Division's capacity in performing the H&HA and no rise certification reviews. These projects may include areas from various areas of social vulnerabilities.

C. Budget Narrative

1. **Estimated total project cost:**
   The total estimated project cost is $30,870.00 for approximately 150 hours of third party consultant review of HHA models and no rise certifications.

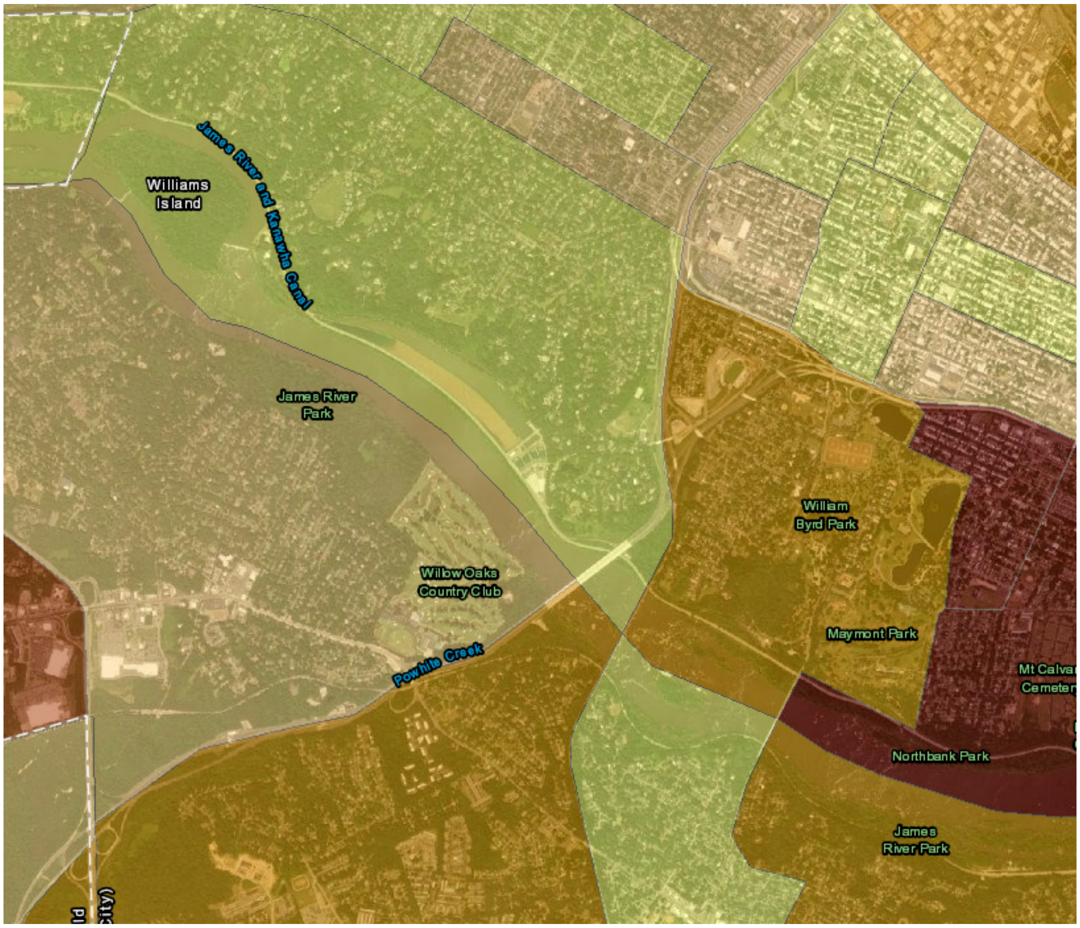
2. **Amount of funds requested from the Fund:**
   The requested dollar amount from the Fund is $23,152.50, which is 75% of the $30,870.00 estimated total project costs. Please find attached the scope of services from Kimley-Horn and Associates, Inc. detailing the scope of the work, budget, and hourly allocation for the third-party consultant engineering review of the survey report.

3. **Amount of cash funds available:**
   Please find attached statement from the City of Richmond indicating the available stormwater operating budget for the year ending June 30, 2022 as $12,638,350.

4. **Authorization to request for funding**:
   Please find attached documentation from City of Richmond indicating their authorization to request funding.

Qualified Opportunity Zones Map

Social Vulnerability Index Map



Legend

Social Vulnerability

Social Vulnerability Index Score

- Very Low Social Vulnerability
- Low Social Vulnerability
- Moderate Social Vulnerability
- High Social Vulnerability
- Very High Social Vulnerability
- Not inlcuded in the analysis

Adapt VA Interactive Map

CITY OF RICHMOND
Department of Public Utilities

November 3, 2021

Virginia Department of Conservation and Recreation
600 East Main Street
24th Floor
Richmond, VA 23219-2094
Henrico, VA 23228

To whom it may concern:

The total contract value of the hydrology and hydraulic analysis and no rise certification review scope is $30,870, which includes150 hours of third party reviews. The City of Richmond, Department of Public Utilities – Stormwater Utility, is an enterprise fund within the City of Richmond. Therefore the Stormwater Utility has a dedicated revenue stream and is appropriated operating funds annually. Those dedicated revenues are projected to be $13.3 million in FY2022 and part of those funds will cover the total estimated project cost ($30,870.00) prior to DCR grant reimbursement. The DPU is committed to contribute 25% of the project fund and the source of the fund is from the Stormwater Operation and Maintenance budget (copy attached).

Sincerely,

Surani Olsen, P.E.
Water Resources Program and Operations Manager

Enclosure

INTRODUCED: March 5, 2021

AN ORDINANCE No. 2021-051

To adopt the Stormwater Utility Budget for the fiscal year commencing Jul. 1, 2021, and ending Jun. 30, 2022; to appropriate the estimated receipts of the Stormwater Utility for the said fiscal year; and to make appropriations from the Stormwater Utility Renewal Fund or Operating Fund for renewing, rebuilding or extending the stormwater utility and for the purchase of vehicles.

Patron – Mayor Stoney

Approved as to form and legality
by the City Attorney

PUBLIC HEARING: APR 12 2021 AT 6 P.M.

THE CITY OF RICHMOND HEREBY ORDAINS:

§ 1. That the budget designated the Stormwater Utility Budget for the fiscal year commencing July 1, 2021, and ending June 30, 2022, is hereby adopted.

§ 2. That the sum of $12,638,350 be and is hereby appropriated from the estimated receipts of the Stormwater Utility for the fiscal year commencing July 1, 2021, and ending June 30, 2022, for the purposes as set forth in the Stormwater Utility Budget.

§ 3. That the sum of $0 be and is hereby appropriated from the stormwater utility renewal fund or operating fund for renewing, rebuilding and extending the utility and for

AYES: 9 NOES: 0 ABSTAIN:

ADOPTED: MAY 24 2021 REJECTED: STRICKEN:

purchasing vehicles as set forth in the Stormwater Utility Budget, the said appropriation having been recommended by the Mayor.

§ 4. That the payment and settlement of claims of any kind heretofore or hereafter asserted against the City growing out of the operation of the Stormwater Utility and final judgments heretofore or hereafter asserted against the City on account thereof, together with all costs, interest, fees for legal services and all other fees and expenses thereto, and all fees, costs and other expenses incurred in providing legal and other services authorized by section 2-57 of the Code of the City of Richmond (2020), as amended, shall be paid upon the approval and order of the City Attorney from the funds herein appropriated for defraying the expense of operating the Stormwater Utility; except that in the case of judgments against the City, payment thereof shall be limited to the extent of funds available in the appropriation for that purpose.

§ 5. This ordinance shall be in force and effect at the first moment of the first day of July, 2021, and shall constitute the Stormwater Utility appropriation ordinance for the fiscal year commencing on that date.

A TRUE COPY:
TESTE:

Candice D. Reid

City Clerk

SCOPE OF WORK AND FEE PROPOSAL

Task 70: Hydrology and Hydraulic Analysis Model and No Rise Certification Review Services City of Richmond

PROJECT UNDERSTANDING

City of Richmond's (OWNER) Water Resources Division currently performs the review of development plans before a construction permit can be issued including review of hydrology and hydraulic analysis (HHA) model and no rise certification for proposed projects that are located in the floodway. The purpose of this scope is for Kimley-Horn (ENGINEER) to a ssist the Water Resources Division in performing the H&HA and no rise certification reviews.

SCOPE OF SERVICES

HHA and No Rise Certification Review

ENGINEER will review and provide comments on civil plans, HHA models, reports and the no rise certifications sent by the OWNER for each project using the requirements of Richmond City Code as expeditiously as practicable with the following schedule goal: within ten (10) calendar days of receipt by ENGINEER.

DELIVERABLES

ENGINEER will deliver electronic comment letters for each plan review.

FEE

Kimley-Horn will perform the services described in **Task** above for a lump sum fee of **$30,870**. Labor fee will be billed on a percent complete basis. Direct reimbursable expenses will be billed at cost.

APPROVED:______________________________________ **DATE:**____________________

KIMLEY-HORN AND ASSOCIATES, INC.
TASK 70 – HHA & No Rise Certification Review Services

Date: 10/24/2021
Revised:

LABOR		SENIOR ENGINEER	PROJECT MANAGER	PROJECT ENGINEER	ANALYST / DESIGNER	TECHNICAL SUPPORT	ADMIN SUPPORT	TOTAL HOURS	TOTAL DOLLARS
		$215.00	$170.00	$140.00	$115.00	$90.00	$65.00		
TASK 1 - PROJECT MANAGEMENT									
1.1	Project Management		16				16	32	$3,760
1.3	Meeting (8 - 1 Hour Meetings)		8	8				16	$2,480
	SUBTOTAL TASK 1	**0**	**24**	**8**	**0**	**0**	**16**	**48**	**$6,240**
TASK 2 - PLAN REVIEWS									
2.1	1st Review (Assume 8 Hours Per Review - 3 Reviews)		6	18				24	$3,540
2.2	2nd Review (Assume 6 Hours Per Review - 3 Reviews)		6	12				18	$2,700
2.3	3rd Review (Assume 4 Hours Per Review - 3 Reviews)		3	9				12	$1,770
	SUBTOTAL TASK 2	**0**	**15**	**39**	**0**	**0**	**0**	**54**	**$8,010**
TASK 3 - FLOODPLAIN REVIEWS									
2.1	1st Review (Assume 8 Hours Per Review - 6 Reviews)		12	36				48	$7,080
2.2	2nd Review (Assume 6 Hours Per Review - 6 Reviews)		12	24					$5,400
2.3	3rd Review (Assume 4 Hours Per Review - 6 Reviews)		6	18					$3,540
	SUBTOTAL TASK 3	**0**	**30**	**78**	**0**	**0**	**0**	**48**	**$16,020**
	TOTAL LABOR	***0***	***69***		***0***	***0***	***16***	***150***	***$30,270***

EXPENSES								TOTAL DOLLARS
TASK A - DIRECT REIMBURSABLE EXPENSES								
	Bond Plots	100	Plots	$3.50	Per Plot			$350
	Scanning Services	100	Scans	$2.50	Per Plot			$250
	SUBTOTAL TASK A							**$600**
	TOTAL EXPENSES							***$600***

TOTAL LABOR AND EXPENSES		***$30,870***

* Categories and Rates per Executed Annual Engineering Services and Non-Professional Related Construction Services dated June 26, 2017

Appendix D: Scoring Criteria for Capacity Building & Planning

Virginia Department of Conservation and Recreation
Virginia Community Flood Preparedness Fund Grant Program

Applicant Name:		
Eligibility Information		
Criterion	**Description**	**Check One**
1. Is the applicant a local government (including counties, cities, towns, municipal corporations, authorities, districts, commissions, or political subdivisions created by the General Assembly or pursuant to the Constitution or laws of the Commonwealth, or any combination of these)?		
$\boxed{\text{Yes}}$	Eligible for consideration	X
No	Not eligible for consideration	
2. Does the local government have an approved resilience plan and has provided a copy or link to the plan with this application?		
$\boxed{\text{Yes}}$	Eligible for consideration under all categories	X
No	Eligible for consideration for studies, capacity building, and planning only	
3. If the applicant is <u>not a town, city, or county</u>, are letters of support from all affected local governments included in this application?		
Yes	Eligible for consideration	N/A
No	Not eligible for consideration	
4. Has this or any portion of this project been included in any application or program previously funded by the Department?		
Yes	Not eligible for consideration	
$\boxed{\text{No}}$	Eligible for consideration	X
5. Has the applicant provided evidence of an ability to provide the required matching funds?		
$\boxed{\text{Yes}}$	Eligible for consideration	X
No	Not eligible for consideration	
N/A	Match not required	

Capacity Building and Planning Eligible for Consideration	☒ Yes ☐ No

Applicant Name:	

Scoring Information		
Criterion	**Point Value**	**Points Awarded**
6. Eligible Capacity Building and Planning Activities (Select all that apply)		
Revisions to existing resilience plans and modifications to existing comprehensive and hazard mitigation plans.	**55**	55
Development of a new resilience plan.	**55**	
Resource assessments, planning, strategies and development.	**45**	45
Policy management and/or development.	**40**	40
Stakeholder engagement and strategies.	**25**	
Goal planning, implementation and evaluation.	**25**	
Long term maintenance strategy.	**25**	25
Other proposals that will significantly improve protection from flooding on a statewide or regional basis.	**15**	
7. Is the area within the local government to which the grant is targeted socially vulnerable? (Based **on ADAPT VA's Social Vulnerability Index Score.)**		
Very High Social Vulnerability (More than 1.5)	**15**	
High Social Vulnerability (1.0 to 1.5)	**12**	
Moderate Social Vulnerability (0.0 to 1.0)	**8**	
Low Social Vulnerability (-1.0 to 0.0)	**0**	
Very Low Social Vulnerability (Less than -1.0)	**0**	0
8. Is the proposed activity part of an effort to join or remedy the community's probation or suspension from the NFIP?		
Yes	**10**	
No	**0**	0
9. Is the proposed project in a low-income geographic area as defined in this manual?		
Yes	**10**	
No	**0**	0
10. Does this project provide "community scale" benefits?		
Yes	**20**	20
No		
Total Points		185

Appendix D: Checklist All Categories

Virginia Department of Conservation and Recreation

Community Flood Preparedness Fund Grant Program

Scope of Work Narrative	
Supporting Documentation	**Included**
Detailed map of the project area(s) (Projects/Studies)	☐ Yes ☐ No ☒ N/A
FIRMette of the project area(s) (Projects/Studies)	☐ Yes ☐ No ☒ N/A
Historic flood damage data and/or images (Projects/Studies)	☐ Yes ☐ No ☒ N/A
A link to or a copy of the current floodplain ordinance	☒ Yes ☐ No ☐ N/A
Non-Fund financed maintenance and management plan for project extending a minimum of 5 years from project close	☐ Yes ☐ No ☒ N/A
A link to or a copy of the current hazard mitigation plan	☒ Yes ☐ No ☐ N/A
A link to or a copy of the current comprehensive plan	☒ Yes ☐ No ☐ N/A
Social vulnerability index score(s) for the project area from ADAPT VA's Virginia Vulnerability Viewer	☒ Yes ☐ No ☐ N/A
If applicant is not a town, city, or county, letters of support from affected communities	☐ Yes ☐ No ☒ N/A
Completed Scoring Criteria Sheet in Appendix B, C, or D	☒ Yes ☐ No ☐ N/A
Budget Narrative	
Supporting Documentation	**Included**
Authorization to request funding from the Fund from governing body or chief executive of the local government	☒ Yes ☐ No ☐ N/A
Signed pledge agreement from each contributing organization	☐ Yes ☐ No ☒ N/A

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Drafts

AutoResponses

More

'CID.510129 - CityRichmond.Grant.Request.Submission.CFPF (2021

Olsen, Surani S. - DPU

to me

Good afternoon,

Please find attached the named 'CID.510129 - CityRichmond.Grant.Request.Submission.CFPF (2021-11-05)2

Thank you very much for the consideration.

Regards,

Surani Olsen, P.E.
Program and Operations Manager
Water Resources Division
Department of Public Utilities-City of Richmond
Phone: (804) 646-7674

...

[Message clipped] View entire message

2017
RVA CLEAN WATER PLAN

Prepared for The City of Richmond's Department of Public Utilities

CITY OF RICHMOND
DEPARTMENT OF PUBLIC UTILITIES

RVA H2O
EVERY DROP COUNTS

LimnoTech
Water Environment | Scientists Engineers

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RVA Clean Water Plan

September 2017

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TABLE OF CONTENTS

Appendices

Acronyms

CBP – Chesapeake Bay Program

CFU – coliform forming units

CPMI – Coastal Plain macroinvertebrate index

CSO – combined sewer overflow

CSS – combined sewer system

CWA – Clean Water Act

DPU – Department of Public Utilities

EFDC - Environmental Fluid Dynamics Code

EPA – Environmental Protection Agency

GI – green infrastructure

GIS – geographic information system

LA – load allocation

LTCP – long term control plan

MGD – million gallons per day

MS4 – municipal separate storm sewer system

NPDES – national pollution discharge elimination system

PRCF - Parks, Recreation, and Community Facilities

SSO – sanitary sewer overflow

STV – statistical threshold value

SWMM – stormwater management model

TN – total Nitrogen

TP – total Phosphorus

TSS – total suspended solids

TMDL – total maximum daily load

UAA – use attainability analysis

USGS – United States Geological Service

VDCR – Virginia Department of Conservation and Recreation

VDEQ – Virginia Department of Environmental Quality

VSCI – Virginia Stream Condition Index

VPDES – Virginia Pollutant Discharge Elimination System

WWTP – wastewater treatment plant

Executive Summary

The City of Richmond's Department of Public Utilities (DPU) manages five utilities, three of which address water and potentially influence local water resources: wastewater, stormwater, and drinking water. The wastewater utility operates the wastewater treatment plant (WWTP), which discharges treated effluent to the James River, a sanitary sewer and combined sewer collection system, pumping stations, the Hampton-McCloy Tunnel, and the Shockoe Retention Basin. The stormwater utility manages the stormwater that runs off impervious surfaces through underground storm sewer systems and open channels into the James River and its tributaries. Approximately two-thirds of the City of Richmond is served by a municipal separate storm sewer system (MS4). The drinking water utility manages the treatment plant and distribution system of water mains, pumping stations, and storage facilities that provide water to more than 500,000 customers in the city and surrounding area using water from the James River.

Historically, the three utilities were managed independently of one another, primarily driven by the fact the regulatory agencies implemented the regulations and permit requirements independently. This approach forced the City to make decisions related to compliance for each utility without being able to consider the interrelated impacts, especially on local waterways. Integration of all of the separate programs into a coordinated approach would eliminate redundant activities, be more efficient and effective addressing wet weather impacts, and improve water resources overall. USEPA has put a significant amount of effort in recent years into describing and publicizing holistic or integrated processes to protect water quality. Richmond has applied EPA's concepts to form a framework, documented in this Richmond, Virginia (RVA) Clean Water Plan, that allows the City to efficiently evaluate, manage, and implement water quality programs, work toward their goals and objectives, and culminate in a single, integrated VPDES permit that encompasses the City's wastewater, CSO, and stormwater discharges.

The James River and its tributaries drain a watershed of over 10,000 square miles. Within the City of Richmond, the James River flows for 24 miles, providing a substantial amount of waterfront. Major features in the river include Bosher's Dam, which is located just upstream of the City along the James River, and smaller dams, levees, and pipe crossings within the City. Just downstream of the City is the Presquile Wildlife Refuge, home to several species of birds and anadromous fish, including the endangered Atlantic sturgeon.

The focus of the RVA Clean Water Plan is on the portion of the James River watershed within the City's municipal boundary and on restoring and protecting the waterways in this watershed. This watershed-wide, water quality-based strategy allows the City to develop an effective and affordable management plan while also meeting regulatory requirements, and demonstrating to the public that the plan protects and improves the watershed and waterways. Richmond's Clean Water Plan includes six elements[1], which summarized here and discussed in more detail in this document.

[1] (1)Stakeholder Involvement; (2) Watershed Characterization; (3) Strategy Identification, Evaluation and Selection; (4) Program Implementation; (5) Progress Measurement; and (6) Adaptive Management

Stakeholder Involvement

Stakeholders can represent many different groups with an interest in the watershed, including, for example, advocates for wildlife and habitat protection; boaters; residential, commercial and business interests; and environmental justice groups. The City has incorporated stakeholder involvement throughout the entire planning process to help ensure stakeholders understood the process from the outset and were part of decision-making efforts throughout the development of the plan. The City's Watershed Characterization Report includes additional discussion of the various stakeholders that have been invited to participate and/or are participating within this planning process.

The City created and initiated RVAH2O (RVAH2O.org), the name representing a citywide effort to arrive at "Cleaner Water Faster", to disseminate outreach information and facilitate communication with stakeholders. Beginning with an initial meeting in November 2014, the City has held technical meetings every 2-3 months. The City also initiated a public outreach effort, including several open houses, to lay a foundation of understanding before laddering up to the more technical conversation around watershed integration. The City's Public Outreach Plan, which includes online and offline communication strategies, has a goal of reaching 20% of the City's population in the MS4 area by 2018. Progress towards this and other goals are being measured by tracking RVAH2O Facebook and Twitter traffic, email campaign, and flier distributions.

Watershed Characterization

Understanding existing water quality, along with the sources of pollutants or stressors that impact the City's waterbodies, are key elements for developing priority actions to address existing or potential problems and developing an effective integrated plan. Collection of data and characterization of the City's watersheds were the City's first steps towards development of the Clean Water Plan. Another key step towards was the development of a water quantity and quality modeling framework, that incorporates models for the CSO areas, the non-CSO areas (including Richmond's MS4 area), and for the James River itself. The purpose of the modeling framework was to quantify present day bacteria (*E. coli*) concentrations in the James River and to predict future bacteria concentrations under the Clean Water Plan strategies.

Watershed Data and Features

The western and very northern portions of the City have experienced the least amount of hydrologic modification and possess the lowest intensely developed land use and most forested land cover. These more western areas also correspond with areas with higher soil infiltrative capacity. Alternatively, the eastern portion of the City corresponds with a higher intensity of developed land and industrial land use corridor as well as the City's urban core. Consequently, this area also corresponds to soils that are considered urban and tend to have less infiltration capacity and possesses a topography that includes some considerably steep slopes.

The James River and several of its tributaries [(Almond Creek, Falling Creek, Goode Creek, Powhite Creek, Reedy Creek, Bernards Creek, and Gillies Creek and Upham Brook (which is a tributary to the Chickahominy River and ultimately the James River)] have all been listed as impaired due to *E. coli* levels. The sources of bacteria in these streams within the City limits include CSOs, the MS4, the WWTP, direct discharge of urban runoff, and wildlife. Upstream sources also impact water quality in the City. Upstream sources include livestock, land application of manure, malfunctioning septic systems, illicit discharge of residential waste, other permitted waste treatment facilities. Reducing bacteria levels in these streams is consistent with the City's goal to provide safe recreational opportunities in the river.

The number of available water quality samples are biased heavily towards the James River, with little-to-no data available in tributary streams. Additionally, there is a lack of hydraulic data within the City, with the only local USGS gauges located outside the City limits. Biological samples and habitat assessments are also limited.

Water Quality Modeling

Water quantity and quality modeling was conducted to allow for longer and continuous periods to be evaluated relative to the water quality monitoring program. The purpose of the modeling framework is to quantify present day bacteria (E. coli) loads and concentrations in the James River and to predict future bacteria loads and concentrations under the Clean Water Plan strategies. The modeling framework also allowed for the quantification of discharge flows and volumes, as well as the occurrence of CSO events.

Three models were used to achieve the modeling objectives and include:

- A watershed model, created using EPA's Stormwater Management Model (SWMM), to simulate flow and bacteria loads from contributing areas of tributaries to the James River within the greater Richmond area, as well as from Richmond's Municipal Separate Storm Sewer System (MS4), but excluding the combined sewer system.
- A collection system model, created using EPA's SWMM framework, to simulate flow and bacteria loads from the combined sewer system (CSS).
- A receiving water quality model, created using EPA's Environmental Fluid Dynamics Code (EFDC) model, which computes bacteria concentrations in the James River resulting from the various sources of bacteria to the river. The outputs of the watershed and CSS models are used as inputs to the receiving water quality model.

After the water quality modeling tools were developed and calibrated, they were jointly applied to assess water quality benefits associated with the selected strategies (described further below). Under current conditions, the model results illustrate that the James River is in violation of both the geometric mean and the statistical threshold value water quality standard criteria for some months out of the three year model simulation period, and the primary cause of a water quality criteria violation can sometimes be linked to Richmond's combined sewer overflows, while at other times it is due to upstream sources coming in from outside of the City. Background (mainly wildlife) and stormwater sources play a smaller overall role in the bacteria water quality violations. The WWTP does not contribute significantly to bacteria water quality violations.

Strategy Identification, Evaluation & Selection

Goals and Objectives Selection

The City implemented a multi-step process with stakeholders to form consolidated lists of overarching goals, refined goals, and objectives. Although a number of opinions and viewpoints were represented through the stakeholder process, ultimately, stakeholders achieved consensus on the overarching goal, refined goals, and objectives.

Weighting was incorporated into this process to reflect the priorities of the City and its stakeholders. This weighting process not only allowed for an understanding of how one goal or objective ranked in relation to another, it also provided information on the extent of the importance of these priorities to one other. The result of this process was a prioritization of refined goals as well as a prioritization of objectives associated with each of these goals.

The goals, objectives, and respective weights are summarized in Table ES.1.

Table ES.1 Clean Water Plan goals and objectives with associated weights

Goals (with weights)	Objectives	Weights
19%: Manage wastewater and stormwater to improve the water quality and water quantity of ground water and surface water.	Develop one stormwater management plan to cover the City's four watershed groupings based on the City's watershed characterization report.	19%
	Reduce nitrogen, phosphorus, and sediment in discharges to achieve VPDES permit requirements (Chesapeake Bay TMDL).	18%
	Reduce bacteria levels to achieve VPDES permit requirements (local TMDL and water quality standards).	18%
	Reduce toxics (e.g., mercury, PAHs, PCBs), trash and other pollutants and address TMDLs for these pollutants.	17%
	Develop green infrastructure, including riparian buffers, and removal of impervious surfaces on development, existing development, and redevelopment.	27%
15%: Protect and restore aquatic and terrestrial habitats to support balanced indigenous[2] communities	Restore streams to improve, restore, and enhance native ecological communities.	25%
	Identify, protect, and restore critical habitats.	36%
	Enhance aquatic and terrestrial habitat connectivity.	23%
	Investigate, and where feasible, promote actions that might surpass regulatory requirements.	16%
14%: Engage and educate the public to share responsibility and take action on achieving healthy watersheds.	Engage and efficiently educate the public about standards, processes, and actions associated with watershed health and public health.	25%
	Assist in the education of citizens about overall water quality issues, benefits of improved water quality.	30%
	Support and encourage local action to improve water quality.	24%
	Provide quicker public notifications of spills or pollution from regulators or other "river watchers"	21%
12%: Implement land	Protect, restore, and increase riparian buffers	21%

[2] The language included here was crafted based on Technical Stakeholder discussion and a resulting consensus process. For clarification, however, this refers to balanced indigenous ecological communities.

conservation and restoration and incorporate these into planning practices to improve water quality.	Reduce impervious surfaces	19%
	Increase natural land cover with a focus on preserving, maintaining, and increasing tree canopy.	24%
	Incorporate green infrastructure in new development and redevelopment	18%
	Conserve lands where possible and consistent with Richmond's Comprehensive Plan	18%
11%: Create partnerships across the watersheds internal and external to the City of Richmond to maximize benefits and minimize impacts to all stakeholders	Develop and implement a source water prevention plan/strategy	33%
	Establish public-private partnerships to secure funding, implement strategies and projects, and to achieve plan goals.	40%
	Maintain and expand the RVAH20 group.	27%
10%: Maximize water availability through efficient management of potable, storm, and wastewater.	Reduce use of potable water for industry and irrigation.	39%
	Achieve water conservation by improving the existing water conveyance system.	30%
	Achieve water conservation by incentivizing upgrades to end-user water fixtures where appropriate.	31%
9%: Provide safe, accessible, and ecologically sustainable water-related recreational opportunities for all.	Improve water quality to promote safe recreation consistent with the City's Riverfront Plan.	36%
	Promote ecologically sustainable management of riverfront and riparian areas.	40%
	Improve river and waterfront access for recreation.	24%
9%: Work collaboratively to gather consistent high-quality data to characterize the status and trends of water resources and to gauge the effectiveness of restoration efforts.	Conduct water quality and biological monitoring	28%
	Provide timely water quality information.	19%
	Collaborate with citizens and local/state agencies for coordinated monitoring.	23%
	Utilize results to target restoration efforts and convey progress.	30%

Strategy Identification

The next step in this process was the identification of strategies that can be expected to achieve the previously identified goals and objectives. Strategies were defined as activities, actions, or items that will help meet goals and objectives.

The first step in brainstorming potential strategies included a workshop for DPU staff involved in stormwater, wastewater, and CSO-related projects. Because the Clean Water Plan would be implemented during the next VPDES permit cycle (2018 - 2023), staff compiled a list of projects that had been identified or proposed to meet various programmatic needs and could be implemented over that period. Because many of these projects impact small-scale areas, these City projects were "rolled up" to a strategy scale where necessary.

In addition to these DPU projects, stakeholders were also asked to submit suggestions for strategies that they felt would achieve the agreed upon goals and objectives. The Clean Water Plan development team created a synthesized set of draft strategies that consolidated ideas put forth by both stakeholders and DPU staff.

Once the draft set of strategies was identified, it was important to determine if these strategies were feasible. Because DPU is ultimately responsible for implementation of this program, the feasibility of strategies was defined as efforts that DPU has the authority to implement.

Final draft strategies and supporting actions were presented to stakeholders who were given the opportunity to edit them further. Supporting actions include efforts that may broaden the main strategy, add specificity on how a strategy could be implemented, or identify additional resources and data needs to fully implement the main strategy. Each of the strategies referenced in the remainder of the Clean Water Plan are considered to be "feasible" and agreed upon by the Technical Stakeholder group (Table ES.2).

Table ES.2. Strategies and associated details

Strategy	Strategy Details
Riparian Areas	Replace or restore 10 acres of riparian buffers according to state guidance. • In MS4 and/or CSS area • Evaluate opportunities for inclusion of access points to waterbody for recreational activities
Green Infrastructure in MS4	Install or retrofit GI draining 104 acres of impervious surfaces, including efforts such as: • 30 acres on DPU property • 18 acres on City-owned vacant properties • 20 acres on Parks department property (one playground/park per year, cemetery roadways, impervious to pervious area in park properties, vacant properties) • Install 100 trees in tree boxes (e.g., Filtera-type practices); 30 acres total drained to this practice • Retrofit 4 DPU stormwater BMPs (e.g., dry ponds to more efficient BMPs), draining at least 6 acres of impervious surface
Green Infrastructure in CSS	Install or retrofit GI draining 18 acres of impervious surfaces, including efforts such as: • 6 acres on DPU property • 2 acres on City-owned vacant properties • 2 acres on Parks department property (one playground/park per year, cemetery roadways, impervious to pervious area in park properties, vacant properties) • Install 24 trees in tree boxes (e.g., Filtera-type practices); 8 acres total drained to this practice
Stream Restoration	Restore 2,500 linear feet of stream: • Through removal of concrete channels, repair of incised banks, etc. • In MS4 and/or CSS area • Evaluate opportunities for inclusion of access points to waterbody for recreational activities
Natives/Invasives	Use 80% native plants in new landscaping at public facilities by 2023.
Trees	• Increase tree canopy on City property by 5% (80 acres added) • Protect existing tree canopy by following maintenance addressed in the Tree Planting Master Plan
Land Conservation	Place an additional 10 acres under conservation easement, prioritizing conservation of land that creates connected green corridors. • Evaluate opportunities for inclusion of access points to waterbody for recreational

	activities
Water Conservation	Reduce water consumption by 10% through implementation of new water conservation technologies and promotion of water conservation efforts, including: • Installing water-efficient fixtures as a policy by 2023 in all new public facility construction • Implementing incentive programs • Encouraging water conservation on City properties
Pollution Identification and Reduction	Reduce contribution of pollutants to the MS4 through: • Conducting at least one special study per year in hot spot areas to identify illicit discharges/connections. (Studies will meet the criteria necessary to achieve Bay TMDL pollutant reduction requirements. Assume that, over five years, three of these studies will result in pollutant reductions that meet Bay TMDL requirements.) • Collecting data associated with non-structural BMPs to facilitate quantification of pollutant reduction (e.g., storm drain clean-outs, pet waste stations, street sweeping)
CSS Infrastructure	LTCP projects, including: • Installing wet weather interceptor to convey more flow to the WWTP • Increasing WWT to 300 MGD at the treatment plant • Expanding secondary treatment at the WWTP to 85 MGD • Expanding Shockoe retention basin by 15 MG to capture more overflow • Disinfecting overflow at Shockoe retention basin (wet weather disinfection facility) *Note that that the modeling framework will be applied during the summer and fall of 2017 to evaluate alternative CSS reduction projects that may provide similar benefits to the LTCP projects, but at a reduced cost.*

Strategy Evaluation

Once strategies were drafted, an analysis was needed to determine which ones would be best for implementation. There are multiple factors at play that influence the selection of strategies. A strategy may do well with one factor, such as permit-related pollutant reductions, but not so well with others, like cost. As a result, the analysis of the various factors did not result in a clear and decisive outcome of one strategy that performed the best across all factors. What the strategy evaluation did determine was that all of the “pieces of the puzzle” needed to be evaluated collectively to achieve a complete picture of how well strategies achieve specific goals (Figure ES.1).

Figure ES.1. Puzzle piece conceptual model demonstrating how various factors fit together to inform the decision making process

An Excel-based strategy scoring calculator was developed to compare the various strategies proposed through this stakeholder process. This tool helped in the decision-making process by allowing the City and stakeholders to evaluate various alternatives by assigning scores to the alternative strategies.

The methodology used for this scoring calculator is a multi-objective decision analysis (MODA). A set of metrics was developed that includes a method of measurement. At least one metric was identified for each objective.

Multiple “puzzle pieces”, or factors, were taken into consideration in the analysis of strategies (Figure ES.1). The **Permit** puzzle piece represents the VPDES permit-related requirements that establish pollutant reduction targets by which the strategies were compared.

The **Strategy Score** “puzzle piece” involved using the calculator tool to evaluate strategy scores in several different ways. These analyses included evaluating:

- Permit-related metrics – metrics that related to total Nitrogen (TN), total Phosphorus (TP), total suspended solids (TSS) and bacteria were isolated in the calculator and scores associated with just these metrics were used to evaluate the effectiveness of strategies in reducing these pollutants of concern
- “Standardization” of strategies addressing permit-related metrics – strategies, which varied in size, were all standardized to 10 acres to compare these permit-related metrics in an “apples to apples” manner
- All metrics – including the full set of metrics associated with all of the objectives in addition to the pollutant-related metrics
- “Standardization” of all metrics – comparing how the same sized strategies (all 10 acres) address all metrics

The calculator tool was also tied to the **Strategy Cost** information. Metrics specific to pollutant reductions (e.g., pounds of pollutant removed by a strategy) were used to calculate **Cost Effectiveness**. Overall, strategy costs were then evaluated in association with **Affordability**.

Another puzzle piece, **Modeling Results,** provided the bacteria reductions associated with several strategies that were used as raw score inputs into the calculator. Modeling results also provided information pertaining to the relative nature of bacteria sources to the James River and tributaries.

After taking the evaluation process through the “Standardization of all metrics”, the following top-ranked strategies resulted:

1. Riparian Area Restoration
2. Stream Restoration
3. Green Infrastructure in the CSS area
4. Green Infrastructure in the MS4

The various “pieces of the puzzle” were used to understand how to best prioritize activities for implementation. What these analyses have shown is that no one strategy consistently scores the highest or performed the best across the analyses, however, several strategies consistently performed well (a summary of the analyses are included in Table ES.3; green highlighted information depicts those that consistently score highest).

Table ES.3. Summary of Strategy Analysis and Strategy Prioritization

Rank	Pollutants of Concern Metrics	Pollutants of Concern Metrics: Standardized*	All Metrics	All Metrics: Standardized*	Cost Effectiveness (TN)	Cost Effectiveness (TP)	Cost Effectiveness (TSS)	Cost Effectiveness (bacteria)
1	**CSO Infrastructure**	**Stream restoration**	**GI in MS4**	**Riparian**	**Stream restoration**	**Stream restoration**	**Stream restoration**	**CSO Infrastructure**
2	**Stream restoration**	**GI in CSS**	**Riparian**	**Stream restoration**	Water conservation	Pollution ID and reduction	**Pollution ID & reduction**	**GI in CSS**
3	**Pollution ID & reduction**	**GI in MS4**	**Stream restoration**	**GI in the CSS**	**GI in MS4**	**GI in MS4**	**GI in MS4**	**GI in MS4**
4	**GI in MS4**	**Riparian**	**CSO Infrastructure**	**GI in MS4**	**GI in CSS**	**GI in CSS**	**GI in CSS**	**Riparian**
5	**GI in CSS**	Water conservation	Water Conservation	Water Conservation	Pollution Identification	Water conservation	Water conservation	
6	**Riparian**	Trees	Trees	Land Conservation	**CSO Infrastructure**	**Riparian areas**	**Riparian areas**	
7	Trees	Pollution ID & reduction	Natives/ invasives	Natives/ invasives	**Riparian**	**CSO Infrastructure**	**CSO Infrastructure**	
8	Water Conservation	Natives / invasives	Land Conservation	Trees	Trees	Trees	Trees	
9	Natives/ invasives	Land Conservation	**GI in the CSS**	Pollution Identification				
10	Land Conservation		Pollution ID and reduction					

*WWTP/CSO strategy cannot be evaluated on a 10-acre basis so it is not included herein

To allow for the consideration of multiple factors in determining priorities, it was determined that rather than ranking 10 strategies individually, that strategies would be grouped into one of three tiers based on effectiveness (Figure ES.2). Tier 1 includes those strategies that best address metrics associated with the pollutants of concern (total Nitrogen, TN; total Phosphorus, TP; total suspended solids, TSS; bacteria) as well as the non-pollutant related metrics. These strategies were also the most cost effective. Tier 2 also addressed pollutant and non-pollutant related metrics, but not as efficiently or cost effectively as those in the Tier 1 grouping. Tier 3 are those strategies that do not address the pollutants of concern.

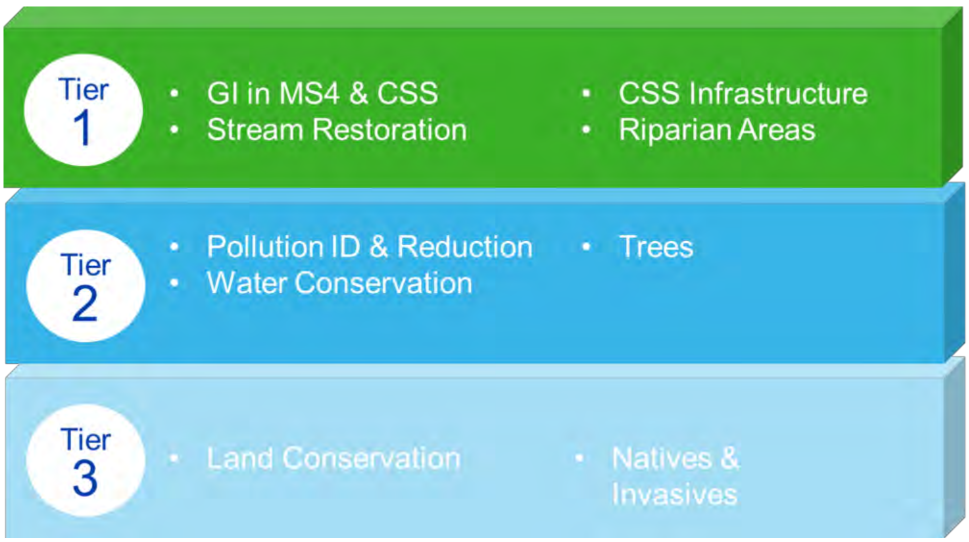

Figure ES.2. Organization of strategies into tiers for prioritization

It is important to note that while select strategies may be *prioritized,* it does not mean that the remaining strategies will be disregarded. Implementation of these strategies will be assessed based on additional resources available to DPU or priorities and resources available from other City departments or other partners.

It is also important to note that this analysis was done at a high level. As DPU moves toward implementation and conducts a more refined evaluation of strategies, there may be modifications to this prioritization.

Program Implementation

An important part of this RVA Clean Water Plan is developing an approach that can help the City implement these strategies in the most efficient and cost effective manner possible. DPU will use a "Framework Planning" approach. The Framework Planning approach provides a methodology that ties together different strategies (and, subsequently, site-specific projects) and, where possible, aligns these strategies with other City or stakeholder-driven initiatives. The goal of the Framework Planning Approach is to identify and sequence a blend of activities that yield the greatest environmental benefit (as measured by identified metrics) in the most cost-effective (and affordable) manner. The Framework Planning approach includes the following elements:

1) Data and information gathering
2) Identification of potential opportunities

3) Prioritization
4) Plan development
5) Implementation

There are several important concepts that will be taken into account through implementation. For instance, it is envisioned that implementation will occur incrementally over the course of the permit cycle (e.g., 10 acres of riparian buffers will not necessarily be restored all at once or within only one project, but may be addressed through the implementation of several projects/project clusters). Flexibility is incorporated into implementation through adaptive management. If it is found that one strategy cannot be implemented in whole or in part, DPU will work to identify an alternative approach to achieving the same or similar pollutant reductions and other identified goals and objectives.

Implementation of projects, particularly those that involve stakeholders or other City departments, will require significant coordination. In addition to regular Technical Stakeholder meetings to provide updates on progress, DPU will convene a workgroup of those organizations involved in these implementation efforts. As projects are implemented, associated benefits (pollutant reductions, area treated, other metrics addressed) will be tracked as well.

Progress Measurement

As the City's implementation moves forward, measuring progress will include determining if goals have been met, if progress has been deemed sufficient, or if changes should be made within the program to try to improve the level of progress made. Measuring progress; however, can be complex. Targets may be established at various scales (i.e., site scale, sub-watershed, watershed, city scale). Implementation actions can also include a wide range of options including structural and non-structural practices as well as practices that address various source sectors (i.e., stormwater, wastewater, non-point sources). As a result, the approach used for measuring progress under the City's program must be flexible enough to account for these variations in scale and options that will be employed to mitigate pollutants and meet the City's goals.

Measuring progress will be done in a holistic manner based on data from the City's monitoring programs, modeling efforts, and other programmatic information (e.g., implementation targets, such as miles of stream buffers restored per year or number of residents reached by outreach efforts). Each element of this process to evaluate Clean Water Plan progress will occur on a regular/annual basis over the course of the permit. Each of these elements is outlined in Table ES.4.

Table ES.4. Monitoring activities and associated outcomes implemented under the Clean Water Plan

Activities		Outcomes
Water Quality Monitoring	Instream water quality, biological (e.g., macroinvertebrates), CSO and WWTP discharge monitoring	Progress made toward pollutant reduction targets in permit
		Progress toward achieving WQS (e.g., measure improvement in aquatic life designated use)
		Identify sources, stressors, or pollutants of concern
		Identify trends over time
	BMP monitoring	Effectiveness of specific BMPs or source reduction efforts
		Progress toward achieving WQS (e.g., measure improvement in aquatic life designated use)
Programmatic Monitoring	Tracking strategy implementation	Progress made toward strategy implementation goals (e.g., acres of green infrastructure implemented)
		Progress made in pollutant reduction through strategy implementation (e.g., pounds of TN reduced through green infrastructure implemented)
		Progress made toward pollutant reduction targets identified in permit
Modeling	Receiving water, CSS, and watershed modeling and analysis	Progress made in bacteria WQS compliance
		Progress made in bacteria load reduction
		Progress made in reduction of CSO events or volume discharged

Next Steps

The RVA Clean Water Plan has resulted in a comprehensive understanding of the City's watersheds and associated water resources. The next step is to use the Clean Water Plan to develop a watershed-based VPDES permit. Watershed-based permitting has been long supported by EPA and allows multiple pollutant sources to be managed under one permit. For Richmond, these pollutant sources are CSO, wastewater, and stormwater via the MS4 and direct drainage. The Clean Water Plan provides the planning framework and strategies to manage these sources and prioritize control projects based on their improvements to local waterways. Therefore, the Clean Water Plan will be included in the VPDES permit as a source of data and provide information to be included in the "Special Condition" section related to best management practices (BMPs) to be implemented and additional monitoring to be done to track progress. The Clean Water Plan will also be included in the Permit Fact Sheet as an information source.

Once the watershed-based VPDES permit is issued to the City, next steps include implementing the projects and programs in the Clean Water Plan and conducting monitoring and modeling to measure progress towards the goals of the plan. The City will also continue to engage stakeholders to inform them of activities and associated progress towards the goals of the Plan, and solicit their input on Plan updates.

The Modeling Framework will continue to be used as needed to evaluate the water quality improvements related to the implementation of projects and strategies. Additionally, it is anticipated that the modeling framework will be applied during the summer and fall of 2017 to evaluate alternative CSS reduction projects that may provide similar benefits to the Long Term Control Plan (LTCP) projects, but at a reduced cost.

1. Background and Introduction

The City of Richmond's Department of Public Utilities (DPU) manages five utilities, three of which address water: wastewater, stormwater, and drinking water. As all three of these utilities can influence local water resources, such as the James River, each operates under regulations and permit requirements established to ensure protection of the environment and public health.

The Wastewater Utility was implemented to operate and maintain the wastewater treatment plant (WWTP), which discharges treated effluent to the James River (45 MGD dry weather flow and 75 MGD wet weather flow). The Utility also operates and maintains a sanitary sewer and combined sewer collection system, pumping stations, and the Hampton-McCloy Tunnel, storage capacity of 7.2 million gallons, and the Shockoe Retention Basin, a 50-million gallon reservoir used during heavy rains.

The Stormwater Utility is relatively new compared to the other utilities. It was implemented in July 2009 to manage the stormwater that runs off impervious surfaces. The Stormwater Utility also enhances public safety and health and protects property by improving the quality and decreasing the quantity of polluted stormwater runoff. Approximately two-thirds of the City of Richmond is served by a municipal separate storm sewer system (MS4). This mixture of underground storm sewer systems and open channels are separate from the sanitary sewer system.

The City of Richmond is one of the largest water producers in Virginia, with a modern plant that can treat up to 132 million gallons of water a day from the James River at the western edge of the City. The Drinking Water Utility manages the treatment plant and distribution system of water mains, pumping stations, and storage facilities that provide water to more than 200,000 customers in the city. The facility also provides water to the surrounding area through wholesale contracts with Henrico, Chesterfield, and Hanover counties. All total, this results in a facility that provides water for approximately 500,000 people.

Historically, the three utilities were managed independently of one another, primarily driven by the fact the regulations and permit requirements established by the regulatory agencies were also implemented independently. This approach forced the City to make decisions related to compliance for each utility without being able to consider the interrelated impacts. There is often overlap in these requirements and sometimes an action occurring under one regulatory program has a direct impact on another. For instance, separating a combined section of sewer leads to impacts on the separate sanitary sewer system and the storm sewer system. Integration of all of the separate programs into a coordinated approach is necessary to eliminate redundant activities and be more efficient and effective addressing wet weather impacts and improving water resources overall.

USEPA Integrated Planning Frameworks

USEPA has put a significant amount of effort in recent years into describing and publicizing its vision of management of these separate programs through the concepts of Integrated Planning (EPA 2011, EPA 2012a), Integrated Watershed Management (EPA 1996, EPA 2008), and Watershed-based Permitting

(EPA 2007, EPA 2003). An emphasis within each of these concepts involves providing an opportunity to examine different possible ways to look at protecting water quality given very limited resources at both the City and the state level. Often these limited resources must be used to manage and implement multiple and costly regulatory requirements, such as:

- Replacing/repairing aging infrastructure;
- Developing and implementing long-term control plans (LTCPs) for combined sewer overflows (CSOs);
- Developing and implementing capacity, management, operation and maintenance programs for sanitary sewer overflows (SSOs);
- Improving peak flow management at WWTPs;
- Addressing requirements to control nutrients and emerging contaminants at the WWTP;
- Managing stormwater to mitigate flooding;
- Developing and implementing MS4 pollution prevention plans;
- Investing in treatment technologies to comply with effluent limits based on total maximum daily loads (TMDLs); and,
- Complying with Safe Drinking Water Act and/or National Pollutant Elimination Discharge System (NPDES) requirements.

All of these issues are currently of importance to the City of Richmond, or will be over time. All of these activities or requirements are rarely coordinated or considered in a holistic manner. Without coordination among these competing demands, the City's constrained resources aren't likely to achieve the maximum benefit to the utility, the public, and the environment. Too often, the need for investment (especially for wet weather controls) greatly exceeds the City's financial capacity, even over a 20-year period. As a result, there is uncertainty in prioritizing investments, and with how to create a plan that progressively moves toward meeting clean water goals.

To address these issues, Richmond is using EPA's Integrated Watershed Management and Integrated Planning frameworks for planning purposes. Because both of these have a number of consistencies between them, these approaches have been combined and organized to form a framework that allows the City to efficiently evaluate, manage, and implement water quality programs and work toward their goals and objectives (see Figure 1.1). The endpoint of this overall effort is a single, integrated VPDES permit that encompasses DPU's wastewater, CSO, and stormwater discharges.

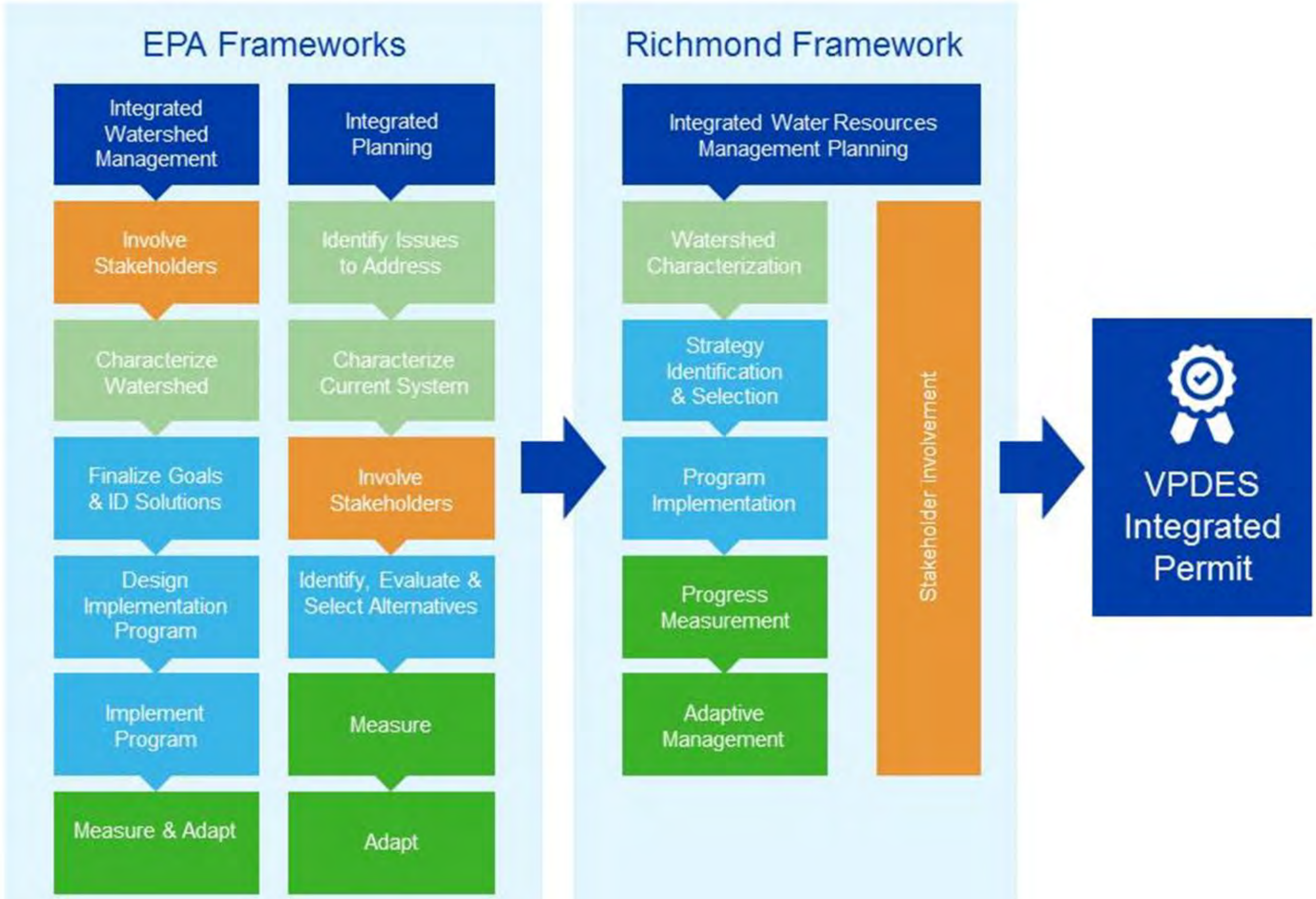

Figure 1.1 – Demonstration of the overlap in elements between EPA's Integrated Watershed Management and Integrated Planning Approaches and how these elements have been merged to develop the framework for the Integrated Water Resources Management Plan where stakeholder involvement is a part of each step of the process.

Richmond's Clean Water Plan Framework

Efforts to prioritize a community's investments have traditionally tended to focus on meeting infrastructure-related goals, such as reduction in the number of CSOs. The focus of the RVA Clean Water Plan, however, is on the watershed and restoring and protecting the waterways in these watersheds. Given this focus, the Clean Water Plan is framed by water quality standards (WQS) and watershed goals rather than solely by municipal infrastructure project considerations. This watershed-wide, water quality-based strategy allows the City to develop an effective and affordable management plan while also meeting regulatory requirements and demonstrating to the public that the plan protects and improves the watershed and waterways. The integration includes the WWTP, CSO, and stormwater programs, and maintaining minimum in-stream flows. Richmond is also taking drinking water and source water protection into consideration to ensure a more comprehensive focus on overall watershed health.

The City's Department of Public Utilities began the Clean Water Planning process in March of 2014 (see Figure 1.2), with the establishment of a Technical Stakeholder Group and related outreach plan. The effort continued in January, 2015 with a watershed characterization effort that culminated in the development of a Watershed Characterization Report (Richmond DPU 2015). Work on the Clean Water Plan began in 2016, which will ultimately be used to inform the development of an integrated Virginia Pollutant Discharge Elimination System (VPDES) permit that collectively addresses DPU's discharge permit requirements. The permit application is due to VDEQ in January, 2018, with the Integrated VPDES permit expected to be reissued in June of 2018.

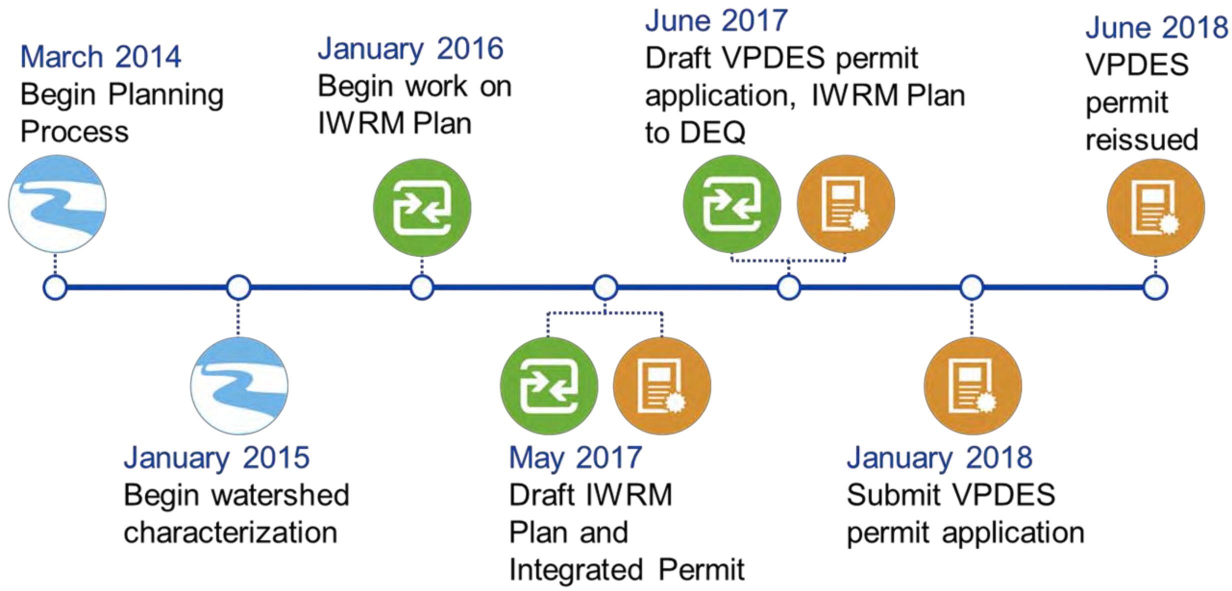

Figure 1 .2– Richmond's schedule for the development of a Watershed Management Plan (WMP), Integrated Plan and Watershed-based Permit (WBP)

Richmond's Clean Water Plan includes six elements, which are summarized below and discussed in more detail in the subsequent sections of this document.

Stakeholder Involvement

DPU determined early on that community input and support would be key to the success of its Clean Water Plan as this support would facilitate development of an integrated VPDES permit as well as future implementation efforts. It was felt that this input and support could be gained by implementing a thoughtful, well-informed approach that demonstrates the Utility's commitment to improving the environment while continuing their good stewardship of their infrastructure assets and local water resources. Community support was especially important in considering priorities and options for improving and protecting the City's waters.

Watershed Characterization

The watershed characterization process within the Clean Water Plan provides the data needed to support this process. This includes data such as monitoring related to meeting receiving water standards and goals, and characterizing receiving water conditions and sources of pollutants throughout the watershed. Existing data are compiled and, if necessary, new data are collected to provide the data needed to complete the watershed characterization. Evaluating data from a watershed perspective helps to facilitate a watershed-based approach to planning and, subsequently, implementation. Ongoing data collection will ensure the Clean Water Plan is up-to-date and accurate, and will facilitate future updates using an adaptive management approach. A beneficial outcome will be that data collected through watershed characterization efforts will serve multiple purposes. For instance the activities associated with the TMDL development and implementation will help determine appropriate targets for the Clean Water Plan.

Strategy Identification, Evaluation, and Selection

The data collected through the watershed characterization effort serves as the basis for helping to identify and quantify problems or issues of concern within the watersheds. This helped guide the selection of goals and objectives the City and its stakeholders identified for this process. As high-level strategies to meet these goals were identified, they were incorporated into an Excel-based strategy scoring calculator that included the weighting of these goals, associated objectives, and metrics by which these strategies were measured. Other factors, such as strategy costs, cost effectiveness, and watershed and water quality modeling results, were also used to prioritize strategies.

Program Implementation

After selection and prioritization of high-level strategies is completed, these high-level strategies (e.g., Green Infrastructure implementation in the MS4 area) will be translated into localized projects (e.g., two acres of bioretention and one acre of pervious pavement in a particular subwatershed). A “Framework Planning” approach is being used to strategically direct implementation in a way that aligns activities that yield the greatest environmental benefit in the most cost-effective manner.

Progress Measurement

Once projects and programs have been implemented, measuring progress will be accomplished through a three-pronged approach. This will include programmatic tracking, which will involve evaluating the progress made toward strategy implementation (e.g., acres or feet of implementation, etc.) as well as the pollutant reduction calculated through this implementation. The City will also conduct water quality monitoring to evaluate progress made toward pollutant reduction targets in the permit, progress made toward achieving WQS, and trends over time. Modeling will also be used to evaluate progress made toward bacteria-related WQS, bacteria load reductions, and reduction of CSO events or volume discharged. Progress will be reported annually through VPDES permit-related reporting.

Adaptive Management

Because the City, its waterbodies, regulatory drivers, and community needs are not static, City and stakeholder priorities may also change over time. The Clean Water Planning process incorporates flexibility to address these changing needs. This flexibility, or adaptive management, is an iterative, ongoing, learning process used to continually improve understanding of the City’s programs and practices by learning from their outcomes over time.

Adaptive management will be critical for the success of Richmond’s Clean Water Plan as new data collected through the course of this effort will be used to refine and modify the Plan so it is up-to-date and accurate.

2. Stakeholder Involvement

From the very beginning, the City knew stakeholder involvement would be a key component of developing and implementing an effective and successful integrated approach to the City's water resources management. While building partnerships is identified as one "Step" in both EPA's Integrated Watershed Management and Integrated Planning processes, the City has actually incorporated stakeholder involvement throughout the entire planning process to help ensure stakeholders understood the process from the very beginning and were part of decision-making efforts along the way. It also helped ensure that stakeholders had a voice to convey any concerns they may have or encourage sharing of data and information that could be helpful with planning, and subsequently, implementation efforts.

To aid in this communication effort as well as in the dissemination of outreach information, DPU created and initiated RVAH2O (RVAH2O.org). The name was formed from "RVA," which is popular shorthand for Richmond, Virginia, and "H2O," which is the chemical formula for water. Together, the name represents a citywide effort to arrive at "Cleaner Water Faster."

The RVAH2O.org website educates the community about ways to keep the City's waterways pollution-free and the importance of integrating drinking water, wastewater, and stormwater under one watershed management program. It is all water. The website is also used to share information conveyed during Technical Stakeholder and public meetings discussing the Clean Water Planning process. RVAH2O has also been expanded into a Facebook page and Twitter feed to reach a larger public audience. The logo and its clean water messages appear on billboards, bumper stickers, community meeting handouts, school bulletin boards, and on DPU booths and water stations at community events and water-related festivals.

A detailed discussion of each of the elements of the stakeholder involvement process is included below, as well as further detail surrounding public outreach.

Stakeholder Identification

Stakeholders can represent many different groups with an interest in the watershed, including, for example, advocates for wildlife and habitat protection; boaters; residential, commercial and business interests; and environmental justice groups. As discussed in the City's Watershed Characterization Report, an initial step in this process was the identification of groups or individuals that would be interested in being more involved in the City's water future and/or would potentially bring data, information, and insight to the table that could assist the City with reviewing the problems and looking at the relative contribution of all sources and stressors on the watershed.

The City reached out to a variety of stakeholders in and surrounding the City, including environmental advocates, recreational users of the James River, property owners, businesses, and state and local governmental agencies and representatives.

The initial stages of the stakeholder involvement process resulted in categorizing these participants into several groups based on expected technical knowledge and perceived level of interest and involvement. As a result, a Technical Workgroup was formed to provide technical insight and feedback on the Clean Water Planning process. This group included representatives of groups such as:

- Chesapeake Bay Foundation
- James River Association & Riverkeepers
- The Nature Conservancy
- Middle James Round Table
- Alliance for the Chesapeake Bay
- Virginia Department of Environmental Quality (VDEQ)
- Virginia Department of Health (VDH)
- City Department of Public Works (DPW)
- The Reedy Creek Coalition
- Fall of the James Scenic River Group
- James River Park System
- Virginia Commonwealth University (VCU)
- Richmond Regional Planning District Commission
- James River Outdoor Coalition
- Capital Region Land Conservancy
- Marine Resources Commission
- University of Richmond
- American Water
- Tree Stewards of Richmond
- The Counties of Hanover, Chesterfield & Henrico (reached through the Planning District Commission)

Additionally, a special interest and public stakeholder group was identified with participants anticipated to have a high level of involvement. This group included representatives of organizations such as:

- Friends of James River Park
- Sierra Club – Falls of the James Group
- Home Builders Association of Virginia
- Hispanic Chamber of Commerce
- Richmond City Council Districts
- Richmond Paddle Sports and other sports organizations

Participants in this special interest and public stakeholder group with an anticipated lower level of involvement included representatives from organizations such as:

- Richmond Audubon Society
- James River Advisory Committee
- Retail Merchants Associations
- Tenant, Civic and Neighborhood Associations

The City's Watershed Characterization Report includes additional discussion of the various stakeholders that have been invited to participate and/or are participating within this planning process.

Once stakeholders were identified, kick-off meetings were held in November 2014 to speak with the technical stakeholders and the special interest/non-technical stakeholder group. A meeting schedule was developed early on to ensure consistent communication with the technical stakeholders on a quarterly basis and with the special interest/public stakeholder group approximately every six months.

Technical Stakeholder Meetings

Since the initial meetings in November 2014, technical stakeholder meetings have been held regularly every two to three months and have accomplished several specific objectives including: identifying issues of concern, setting goals, developing indicators to track progress, and conducting public outreach. Information on the Technical Stakeholder meetings (including when and what information was discussed at each meeting) can be found on the RVAH2O.org website under meetings.

The activities of the Technical Stakeholder workgroup have included:

- Determining the overarching goal for the City of Richmond's watershed plan
- Identifying and weighting goals and multiple objectives and strategies
- Meeting bi-monthly to shape the plan's contents and discuss outstanding issues
- Forming partnership agreements that will aid in achieving cleaner water faster

The majority of technical stakeholders have found the meetings to be important opportunities to learn about and discuss watershed issues, and have expressed interest in continuing to meet regularly once the Plan and Permit are in place.

Public Meetings

At the outset of this initiative, a survey of the Richmond public was conducted to establish a baseline of knowledge about Richmond's water systems. It was determined that Richmond residents had limited knowledge about water sources, water quality and their role in helping to keep waterways clean and litter-free. Using RVAH2O as a platform, 2015 was the start of a public outreach effort to lay a foundation of understanding before laddering up to the more technical conversation around watershed integration.

First, a flier was created to illustrate how a household contributes to stormwater pollution. This was widely distributed at libraries, schools, neighborhood meetings, and public events.

Then, a series of posters were created to be put up around the City, each with a theme related to its location: 1) Pet waste poster mounted at dog parks and veterinary offices; 2) Automotive oil poster mounted at service stations and oil-changing stations; 3) Cigarette butt poster mounted at workplaces where people take smoking breaks, etc. In all, six themed posters were created.

An initial public meeting was held in October of 2014. This provided an opportunity for a high-level introduction to the City's regulatory requirements, what has been done to date to address water quality in the City, and the City's goals moving forward. On June 9, 2015, an open house was held at the Science Museum of Virginia to provide opportunity for the general public to be introduced to the City's Integrated Planning process (Figure 2.1). Five different stations were set up, each at which a different topic area was discussed. There were over 50 attendees recorded from the general public. Each station was staffed with members of the RVAH2O team or other DPU staff. This provided a one on one opportunity for the public to ask questions about each station including:

- The watersheds

- The stormwater, sanitary, and wastewater collection systems
- Stormwater issues
- The James River and associated creeks and streams
- Outreach and educational information

A station was also set up at which the public could sit down and anonymously submit questions and comments for the RVAH2O team.

In general, it was observed that attendees expressed knowing little about the river's needs coming in, but by the end, their post-it note comments and comment cards seemed to demonstrate that they had obtained a real grasp of the needs and concerns for water quality in Richmond.

This public open house was deemed a success and in the following year, August 2016 and September 2016, two more open houses were held in local parks (Figure 2.2). Attendance at the first 2016 event was 52; at the second, due to a storm, attendance was less than 10. However, this format for sharing information as the watershed program evolves will continue.

Figure 2.1. Flier advertising the June 9, 2015 community open house

Conducting Public Outreach

While technical stakeholders have been involved during each step of the Clean Water Planning process, the City also recognized the need to conduct a wider public outreach effort related to the City's water resources. The RVAH2O initiative also aims to further educate and identify ways in which the community can be involved in clean water management. The benefits of the effort are two-fold: to help ensure a wider dissemination of information associated with the RVAH2O initiative (integrated water resources planning) as well as to conduct outreach and education related to the City's various water related programs.

Outreach and involvement in association with the Clean Water Planning process are also closely coordinated and consistent with other DPU and City communication programs. For instance, a plan for public outreach and communication will be incorporated as part of the monitoring plan, to achieve the objective of making the monitoring data (historical and current) available to the public. This plan includes a web-based component as well as other print media.

Both online and offline communication strategies make up a Public Outreach Plan that builds awareness and encourages support for the goals of RVAH2O. This effort has also been designed to meet the requirement of the City's VPDES MS4 permit, which is to reach 20% of the City's population in the MS4 area by 2018.

DPU, using RVAH2O as the communications platform, has invited the public to numerous events and shared its water quality message widely through email, social media, the RVAH2O website, billboards, fliers, school education and community meetings. For example:

- Thousands of Richmonders and others were able to fuel themselves with public water at the September 2015 Union Cycliste Internationale (UCI) bike competitions, where eight drinking stations were hooked up to fire hydrants and draped with RVAH2O logo and information.
- At the 2016 Earth Day and Riverrock festivals, DPU employees at an RVAH2O booth greeted nearly 1,100 people personally, passed out literature, and held drawings for rain barrels.
- The first annual Storm Drain Art Contest attracted several dozen entries and drove hundreds of visitors to RVAH2O social media pages; over 450 people voted for their favorite Storm Drain. Each drain selected flows directly into the James River; one of the requirements was that each drain feature a stormwater/pollution message.
    - This contest's art submissions were showcased at Richmond City Hall for one month.
    - The contest received numerous online and print articles, with front page news in the Richmond Times Dispatch on two occasions when the City's mayor toured the drains in July 2016.
    - The project won a national award by the National Association of Clean Water Agencies and Richmond local ad club award, furthering the news coverage.

Figure 2.2. Flier for Watershed Open House public meeting held at a local park

- A "How-To" flier was created to assist other U.S. municipalities in setting up their own storm drain projects. So far, approximately two dozen communities have requested guidance.
- The 2017 RVAH2O Storm Drain Art Project has already launched, and storm drains for this annual promotional effort are earmarked through 2020.

- RVAH2O took its message to neighborhood associations and universities, engaging students at VCU and the University of Richmond, some of whom have joined outreach causes.
- RVAH2O representatives have met with the James River Association to help them further their outreach efforts with a storm drain stencil art project. It's anticipated that more collaboration with special interest groups will take place in the future.
- A billboard campaign took place throughout the summer of 2016 in both English and Spanish and will be repeated in 2017 and include bus wraps on routes passing through under-served neighborhoods.
- 100 sets of "James River Pollution and Water Conservation" messages have been printed for bulletin boards in elementary school classes, libraries and community centers.

The Future of Public Outreach

The goals associated with stakeholder involvement and transparency to the public are critical and have been incorporated into this process to ameliorate concerns regarding:

- If progress is being made;
- If limited resources are being expended wisely;
- If benefits are being realized; and,
- If adjustments are being made based on what has been learned.

With a foundation of knowledge about the importance of keeping Richmond's waterways litter-free, Richmond's water sources and systems, and the public's role and responsibility in assuring a cleaner water future, DPU will turn its attention to bringing Richmonders up to speed on the Clean Water Planning process. In late 2017, it will focus more attention on business and civic leaders as well as on partnerships with the technical stakeholders to deliver a unified message to the public.

Tracking process of outreach efforts included (depicted in Figure 2.3):

- Email campaign to "public" attendees
- Flier distributed at Riverrock 2015
- Social media campaign drove up on-line engagement

On Facebook:

- RVAH2O Facebook page likes increased by 8%
- RVAH2O received at least 25 direct event responses and reached 4,967 people through Facebook Ads –on less than a $70 budget

- 45 people joined the event through Facebook (organic and paid)

On Twitter:

- Tweet mentions were up 28.6%.
- RVAH2O followers increased by 14.85%.

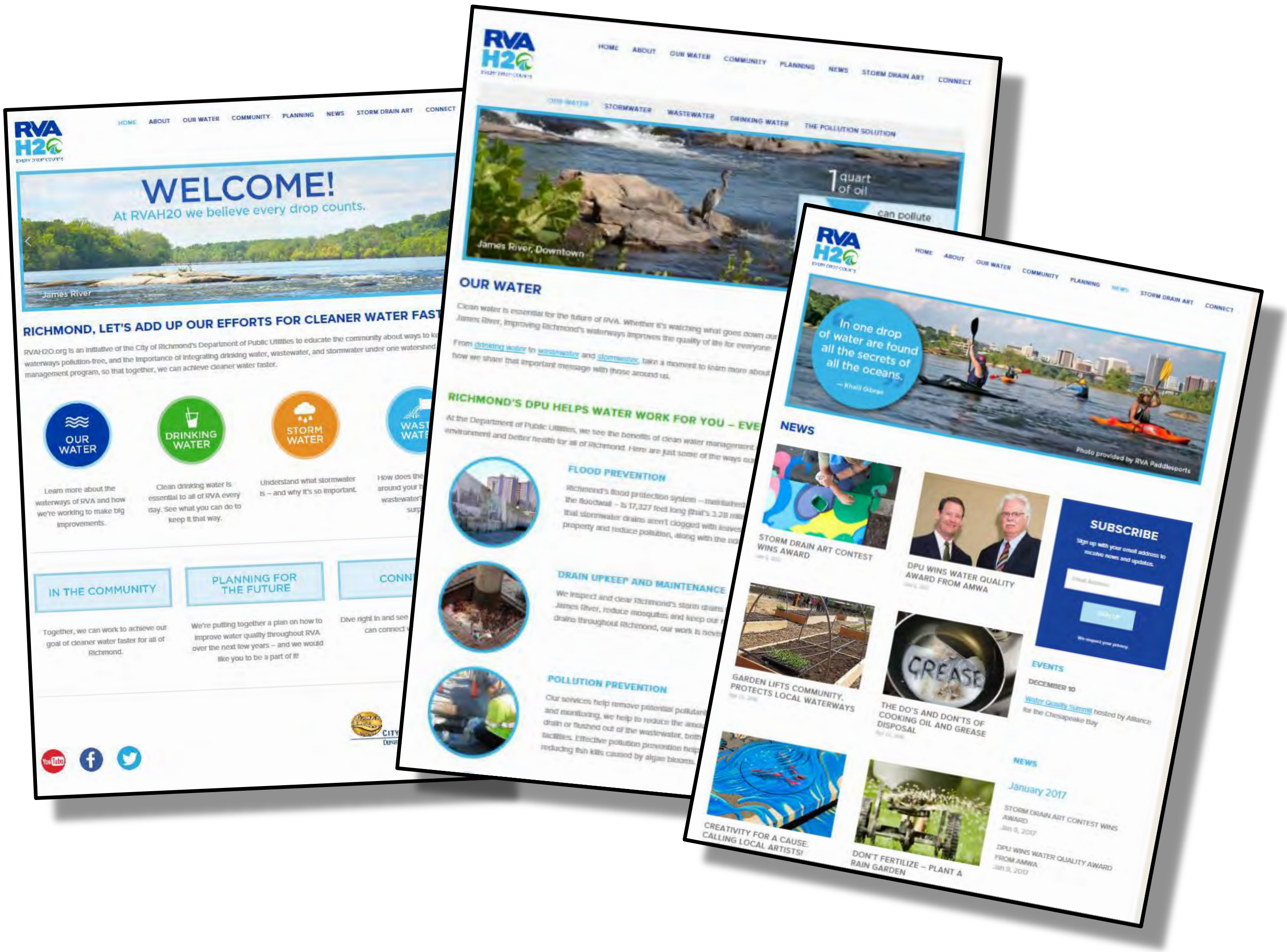

Figure 2.3. Examples of RVAH2O website and Facebook pages.

Stakeholder Partnerships

As discussed further in Chapter 5 (Strategy Identification), DPU is limited in terms of the land and other resources available for strategy implementation. Opportunities to expand strategies will require tapping into the resources from other entities, including other City departments and stakeholder organizations within the City. One way to address this challenge was to create partnerships among the RVAH2O technical stakeholders who have an interest in helping the City implement the goals and objectives that form the basis for the RVA Clean Water Plan.

DPU presented on partnerships at several Technical Stakeholder meetings and discussed ways organizations may wish to partner by making commitments at varying levels of involvement. Examples include participating in the ongoing RVAH2O technical advisory committee, providing volunteer assistance for different types of work (e.g., water quality monitoring, habitat monitoring, tree planting and maintenance), or partnering on larger projects involving land conservation, green infrastructure or stream restoration.

Figure 2.4 Partnership survey circulated to technical stakeholders

A partnership survey was circulated to stakeholders (Figure 2.4) and additional detail on partnership efforts will be documented as these conversations continue over 2017.

3. Watershed and System Characterization

Effective integrated planning and watershed management rely upon identification of the conditions and issues that characterize the watershed. Understanding existing water quality, along with the sources of pollutants or stressors that impact the City's waterbodies, are key elements for developing priority actions to address any existing or potential problems. Characterization of existing collection systems and drainage areas within the City also helps assist in meeting regulatory requirements and implementing other watershed improvements.

Collection of data and characterization of the City's watersheds were the City's first steps towards development of the Clean Water Plan. The City's Watershed Characterization Report (Richmond DPU 2015) includes a detailed discussion of this information. This chapter summarizes this information and highlights how the information and data collected through the effort served as the foundation for subsequent steps of the watershed planning process.

Another key step towards the development of the Plan was the development of a water quantity and quality modeling framework, that incorporates models for the CSO areas, the non-CSO areas (including Richmond's MS4 area), and for the James River itself. The purpose of the modeling framework was to quantify present day bacteria (*E. coli*) concentrations in the James River and to predict future bacteria concentrations under the Clean Water Plan strategies. The modeling framework also allowed for the quantification of discharge flows and volumes, as well as the occurrence of CSO events. The City's Clean Water Plan Modeling Report (Appendix A) includes a detailed discussion of the model development, calibration, and application.

Regulatory Drivers

To understand how the characterization of the collection systems and the City's watersheds can help assist in meeting regulatory requirements, it is important to first understand the regulatory drivers associated with the design and management of these systems and associated programs. Each of these drivers is discussed further below.

Water Quality Standards (WQS)

The Clean Water Act (CWA) establishes the requirement for states to develop and set WQS (see CWA § 303(c)). Once approved by EPA, the WQS are then to be used for CWA purposes, such as in establishing VPDES permit requirements.

The WQS have three distinct parts:

- A designated use;
- Criteria to protect the designated use (generally referred to as ambient water quality criteria and often expressed as chemical-specific concentration values); and

- An antidegradation policy and implementation method.

The designated uses are established based upon data available and are expected to be consistent with the goals established in § 101 of the CWA.

Virginia's regulations set at a minimum that all waters have these designated uses:

- recreational uses (e.g., swimming and boating);
- propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them;
- wildlife; and
- production of edible and marketable natural resources (e.g., fish and shellfish).

The regulations provide authority to establish more specific subcategories of designated uses, such as for the Chesapeake Bay – "Subcategories of the propagation and growth of a balanced indigenous population of aquatic life, including game fish designated use for waters in the Chesapeake Bay and its tidal tributaries are listed in this subsection."

As noted, water quality criteria are required as part of the WQS and must be established at a level to protect the designated use. Criteria protecting recreational uses rely primarily on fecal indicator bacteria levels to prevent an unacceptable level of illnesses when recreating on or in the water. Criteria for aquatic life uses, such as cold water fishery or areas designated as habitat for specific sensitive species can include temperature, dissolved oxygen, and toxic pollutant limitations designed to ensure healthy populations of organisms that are expected to be present in those areas. Criteria for aquatic life uses may also be based on biological indices. States may designate water bodies for agricultural water supply to ensure that water quality is appropriate for irrigation of crops.

The applicable WQS can be found at:

9VAC25-260

http://leg1.state.va.us/000/lst/h2568263.HTM

The third part of the WQS is the antidegradation policy and its purpose is to protect existing uses and the level of water quality necessary to support these uses, to protect high quality waters, and to provide a transparent analytic process for states and tribes to use to determine whether limited degradation of high quality waters is appropriate and necessary. It is important to note that antidegradation focuses on "existing uses" not "designated uses."

Assessing Water Quality Standard Attainment and Total Maximum Daily Loads (TMDLs)

In addition to addressing state requirements to develop WQS, § 303 of the CWA requires states to periodically assess whether waters are attaining WQS and provide a list to EPA detailing the locations of nonattainment and the suspected reasons for impairments. States submit this list for EPA approval every two years and it is referred to as the "impaired waters list" or 303(d) list. For waters placed on the 303 (d) list, states are also required to develop a TMDL. A TMDL calculates the maximum pollutant load that the water body can receive and still attain WQS. The CWA requires that the "load shall be established at a level necessary to implement the applicable WQS with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality[3].”

The CWA categorizes pollutant sources as either point sources or non-point sources. A point source is defined as any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, or container. Control of point sources is handled primarily through the NPDES permit program, in Virginia it is the state VPDES permit program. In the CWA, point sources are clearly the focal point to be controlled, as the legal prohibition against pollutant discharge without a permit or other specific allowance applies only to point source discharges.

A nonpoint source is not specifically defined in the CWA, but is any source that is not a point source. Typical nonpoint sources include runoff from rural areas, including farming, animal grazing, and timber harvesting. The CWA does not establish a control program for nonpoint sources, as it did for point sources. Nonpoint sources are primarily addressed through voluntary programs that include grant funding as incentive for reducing pollutant loads. Significant differences between the two approaches to source control are problematic, especially in situations involving TMDLs for waterbodies with both point sources and nonpoint sources. In many cases, the focus to achieve pollutant reductions will be on point sources regardless of the load delivered by point sources versus nonpoint sources.

The TMDL establishes a ceiling for the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, natural background sources, seasonal variations, and a margin of safety. EPA has issued numerous guidance documents and policy memos to assist states (and stakeholders) in developing TMDLs, as well as in developing permits and assessing WQS attainment[4].

VPDES WWTP Permit

The City has a VPDES permit for discharges into the James River from the wastewater treatment plant. The permit, issued by the Virginia Department of Environmental Quality, regulates discharges from the WWTP and the CSOs, which serve as relief points in the combined sewer system (CSS). The permit includes effluent limits and monitoring requirements, as well as nine minimum control measures required for the combined sewer system under EPA’s 1994 Combined Sewer Overflow Policy. Development of a Long Term Control Plan (LTCP) for the CSS is also required under this permit.

Richmond’s CSO LTCP involves construction of conveyance systems and retention facilities to help control discharges from the combined sewer system (Richmond DPU 2002). The goals of the LTCP are to correct or minimize the public health, water quality, and aesthetic impact on the James River caused by CSOs.

State Consent Order

Implementation of Richmond’s CSO LTCP is required under a consent order from the State Water Control Board. The consent order was issued in 2005 and includes an implementation schedule and a

[3] See CWA Section 303(d)(1)(C)

[4] Guidance and information on impaired waters and TMDLs can be found at: https://www.epa.gov/tmdl/impaired-waters-and-tmdls-tmdl-information-and-support-documents

description of LTCP projects that will be implemented. These projects were used as the basis for the CSO Infrastructure strategy that is discussed further in Chapter 5.

VPDES General Nutrient Watershed Permit

The General VPDES Watershed Permit Regulation for Total Nitrogen and Total Phosphorus Discharges and Nutrient Trading in the Chesapeake Bay Watershed is also applicable to the City. The City's WWTP has nutrient discharge limits that are established by this permit. These limits were used in the evaluation of the Clean Water Plan strategies (see Chapter 5 for additional discussion).

VPDES MS4 General Permit

The City's MS4 system is authorized to discharge into the James River and its tributaries under a general VPDES permit. The permit requires compliance with TMDL waste load allocations and implementation of minimum control measures, including public education/involvement, illicit discharge detection and elimination, runoff control at construction sites and new developments, and pollution prevention/good housekeeping to the maximum extent practicable.

Watershed Data

As discussed above, the previously developed Watershed Characterization Report compiled a significant amount of information on the following elements that was used to inform the Clean Water Planning process:

- Evaluation of existing geospatial (GIS) data including watershed features
    - Physical and natural features (including topography, soils, hydrology, geology, and land cover)
    - Land use and population characteristics
    - Infrastructure features
    - Wastewater collection system
    - Wastewater treatment system
    - Stormwater system
    - Sensitive areas

- Water quality data
    - Designated uses
    - 303(d) status / TMDLs (water quality issues - identification and characterization of water quality impairments and threats - and WLAs of approved TMDLs)
    - Monitoring programs
    - Water quality data
    - Flow data
    - Biological conditions
    - Pollutant sources
    - Stressors

A summary of some of this key information is discussed below in addition to how it has helped direct the Clean Water Planning process.

Watershed Features

The James River and its tributaries drain a watershed of over 10,000 square miles. Within the City of Richmond, the James River flows for 24 miles, providing a substantial amount of waterfront. Because of its location and access to the waterfront, Richmond was established as a shipping and industrial center. While shipping is still an important function of the river, it also provides passive and active recreation through its waterfront and rapids, and serves as the drinking water source for the City and most of the metropolitan area. Major features in the river include Bosher's Dam, which is located just upstream of the City along the James River, and smaller dams, levees, and pipe crossings within the City. There are multiple locations along the river for swimming, kayaking, and canoeing. These include:

- Huguenot Flatwater – near the crossing of N. Huguenot Road and the James River, this site provides canoes, kayaks, and inner tubes. This is also a popular fishing spot.
- Pony Pasture – a popular swimming and sunbathing area, the site provides access for Class II whitewater boating and fishing.
- Texas Beach – at the end of Texas Avenue, a trail leads to a sandy beach and sunbathing rocks and connects to the Belle Isle Pedestrian Bridge to the east.
- Ancarrow's Landing/Manchester Slave Docks – this is a popular fishing spot and includes boat ramp.
- James River Park – near the crossing of Riverside Road and Hillcrest Road, this location provides the opportunity for Class IV whitewater boating

Just downstream of the City is the Presquile Wildlife Refuge, home to several species of birds and anadromous fish, including the endangered Atlantic sturgeon.

Physical and Natural Features and Land Use Characteristics

There are a number of observations that can be made about the City's watersheds. The western and very northern portions of the City have experienced the least amount of hydrologic modification and possess the lowest intensely developed land use and most forested land cover. These more western areas also correspond with areas with higher soil infiltrative capacity. Alternatively, the eastern portion of the City corresponds with a higher intensity of developed land and industrial land use corridor as well as the City's urban core. Consequently, this area also corresponds to soils that are considered urban and tend to have less infiltration capacity and possesses a topography that includes some considerably steep slopes.

While any project slated for implementation will require a more detailed, site-specific assessment, the watershed-scale analysis in the Watershed Characterization Report provided information that helped guide the selection of high-level strategies. These strategies were created at this larger scale, rather than at a localized or neighborhood scale at which a project would be identified, to allow flexibility in the subsequent stages of integrated planning. For instance, in the assessment of green infrastructure as a strategy, GIS data were evaluated. Given the presence of steep slopes and soils in certain areas of the City that are not conducive to the infiltration necessary for green infrastructure, the total available land for this strategy was reduced by half. This conservative approach to identifying land availability incorporates an inherent flexibility that can allow for inclusion of additional acres into the strategy as more site specific data are collected. Chapter 5 includes additional discussion on strategies identification, Chapter 6 discusses the evaluation and prioritization of these strategies and Chapter 7 discusses implementation.

Infrastructure and Collection Systems

Similar to other older cities, especially in the eastern United States, the City of Richmond is served by both a CSS and a MS4. The distribution of area covered by these systems is shown in Table 3.1 and depicted in Figure 3.1.

Table 3.1. Area located within sewered sections of the City

Sewered Area	Area Served by (acres)
Combined Sewer System	12,000
Separate Sewer System	26,000 (24,500 in MS4; 1,500 in direct drainage)
Total	**38,000**

In dry weather conditions, both sanitary discharges and flows from the CSS are treated by the Richmond WWTP. The capacity of the City's WWTP, which serves approximately 215,000 people, is 45 million gallons per day during dry weather and up to 75 million gallons per day during wet weather. Combined sewer flows during wet weather events which would exceed the plant's capacity can be stored at the Shockoe Retention basin with a capacity of 44 million gallons[5] as well as the Hampton / McCloy CSS retention tunnel with a capacity of seven million gallons. Any remaining wet weather flow volumes are discharged through the City's 26 active CSOs.

The MS4 system, in the remaining portion of the City, includes over 220 miles of pipe, 280 miles of open channel and 50 miles of culverts that discharge stormwater flows at over 1,200 outfalls into receiving waters. Additional discussion of the MS4 area as well as the sanitary and combined sewer systems is included in the City's Watershed Characterization Report (2015).

[5] The basin holds 35 MGD, while in-line storage holds an additional 9 MGD

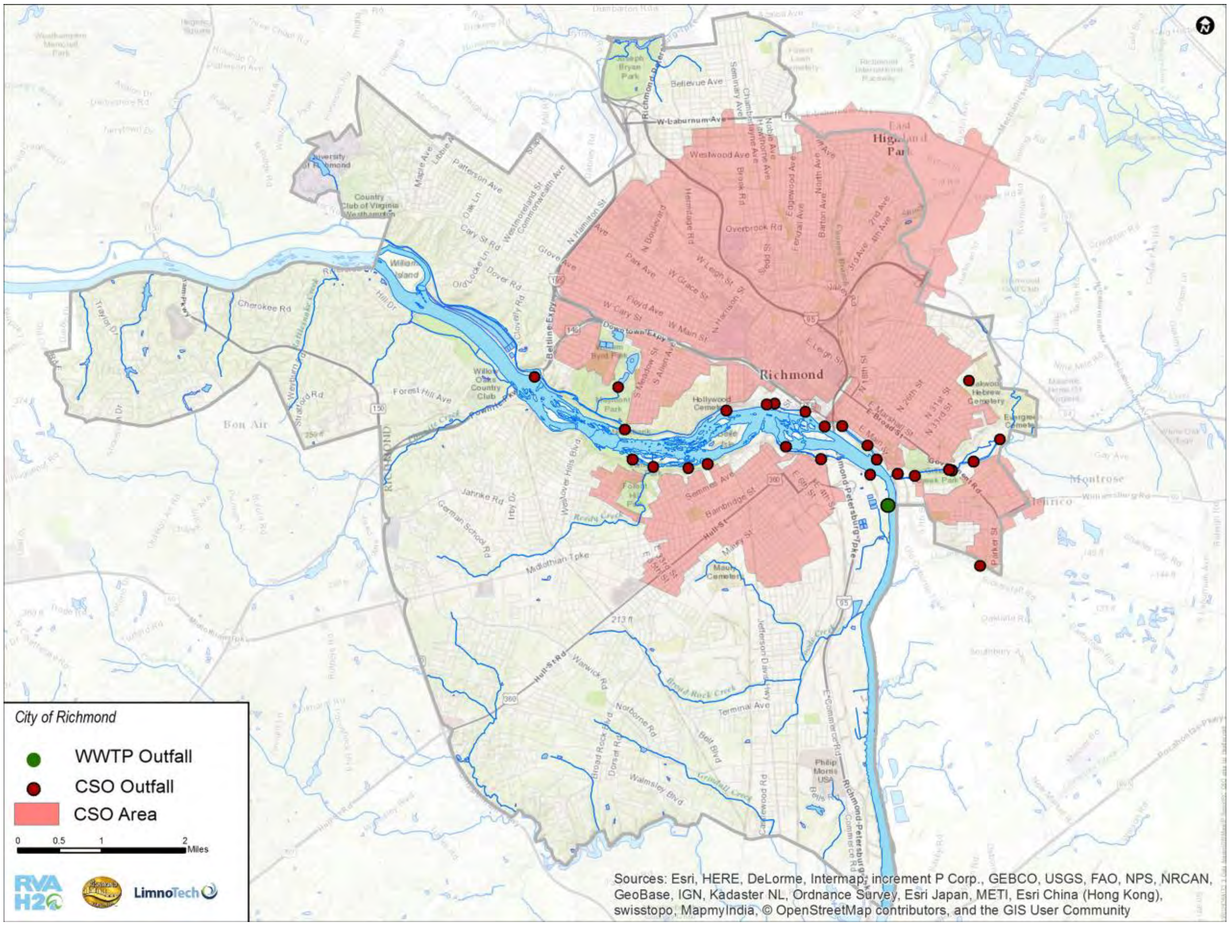

Figure 3.1. Combined sewer overflow area within the City of Richmond and location of CSOs

Understanding these areas within the City, and their associated sources and stressors, were essential to determining the extent to which they were contributing to impairments and the strategies that would be necessary to help the City mitigate these impacts.

Sensitive Areas

EPA's CSO Control Policy (Federal Register 59 [April 19, 1994]: 18688-18698) provides a framework for the control of CSO discharges through the NPDES permitting process. This policy establishes the expectation that CSO communities will give the highest priority to the control of CSO discharges within "sensitive areas". The Policy and EPA Combined Sewer Overflows Guidance for Long-Term Control Plans (EPA 832-B-95-002) define sensitive areas as:

- Outstanding National Resource Waters ("Exceptional State Waters" or "Tier III" waters in Virginia)
- National Marine Sanctuaries
- Waters with threatened or endangered species or their designated critical habitat
- Primary contract recreation waters, such as bathing beaches
- Public drinking water intakes or their designated protection areas

- Shellfish beds

While this sensitive area analysis is applicable only to Richmond's CSO area, the data and information provided do help better characterize the City and potential concerns that should be taken into consideration in the development of goals, objectives, and high-level strategies for future implementation.

The City's LTCP discusses how the six criteria for sensitive areas identified in the CSO policy were evaluated for the James River and its tributaries in the vicinity of Richmond's CSO outfalls. No Outstanding National Resource Waters have been designated in the vicinity of Richmond (State of Virginia, 9 VAC 25-260). No National Marine Sanctuaries have been designated within the state of Virginia. Additionally, no commercial shellfish harvesters operate within the area.

The Virginia Department of Conservation & Recreation (DCR) Natural Heritage Program's Database was used to assess the presence of threatened or endangered species in the CSO area of Richmond. The database did not include or indicate the presence of any species on the Federal- or State-listed threatened or endangered species or critical habitat of any species in the CSO area.

Richmond's drinking water intake is on the James River over three miles upstream of the CSO area.

The original LTCP study identified the sensitive areas associated with the City's CSS as the south and north James River Park areas. These two areas are primarily in the vicinity of public contact recreation waters, especially the south side James River Park, which receives a large number of visitors each year, particularly during the summer months. CSOs in these areas discharge into canals and pools which can be slow moving and therefore have limited capability for flushing and diluting pollutants as they progress toward the main channel of the river. For this reason, CSO discharges to these areas exerted significant public health, aesthetic and water quality impacts, although the pollutant loads of these areas are relatively small compared to the total pollutant load for all CSOs in the City.

These issues are all of particular concern with regard to localized bacteria issues, especially in areas where in-stream recreation is common or where the community would like to expand on such in-stream recreational activities in the future.

Water Quality Data

In addition to geographical data, the Watershed Characterization Report included an extensive amount of water quality-related data on the following topics:

- Pollutant sources
- Stressors
- Designated uses
- 303(d) status / TMDLs (water quality issues - identification and characterization of water quality impairments and threats - and WLAs of approved TMDLs)
- Monitoring programs
- Water quality data

- Flow data
- Biological conditions

A summary of some of this key information is also discussed below in addition to how it has helped direct the Clean Water Planning process.

Sources and Stressors of Watershed Impacts

The 2012 Integrated Report GIS data included suspected pollutant sources for each impaired waterbody segment. Common impacts include:

- MS4 discharges
- Combined sewer overflows
- Non-point sources
- Wastewater discharges
- Industrial point source discharges
- Atmospheric deposition (nitrogen, toxics)
- Clean sediments
- Internal nutrient cycling
- Loss of riparian habitat

Waterbody stressors are described as actions or impacts that may adversely affect (apply some form of stress) the ecosystem in some way. Stressors are categorized by whether or not they have an accompanying water quality standard or screening value. Virginia DEQ has identified the following stressors as being most prevalent:

- Biomonitoring Indices (VSCI/CPMI)
- Streambed Sedimentation
- pH below 6
- Habitat Disturbance
- Nickel in Sediment
- Total Phosphorus
- Dissolved Nickel
- Total Nitrogen
- Dissolved Cadmium
- CCU Metals Index
- Mercury in Sediment
- Ionic Strength
- Dissolved Oxygen

Based on the watershed characterization analysis, key regulatory drivers, and additional modeling [discussed further in Appendix A], it was determined that the sources of particular concern include CSOs and MS4 discharges. Other sources, such as clean sediment (from in-stream erosion and scouring) and loss of riparian habitat, were taken into consideration in the development of strategies (see Chapter 5 on Strategy Identification for further discussion).

Again, key regulatory drivers, watershed analysis and modeling also focused the prioritization of stressors on total nitrogen, total phosphorus, total suspended solids, and bacteria. These key pollutants were used as a priority metric for evaluating the effectiveness of strategies in achieving goals and objectives related to water quality improvements.

Existing Water Quality Data

Obtaining sufficient water quality data to assess the status of the City's waterbodies and impacts to these waterbodies is essential to developing an effective Clean Water Plan. As part of the City's

Watershed Characterization process, monitoring data from all available sources were compiled from entities such as Virginia DEQ, local universities, and watershed groups. These data supported the watershed characterization as well as the City's watershed and water quality monitoring (discussed further in Chapter 3). Moving forward, this data assessment can help the City determine how its existing monitoring program may need to be modified or how to better coordinate with local partners to integrate monitoring efforts.

The existing water quality data analysis showed that the number of available samples across data types (water quality sampling, biological sampling, and habitat assessments) are biased heavily towards the James River, with little-to-no data available in tributary streams. Additionally, there is a lack of hydraulic data within the City, with the only local USGS gauges located outside the City limits. Table 3.2 summarizes samples by data type and receiving water category. This table also highlights the dearth of biological samples and habitat assessments.

Dividing the data on a regional basis (watershed groupings discussed in the Watershed Characterization Report) reveals that the majority of available water quality samples were collected in the Lower James CSO and Lower James MS4 watershed groupings, while the majority of biological and habitat samples were collected in the Lower James CSO and the Middle James MS4. Table 3.3 summarizes samples by data type and watershed group.

Table 3.2: Overall Sample/Assessment Counts by Data Type and Receiving Water Category

Data Type	James River	Tributaries
Water Quality	4,759	368
Biological	44	5
Habitat	44	5

Table3.3: Overall Sample/Assessment Counts by Data Type and Watershed Group

Data Type	Lower James CSO	Lower James MS4	Lower James-Chickahominy MS4	Middle James MS4
Water Quality	2,012	2,341	85	689
Biological	30	1	3	15
Habitat	30	1	3	15

Other types of data, such as hydraulic and meteorological samples, are more limited. There are no hydraulic data available within the City limits. While there are two USGS stations within the City limits (James River at Boulevard Bridge [USGS #02037618] and James River at City Locks [USGS #02037705]), neither station has flow data. The two closest USGS gaging stations with daily flow data are James River and Kanawha Canal Near Richmond (USGS #02037000) and James River Near Richmond (USGS #02037500), both of which are located upstream of the city. There is meteorological data available, but there are only two stations within the City (one in the Lower James CSO and another in the Lower James-Chickahominy MS4), both of which provide daily rainfall totals.

The lack of data in certain portions of the City and in the various tributaries emphasized the need for not only the collection of additional monitoring data, but the collection of monitoring data in a more coordinated manner between the City and various partners. Various supporting actions related to monitoring were recommended in association with the development of strategies. Part of supporting actions includes the establishment of a workgroup made up of the City and technical stakeholders to plan and implement an integrated monitoring strategy to identify efficiencies across partner monitoring efforts, coordinate efforts, and facilitate the sharing of data.

Surface Water Quality Issues

As discussed above, all Virginia waters are designated for the following uses:

- Recreation (e.g., swimming and boating);
- Propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them;
- Wildlife; and
- Production of edible and marketable natural resources (e.g., fish and shellfish)[6].

Waterways may also be considered for primary shellfish harvesting status (Richmond DPU 2016).

> **Waterbody Impairments**
>
> *If a water body contains more contamination than allowed by water quality standards, it will not support one or more of its designated uses. Such waters have "impaired" water quality. In most cases, a cleanup plan (called a "total maximum daily load") must be developed and implemented to restore impaired waters.*
>
> *- Virginia DEQ*

The City's Watershed Characterization Report (2015) discusses the water quality criteria for the waterways in the Richmond area (Class II Estuarine waters for the tidal James River; Class III Non-tidal waters for the falls of the James and other tributaries).

Impairments to Richmond's waters are discussed further in the 2014 Integrated Report (VDEQ 2016) and are summarized in Table 3.4. Impairments include Chlorophyll-a, *E. coli,* Estuarine Bioassessments, benthic macroinvertebrate bioassessments, dissolved oxygen, PCB in fish tissue, PCB in water column, aquatic plants (macrophytes), pH, chlordane, DDE, DDT, and mercury in fish tissue.

The TMDLs applicable to the City include the James River bacteria TMDL and the Chesapeake Bay TMDL, which addresses total nitrogen, total phosphorus, and sediments. These TMDLs were identified as the main drivers behind this planning process. When other TMDLs, such as that for PCBs in the James River,

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[6] See http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityStandards/DesignatedUses.aspx

are developed, the City will evaluate the need to adjust the Clean Water Plan as part of the adaptive management approach.

Human, Aquatic Life, and Wildlife Health Issues

Several of the City's impaired waters pose health hazards for humans, aquatic life, and wildlife. The issues specifically addressed by this Clean Water Plan are those caused by bacteria, nutrients, and sediments. These are the same pollutants addressed by the TMDLs which will be included in the City's VPDES permit.

The James River (lower and tidal reaches) and several of its tributaries (Almond Creek, Falling Creek, Goode Creek, Powhite Creek, Reedy Creek, Bernards Creek, and Gillies Creek) and Upham Brook (which is a tributary to the Chickahominy River and ultimately the James River) have all been listed as impaired due to *E. coli* levels. These stream segments do not support the primary contact recreation use. The sources of bacteria in these streams within the City limits include CSOs, the MS4, the WWTP, direct discharge of urban runoff, and wildlife. Upstream sources also impact water quality in the City. Upstream sources include livestock, land application of manure, malfunctioning septic systems, illicit discharge of residential waste, other permitted waste treatment facilities. Presence of these bacteria is strongly linked with gastrointestinal illness in recreational users of the waterways. Reducing bacteria levels in these streams is consistent with the City's goal to provide safe recreational opportunities in the river.

While the James River bacteria TMDL addresses near-field water quality issues that must be addressed with localized strategies, the Chesapeake Bay TMDL, which applies to the James River and all its tributaries, sets targets for nutrient and sediment reductions downstream in the Chesapeake Bay. An excess of nutrients (nitrogen and phosphorus) in water can lead to an overgrowth of algae in water, or harmful algal blooms. Algal blooms can produce toxins harmful to humans and animals, create dead zones, and increase drinking water treatment costs for downstream communities. Sediments and algae in the water lead to murky conditions that block sunlight from underwater grasses and create low levels of oxygen for aquatic life. Safe nutrient and sediment levels are needed to maintain safe recreational opportunities and protect aquatic life in the river.

Again, while Richmond's waterbodies have impairments for a number of different pollutants (Table 3.4), the key focus for this Clean Water Plan are bacteria, nutrients, and sediment. Additional discussion of specific targets for these pollutants is included in Chapter 6.

Table 3.4 Impairments of waterbodies within the City of Richmond

River Segment	Segment	HUC Code(s)	Length (miles)	Benthic	Chlorophyll *a*	DO	E. coli	Estuarine Bioassessments	Macrophytes	Mercury	Chlordane	DDE	DDT	PCB	pH
North of the River															
Upham Brook	Flippen Creek to confluence with Chickahominy River	JL18	1.2			X									
Upham Brook	Headwaters to confluence with Chickahominy River	JL18	55.72				X								
Stony Run Creek	Headwaters to mouth of Gillie's Creek	JL01	3.23				X								
Gillie's Creek	Headwaters to mouth of James River	JL01	6.02				X							X	X
South of the River															
Powhite Creek	Headwaters to mouth of James River	JM86	8.05	X			X								
Rattlesnake Creek	Headwaters to mouth of James River	JM86	2.32				X								
Reedy Creek	Headwaters to trib above Roanoke St.	JM86	2.34			X	X								
Reedy Creek	Trib above Roanoke St to Forest Hill Ave.	JM86	0.6												X
Manchester Canal	Manchester Canal	JM86	0.75				X								
Pocoshock Creek	Headwaters to mouth of Falling Creek Reservoir	JL02	8.7				X								
Falling Creek Reservoir	Falling Creek Reservoir	JL02	88.37 (acres)			X	X								
Broad Rock Creek	Headwaters to mouth of Goode's Creek	JL01	3.15				X								
Goode's Creek	Mouth of Broad Rock Creek to confluence with James River	JL01	1.25				X							X	
James River															
James River	Blvd bridge to fall line at Mayo's Bridge	JM86	2.91			X	X			X	X	X	X		
James River	Mayo Bridge to mouth of Appomattox River	JM86, JL01	1.47		X	X	X	X	X						
James River	Big Island Dam to I-95 bridge		13.28											X	

Water Quality Modeling

Water quantity and quality modeling was conducted to allow for longer and continuous periods to be evaluated relative to the water quality monitoring program. Therefore, a key step towards the development of the Clean Water Plan was the development of a water quantity and quality modeling framework. The purpose of the modeling framework is to quantify present day bacteria (E. coli) loads and concentrations in the James River and to predict future bacteria loads and concentrations under the Clean Water Plan strategies. The modeling framework also allowed for the quantification of discharge flows and volumes, as well as the occurrence of CSO events. The City's Clean Water Plan Modeling Report (Appendix A) includes a detailed discussion of the model development, calibration, and application. A summary of each step is provided here.

Model Development

Three models were used to achieve the modeling objectives, and together they comprise the modeling framework. These three models include:

- A watershed model to simulate flow and bacteria loads from contributing areas of tributaries to the James River within the greater Richmond area, as well as from Richmond's Municipal Separate Storm Sewer System (MS4), but excluding the combined sewer system. This model was developed using the EPA SWMM software.
- A collection system model to simulate flow and bacteria loads from the combined sewer system (CSS). The CSS model is an existing model that is used to by the City of Richmond for Wastewater Master Planning, to support implementation of the CSO Long Term Control Plan, and to prepare the Annual CSS Reports. This model was developed using the EPA SWMM software, and was adapted for use in this study.
- A receiving water quality model that computes bacteria concentrations in the James River resulting from the various sources of bacteria to the river. The outputs of the watershed and CSS models are used as inputs to the receiving water quality model. The receiving water quality model was developed using the EPA-supported EFDC software.

Model Calibration

Model calibration is the process of adjusting model parameters and assumptions within defensible ranges to achieve reasonable agreement between modeled and observed environmental conditions. The calibration process demonstrated that the modeling framework is sufficiently well calibrated to support the following modeling objectives:

- Design the modeling framework to provide a reliable and reasonably complete accounting of bacteria sources to the James River;
- Develop the modeling framework using sufficiently complete and accurate site specific data;
- Calibrate the models using reasonable assumptions consistent with the site data, literature, and professional judgment;
- Achieve a level of model accuracy that is adequate to support decision making;

- Apply the models for a period including a wide range of common environmental conditions (i.e. river flow and precipitation conditions); and,
- Evaluate and synthesize model output to interpret major sources of current water quality impairment and to forecast future water quality conditions.

Model Application

After the water quality modeling tools were developed and calibrated, they were jointly applied to assess water quality benefits associated with the selected strategies. For this purpose, the model was applied for a 3-year simulation period that includes a dry year (less than normal precipitation), and average rain year, and a wet year (more than normal precipitation). To date, the model has been applied to evaluate the following conditions or strategies:

- Current conditions: Best representation of current conditions, and includes all the Phase I and Phase II CSO improvements from the CSO Long Term Control Plan (LTCP).
- Baseline Conditions: represents the current conditions, plus all the currently funded Phase III collection system improvement projects from the LTCP.
- Green Infrastructure in the MS4 area Strategy: represents the baseline conditions, plus the implementation of 104 acres of green infrastructure on city-owned area in the MS4.
- Green Infrastructure in CSS area Strategy: represents the baseline conditions, plus the implementation of 18 acres of green infrastructure on city-owned area in the CSS area.
- CSS Infrastructure Strategy: Implementation of CSS projects included in the LTCP: represents the baseline conditions, plus all the remaining unfunded Phase III collection system improvement projects from the LTCP.

These strategies were evaluated using several metrics related to bacteria reduction, including:

- Bacteria load reduction from combined sewer and tributary discharges, expressed as billion CFU per year
- Percent increase in monthly geomean water quality standard compliance in the James River at the downstream city limit
- Reduction in number of CSO events per year
- Reduction in CSO volume, expressed as million gallons per year

These water quality benefits were then entered into a calculator tool that integrates the benefits of strategies across a wide range of Goals and Objectives, as further explained in the next chapter. Water quality benefits were also assessed relative to the two existing water quality standards: a monthly geometric mean standard and a statistical threshold value (STV) standard.

Assessing Current Conditions

The Clean Water Plan Modeling Framework was applied to better understand the sources and impacts of bacteria in the James River. The main metrics evaluated by the model include average bacteria loads entering the river from the main sources, *E.coli* concentration in the James River and comparison to the water quality standards, number of CSO discharge events, and CSO discharge volume.

An evaluation of current conditions helped assess the impact of the five major sources of bacteria in Richmond (upstream, CSO, stormwater, background, and WWTP sources), and how each contributes to water quality standard exceedances relative to the other sources. Figure 3.2 graphically shows these results for both the monthly geomean and statistical threshold value (STV) standard. The model results illustrate that the James River is in violation of both the geometric mean and the statistical threshold value water quality criteria for some months out of the three year model simulation period, and the primary cause of a water quality criteria violation can sometimes be linked to Richmond's combined sewer overflows, while at other times it is due to upstream sources coming in from outside of the City. Background (mainly wildlife) and stormwater sources play a smaller overall role in the bacteria water quality violations. The WWTP does not contribute significantly to bacteria water quality violations.

Because the model shows that Richmond's CSOs contribute in large part to the bacteria water quality criteria exceedances, this information was used to support the prioritization of strategies, such as CSO infrastructure, to address this source. Figure 3.3 shows the relative volume of CSO discharges at the CSO outfalls (based on data from 2004 to 2016), and may present potential opportunities for targeting specific CSO discharge points.

Other important metrics evaluated by the model are shown below in Table 3.5.

Table 3.5 Model Output for Current Conditions

Model Output	Model Value
Average yearly E.coli load (billion cfu)	9.65E6
Average annual number of CSO events	53
Average yearly CSO volume discharged (million gallons)	1,670

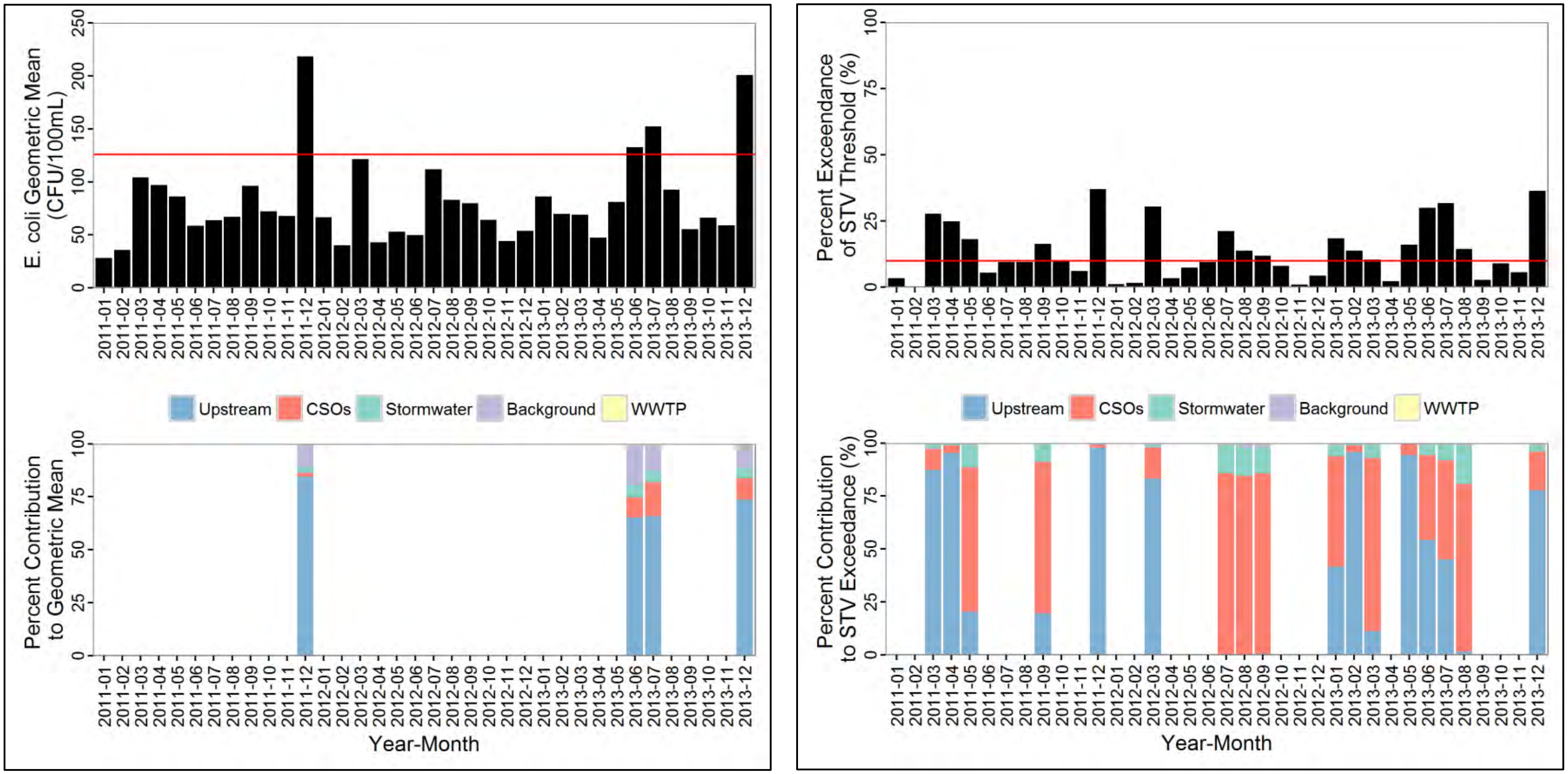

Figure 3.2. E.coli Monthly Geometric Mean and STV Standard Model Results for Current Conditions

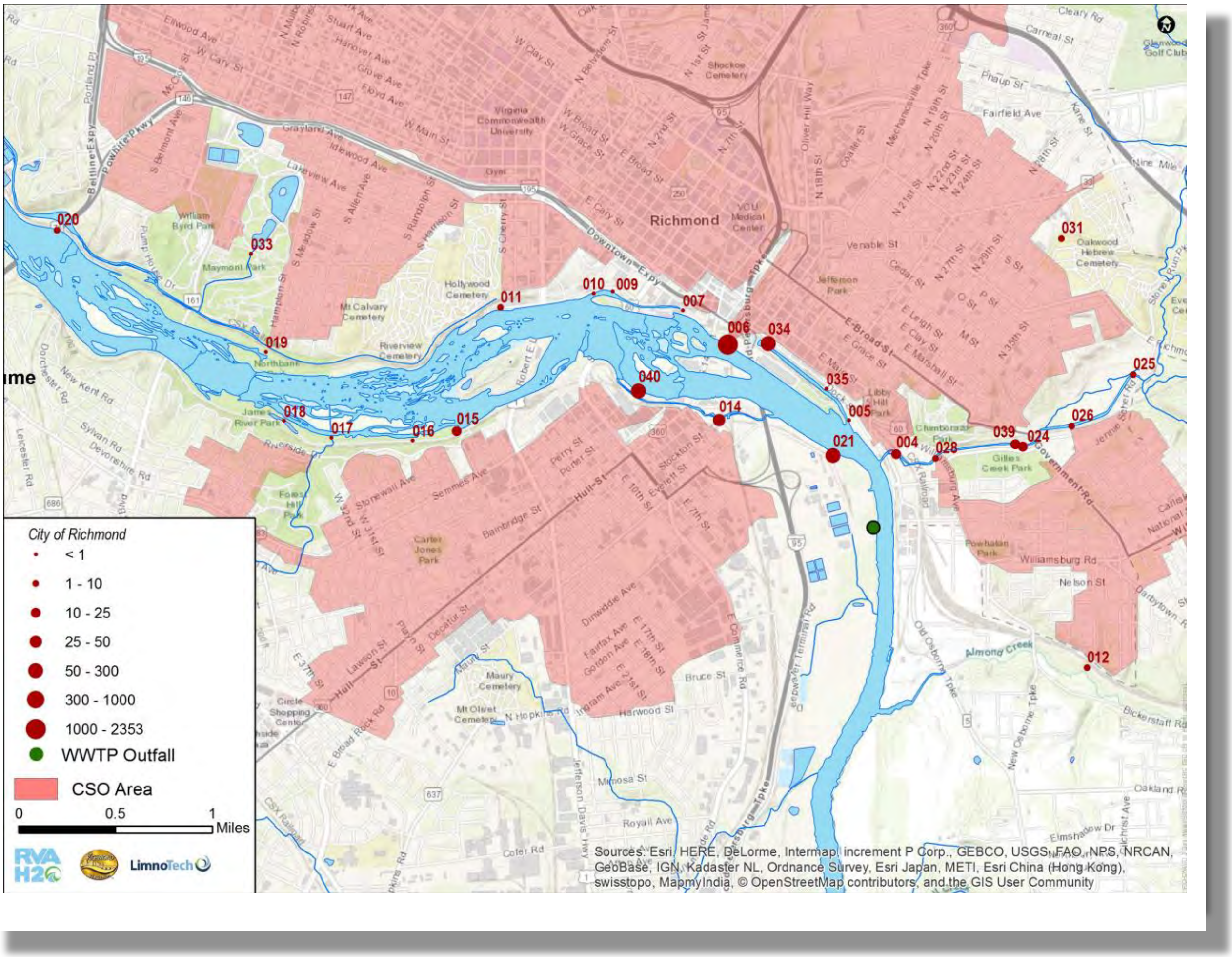

Figure 3.3. CSO Overflow volume by CSO outfall (million gallons/year)

Additional information on the modeling results can be found in Appendix A.

4. Goals & Objectives Selection

Traditional integrated planning efforts tend to focus on meeting infrastructure goals, such as reduction in the number of CSOs. The City's Clean Water Plan, however, is built around a watershed framework that accounts for the City's collective water needs and requirements (including, but not limited, to infrastructure) while considering watershed characteristics. While DPU's understanding of these needs and requirements provide a starting point for establishing the goals and objectives of the Clean Water Plan, DPU recognized that stakeholder input would also be critical to fully capturing the desired direction and outcome of the Plan. This process included not only extensive stakeholder feedback to develop the goals/objectives, but included a weighting process to assign a degree of relative importance of these goals/objectives to one another. The goals, objectives, and respective weights are summarized in Table 4.1 and the approach used to develop this is described below.

Table 4.1 Clean Water Plan goals and objectives with associated weights

Goals (with weights)	Objectives	Weights
19%: Manage wastewater and stormwater to improve the water quality and water quantity of ground water and surface water.	Develop one stormwater management plan to cover the City's four watershed groupings based on the City's watershed characterization report	19%
	Reduce nitrogen, phosphorus, and sediment in discharges to achieve VPDES permit requirements (Chesapeake Bay TMDL)	18%
	Reduce bacteria levels to achieve VPDES permit requirements (local TMDL and water quality standards)	18%
	Reduce toxics (e.g., mercury, PAHs, PCBs), trash and other pollutants and address TMDLs for these pollutants	17%
	Develop green infrastructure, including riparian buffers, and removal of impervious surfaces on development, existing development, and redevelopment	27%
15%: Protect and restore aquatic and terrestrial habitats to support balanced indigenous communities	Restore streams to improve, restore, and enhance native ecological communities	25%
	Identify, protect, and restore critical habitats	36%
	Enhance aquatic and terrestrial habitat connectivity	23%
	Investigate, and where feasible, promote actions that might surpass regulatory requirements	16%
14%: Engage and educate the public to share responsibility and take action on achieving healthy watersheds.	Engage and efficiently educate the public about standards, processes, and actions associated with watershed health and public health	25%
	Assist in the education of citizens about overall water quality issues, benefits of improved water quality	30%
	Support and encourage local action to improve water quality	24%
	Provide quicker public notifications of spills or pollution from regulators or other "river watchers"	21%
12%: Implement land conservation and restoration and incorporate these into	Protect, restore, and increase riparian buffers	21%
	Reduce impervious surfaces	19%
	Increase natural land cover with a focus on preserving, maintaining, and increasing tree canopy	24%

planning practices to improve water quality.	Incorporate green infrastructure in new development and redevelopment	18%
	Conserve lands where possible and consistent with Richmond's Comprehensive Plan	18%
11%: Create partnerships across the watersheds internal and external to the City of Richmond to maximize benefits and minimize impacts to all stakeholders	Develop and implement a source water prevention plan/strategy	33%
	Establish public-private partnerships to secure funding, implement strategies and projects, and to achieve plan goals	40%
	Maintain and expand the RVAH20 group	27%
10%: Maximize water availability through efficient management of potable, storm, and wastewater.	Reduce use of potable water for industry and irrigation	39%
	Achieve water conservation by improving the existing water conveyance system	30%
	Achieve water conservation by incentivizing upgrades to end-user water fixtures where appropriate	31%
9%: Provide safe, accessible, and ecologically sustainable water-related recreational opportunities for all.	Improve water quality to promote safe recreation consistent with the City's Riverfront Plan	36%
	Promote ecologically sustainable management of riverfront and riparian areas	40%
	Improve river and waterfront access for recreation	24%
9%: Work collaboratively to gather consistent high-quality data to characterize the status and trends of water resources and to gauge the effectiveness of restoration efforts.	Conduct water quality and biological monitoring	28%
	Provide timely water quality information	19%
	Collaborate with citizens and local/state agencies for coordinated monitoring	23%
	Utilize results to target restoration efforts and convey progress	30%

Establishing Goals & Objectives

The first step of the Clean Water Planning process was determining the direction in which the City and its stakeholders wished to take this effort. To accomplish this, goals and objectives were selected through an extensive stakeholder communications process. The watershed characterization efforts, described in Chapter 3, were used as a basis for understanding the City's watershed features, water quality, and any issues of concern within the watersheds. While this helped inform the City and stakeholders, the selection of overarching goals, refined goals, and objectives was also influenced by the mission of stakeholder organizations or City department as well as stakeholder's additional first-hand knowledge of local issues.

To account for the multiple opinions and perspectives that were anticipated, the City implemented a multi-step process to form consolidated lists of overarching goals, refined goals, and objectives. The first step in this process was to survey stakeholders (Figure 4.1). The City requested that stakeholders submit what they felt were appropriate overarching goals, refined goals, objectives, and metrics (discussed further in Chapter 6) based on definitions and guidance on what these terms included.

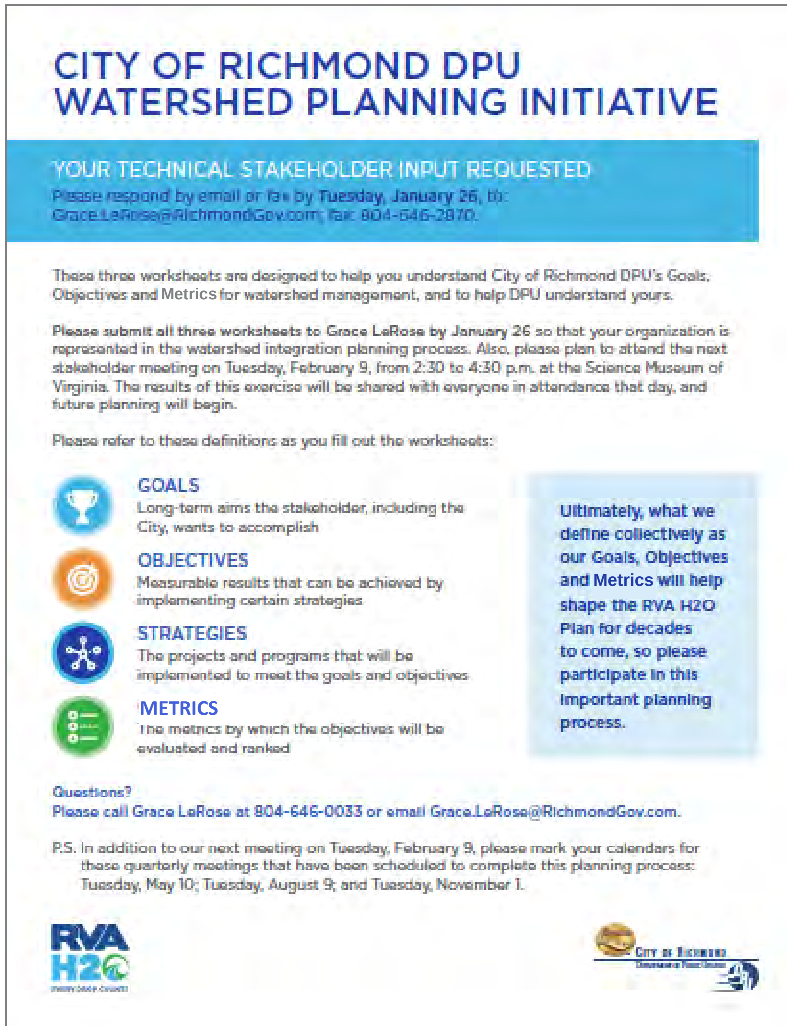

Figure 4.1. Guidance provided to technical stakeholder to support the gathering of input on goals, objectives, and metrics.

Fifteen stakeholders provided input through responding to the request. Given the large amount of feedback to discuss, the City addressed the discussion of overarching goals and refined goals during the February, 2015 meeting and objectives during the May, 2015 meeting.

Prior to the February meeting, the City evaluated all of these submissions and identified a number of themes. It was important to the City that no feedback was lost in this process, so all input was incorporated verbatim into one of these themes:

Overarching Goal Themes:

- Collaboration
- Water consumption
- Preservation and restoration
- Water quality

Refined Goal Themes:

- Recreation
- Aquatic and riparian habitat
- Stormwater peak flows
- Pollution
- Land conservation and management
- Partnerships
- Monitoring
- Public engagement & action
- Water conservation

At the stakeholder meetings, attendees were broken into small groups with each group being provided one of these themes and its associated goals. Each small group was then asked to combine and synthesize the items within that theme. Goals could be combined, reworded, or moved to another goal topic area. Goals could also be re-categorized as an objective or a strategy if deemed more appropriate. Ultimately, one goal was developed for each topic area.

A similar approach was taken in developing a refined list of objectives. Stakeholders provided objectives associated with each of the proposed goals. Stakeholders then refined these objectives so there were between one and six objectives associated with each of the refined goals.

Striving for Consensus

A number of opinions and viewpoints were represented through the stakeholder process. While the City felt it was important for the Clean Water Planning process to reflect these views, it was also important for the process to move forward in a timely manner. To accomplish this, the City strived to reach consensus on each of the steps of this process and the associated decisions made.

The goal behind *striving* for consensus is that everyone will be able to live with and support the idea or issue, or, at least, no one opposes it. If the group was not able to support an element of the issue/item up for discussion, additional discussion was deemed necessary.

While stakeholders were a key part of the process for identifying goals and objectives, they did represent many different groups with interests in the City. To ensure stakeholders all shared the same amount of influence during this process, each interest group was allowed one member at the table who could participate (i.e., vote) in the consensus process.

As shown in Figure 4.2, each voting stakeholder could select either “1”, “2”, or “3” to represent their level of agreement with a particular goal or objective being discussed. If any stakeholder selected “1”, then the topic was discussed further until the stakeholder agreed, the item for discussion was modified so that all stakeholders could at least live with the decision, or the item/topic was removed from the options moving forward.

Ultimately, stakeholders achieved consensus on the overarching goal, refined goals, and objectives.

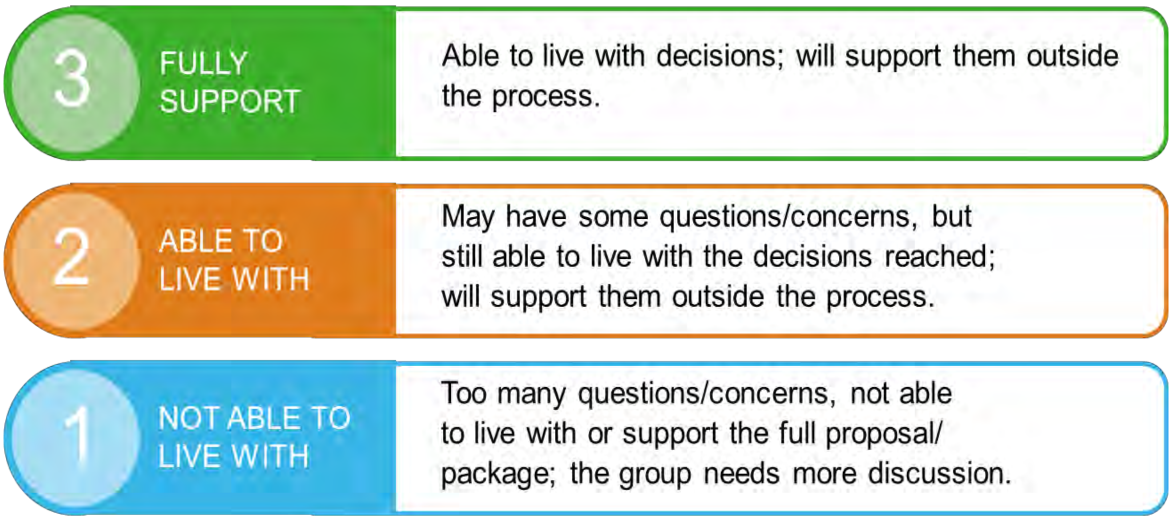

Figure 4.2 Consensus voting process for the Clean Water Plan

Prioritizing through Weighting

Weighting was incorporated into this process to reflect the priorities of the City and its stakeholders. This weighting process not only allowed for an understanding of how one goal or objective ranked in relation to another, it also provided information on the extent of the importance of these priorities to one other.

Weighting included the process of assigning a portion of 100 points to each of the items in a grouping. As shown in the example in Table 4.2, 100 points are apportioned across a grouping of refined goals. In this example, refined goal #2 was given the highest priority, with 50 points. One or more objectives were assigned to each refined goal. Each grouping of objectives

Table 4.2 Example weighting process

Refined Goals	Weight	Objectives	Weight	
Refined goal #1	15	Objective #1	50	Total: 100
		Objective #2	30	
		Objective #3	10	
		Objective #4	10	
Refined goal #2	50	Objective #1	10	Total: 100
		Objective #2	60	
		Objective #3	30	
Refined goal #3	30	Objective #1	40	Total: 100
		Objective #2	60	
Refined goal #4	5	Objective #1	20	Total: 100
		Objective #2	40	
		Objective #3	10	
		Objective #4	30	
Total:	**100**			

was also given a proportion of 100 total points.

The result of this process was a prioritization of refined goals as well as a prioritization of objectives associated with each of these goals.

Once the goals and objectives were finalized by the City and its stakeholders, Surveymonkey.com was used to circulate a questionnaire to each stakeholder organization to obtain their opinion on the weights of each goal and objective. The weights provided by each stakeholder organization were then averaged to produce a weight for each refined goal and for each objective. These averaged weights were presented and discussed at a technical stakeholder meeting. Stakeholders were allowed to suggest modifications to the weights of the goals or objectives as long as the overall ranking of these weights remained the same. Using the example in Table 4.1, while the order of the refined goals must remain #2, #3, #1, and #4, stakeholders might collectively decide that refined goal #3 should be 38 points, while refined goal #2 should be changed to 42 points.

5. Strategy Identification

The next step in this process was the identification of strategies that can be expected to achieve the previously identified goals and objectives. Strategies were defined as activities, actions, or items that will help meet goals and objectives. The process that was used to develop the strategies is discussed below.

Brainstorming Potential Strategies

Implementation of projects and programs that may benefit the City's water resources are undertaken by numerous departments within the City as well as other entities, such as local universities, watershed organizations, or private developers. While the City can coordinate or partner with these entities to implement such efforts (as was discussed in Chapter 2), DPU recognized that the starting point in determining a list of strategies for the Clean Water Plan was determining what projects and programs the Department could implement and maintain itself.

Strategies vs. Projects

The Clean Water Plan-related planning is occurring at the sub-watershed to the City-scale. As such, projects or programs at a finer scale needed to be "rolled up", or grouped, to produce a higher level strategy.

The first step in brainstorming potential strategies included a workshop for DPU staff involved in stormwater, wastewater, and CSO-related projects. Staff compiled a list of projects that had been identified or proposed to meet various programmatic needs. Because the Clean Water Plan would be implemented during the next VPDES permit cycle (beginning in June of 2018), any project that would be funded, initiated, or implemented prior to this date was removed from the list. The resulting list included the remaining potential projects that could be implemented over the next VPDES permit cycle (2018 through 2023). City staff also brainstormed other ideas, such as opportunities for expanding existing efforts like the residential stormwater credit process, to help increase implementation.

It is important to note, however, that the initial stages of the Clean Water Planning process is being developed at a high-level scale (sub-watershed, watershed, to City-scale). Because many of these projects impact small-scale areas, these City projects were "rolled up" to a strategy scale where necessary. For example, several bioretention or permeable paving projects were rolled up, or grouped, into a Green Infrastructure strategy.

In addition to these DPU projects, stakeholders were also asked to submit suggestions for strategies that they felt would achieve the agreed upon goals and objectives. Numerous ideas were gathered with varying levels of detail. Because there were a number of distinct themes to these suggested strategies, the Clean Water Plan development team created a synthesized set of draft strategies that consolidated ideas put forth by both stakeholders and DPU staff.

It was determined that a number of the ideas put forth, while important, were not strategies in and of themselves. A number of these ideas could also be tied to more than one strategy. These ideas were defined as "supporting actions". Supporting actions include efforts that may broaden the main strategy, add specificity on how a strategy could be implemented, or identify additional resources and data needs to fully implement the main strategy. These supporting actions are not necessarily quantifiable in and of themselves and may be components of multiple main strategies. Actions, such as those related to partnerships, may also involve activities on non-City property and rely on resources that are outside the DPU's authority.

Supporting actions include:

- Partnerships – establishing partners to facilitate a greater level of future implementation of projects and programs (partners include those within the City, such as the Department of Public Works (DPW), as well as with non-City agencies, such as watershed groups)
- Maintenance – including resources and funding to ensure a strategy will continue to meet its intended objectives
- Monitoring, Assessment & Planning – gathering data and information and using these results to help guide and implement future implementation
- Incentives/Credits – evaluating and implementing mechanisms to incentivize new initiatives or higher levels of future implementation
- Regulations/Ordinances/Codes – analyzing and modifying, if necessary, the framework within which implementation will occur
- Outreach – including ways to potentially expand upon future implementation by conveying information on resources available or ways for partners and the public support a strategy

Some of these Supporting Actions are specific to a particular strategy, but others, such as some related to monitoring or public outreach, cut across various strategies.

Strategy Feasibility

Once the draft set of strategies was identified, it was important to determine if these strategies were feasible. Because DPU is ultimately responsible for implementation of the Clean Water Planning program, the feasibility of strategies was defined as efforts that DPU has the authority to implement. For instance, a strategy could be identified as infeasible if it requires implementation on land not owned by the City, and where it is not possible for the City to purchase or obtain the land in some way.

Because the City's Parks, Recreation, and Community Facilities (PRCF) Department works so closely with DPU and shares similar departmental objectives for project implementation and maintenance, PRCF land was also considered to be available for the feasible implementation of a strategy.

Feasibility also takes into account the potential limitations on strategy implementation due to physical constraints such as steep slopes or soils with poor infiltration that are unsuitable for some strategies such as green infrastructure. Therefore, the acreage included in the strategies reflects a portion of DPU/PRCF in the City that is appropriate for that particular strategy. For example, based on an evaluation of slopes and soils GIS data and best professional judgement, a decision was made to conservatively include 50% of the total DPU and PRCF lands within the Green Infrastructure Strategy in both the MS4 and CSS areas. Details on assumptions made for each of the strategies is included in Appendix B.

Final Strategies

Once feasibility was evaluated, final draft strategies and supporting actions were presented to stakeholders who were given the opportunity to edit them further. Once all feedback was incorporated, a final set of strategies and supporting actions was presented to the stakeholders for a consensus vote.

Each of the strategies referenced in the remainder of the Clean Water Plan are considered to be "feasible" and agreed upon by the Technical Stakeholder group (Table 5.1).

Table 5.1. Strategies and associated details

Strategy	Strategy Details
Riparian Areas	Replace or restore 10 acres of riparian buffers according to state guidance. • In MS4 and/or CSS area • Evaluate opportunities for inclusion of access points to waterbody for recreational activities
Green Infrastructure in MS4	Install or retrofit GI draining 104 acres of impervious surfaces, including efforts such as: • 30 acres on DPU property • 18 acres on City-owned vacant properties • 20 acres on Parks department property (one playground/park per year, cemetery roadways, impervious to pervious area in park properties, vacant properties) • Install 100 trees in tree boxes (e.g., Filtera-type practices); 30 acres total drained to this practice • Retrofit 4 DPU stormwater BMPs (e.g., dry ponds to more efficient BMPs), draining at least 6 acres of impervious surface
Green Infrastructure in CSS	Install or retrofit GI draining 18 acres of impervious surfaces, including efforts such as: • 6 acres on DPU property • 2 acres on City-owned vacant properties • 2 acres on Parks department property (one playground/park per year, cemetery roadways, impervious to pervious area in park properties, vacant properties) • Install 24 trees in tree boxes (e.g., Filtera-type practices); 8 acres total drained to this practice
Stream Restoration	Restore 2,500 linear feet of stream: • Through removal of concrete channels, repair of incised banks, etc. • In MS4 and/or CSS area • Evaluate opportunities for inclusion of access points to waterbody for recreational activities
Natives/Invasives	Use 80% native plants in new landscaping at public facilities by 2023.
Trees	• Increase tree canopy on City property by 5% (80 acres added) • Protect existing tree canopy by following maintenance addressed in the Tree Planting Master Plan
Land Conservation	Place an additional 10 acres under conservation easement, prioritizing conservation of land that creates connected green corridors. • Evaluate opportunities for inclusion of access points to waterbody for recreational activities
Water Conservation	Reduce water consumption by 10% through implementation of new water conservation technologies and promotion of water conservation efforts, including: • Installing water-efficient fixtures as a policy by 2023 in all new public facility construction • Implementing incentive programs

	• Encouraging water conservation on City properties
Pollution Identification and Reduction	Reduce contribution of pollutants to the MS4 through: • Conducting at least 1 special study per year in hot spot areas to identify illicit discharges/connections. (Studies will meet the criteria necessary to achieve Bay TMDL pollutant reduction requirements. Assume that, over 5 years, 3 of these studies will result in pollutant reductions that meet Bay TMDL requirements.) • Collecting data associated with non-structural BMPs to facilitate quantification of pollutant reduction (e.g., storm drain clean-outs, pet waste stations, street sweeping)
CSS Infrastructure	LTCP projects, including: • Installing wet weather interceptor to convey more flow to the WWTP • Increasing WWT to 300 MGD at the treatment plant • Expanding secondary treatment at the WWTP to 85 MGD • Expanding Shockoe retention basin by 15 MG to capture more overflow • Disinfecting overflow at Shockoe retention basin (wet weather disinfection facility) *Note that that the modeling framework will be applied during the summer and fall of 2017 to evaluate alternative CSS reduction projects that may provide similar benefits to the LTCP projects, but at a reduced cost.*

Table 5.2 includes the final, agreed upon supporting actions for the strategies.

Table 5.2. Supporting Actions associated with the various strategies

Supporting Actions	Details
Partnerships	Restore 20 acres of riparian buffers on private properties through efforts such as: • Purchases of land • Partnerships with residents: Promote program for buffers on private properties (include tiers of level of involvement – (1) maintenance agreement with City, (2) conservation agreement/ easement.) • Partnerships with Master Naturalists to enlist their support for assistance with riparian restoration.
	Implement 10 acres of GI on private property
	Implement 5 acres of GI on DPW property (rights of way, roadways, green alleys) through efforts such as: • Adopt a rain garden program – coordinate with residents, non-profits, commercial entities • Partnering with the City's community garden program to identify 0.5 acres of area for additional GI implementation • Partnering with Public Works to ensure City greenways include GI
	Develop a program to encourage the use of native plants in private landscaping – sign up 20 private landscapers.
	Initiate an Adopt a Lot program (10 lots with invasive species removed, replanted and maintained)
	Partner with organizations such as the James River Park System Invasive Plant Task Force to better determine areas with significant invasive species issues and identify resources to deal with the problem.
	Partner with the public and other stakeholders, such as the Richmond Tree Stewards, to plant and maintain trees on public properties.

	Promote requests for stream restoration by private landowners and streamline the process by which these requests are addressed.
	Hire DPU staff member or assign 1 FTE to coordinate volunteers from corporate entities, watershed/environmental groups and public with partnership opportunities associated with the IP effort. Staff to enlist/maintain 6 partnerships per year.
	Hold 3 stakeholder meetings per year to continue communication with partners/stakeholders and add purpose to the IP effort.
	Evaluate partnership network in 5 years (at the end of the permit cycle) to assess gaps and identify new public/private partners.
	Partner with the public and other stakeholders to identify land to put in conservation easements.
	Partner with the Richmond Redevelopment and Housing Authority to identify homes/properties that are eligible for upgrades to water-efficient fixtures.
	Partner with upstream localities and Virginia Department of Health to update/maintain Source Water Protection Plan.
Maintenance	Include funding to support maintenance of newly replanted/restored riparian buffers (to ensure success of plantings, prevention of establishment of invasive species, etc.).
	Include funding to support maintenance of newly planted native plants and maintain newly established plantings where invasives have been removed from the landscape.
	Provide funding to support maintenance of trees on City property to ensure their survival and health.
Monitoring, Assessments & Planning	Inventory and map riparian areas to better understand loss or growth of riparian buffers.
	Inventory and map locations of trees and tree boxes to better understand loss or growth of tree coverage.
	Continue monitoring of 8 locations across the City for macroinvertebrate, habitat and in-stream water quality. Continue monitoring at 2 locations for flow. Evaluate opportunities to expand the flow monitoring network across the City.
	Evaluate the development of a monitoring data portal to facilitate sharing of data collected within the City with stakeholders and the public.
	Initiate monitoring work group in year one made up of technical stakeholders and other key groups/individuals to evaluate current monitoring efforts and identify potential efficiencies and additional monitoring needs moving forward.
	Evaluate potential for conducting pre- and post-construction monitoring of key stormwater BMPs.
	Conduct assessments of 4 stream segments across the 4 watershed groupings to support the development of watershed restoration plans to address pollutant sources and watershed stressors.
	Monitor growth/expansion of invasive species.
	Implement IDDE-related monitoring to support this effort – supported by a desktop analysis of high-risk dischargers.
Incentives/ credits	Reevaluate the stormwater credit program to determine potential to include practices such as replacing or restoring riparian buffers.
	Evaluate incentives/credits for purchasing/planting native species (such as Montgomery County, MD).
	Reevaluate the stormwater credit program to determine potential to include practices such as

	planting trees on private property. Provide 500 trees for planting on private property or equivalent incentives to purchase native trees.
	Offer grants to replace 20% of inefficient fixtures in moderate- to low-income units Evaluate expansion of incentive program to cover washing machines and dishwashers
Regulations/ ordinances/ codes	Evaluate expanding the regulatory buffer from 100 ft. to 200 ft.
	Evaluate inclusion of language in City zoning and planning-related ordinances to protect existing trees and add new trees on developed property.
	Adopt permitting standards for water-efficient appliances/fixtures in City code.
Outreach	Conduct outreach to educate the general public about the goals and objectives of RVAH2O, and the resources and services available through the City.
	Conduct outreach to advertise the resources, requirements and services available through the City related to green infrastructure for private property owners.
	Conduct outreach to advertise the resources, requirements and services available through City related to tree planting and maintenance.
	Promote ability to use grey water for toilet flushing as a way to achieve higher LEED standards
	Encourage and incentivize water capture and reuse for landscaping
	Promote water conservation for commercial, industrial and residential customers through efforts such as “Fix a Leak Week” and the City’s Every Drop Counts initiative.
	Conduct targeted outreach to high-risk industries, particularly in areas of the City identified as hot spots.

6. Strategy Evaluation

Once strategies were drafted, an analysis was needed to determine which ones would be best for implementation. Figure 6.1 provides an overview of the multi-step strategy evaluation process that was used to make this determination. This process constrains proposed strategies by feasibility, relative achievement of goals/objectives, compliance with permit and regulatory drivers, and cost-related factors.

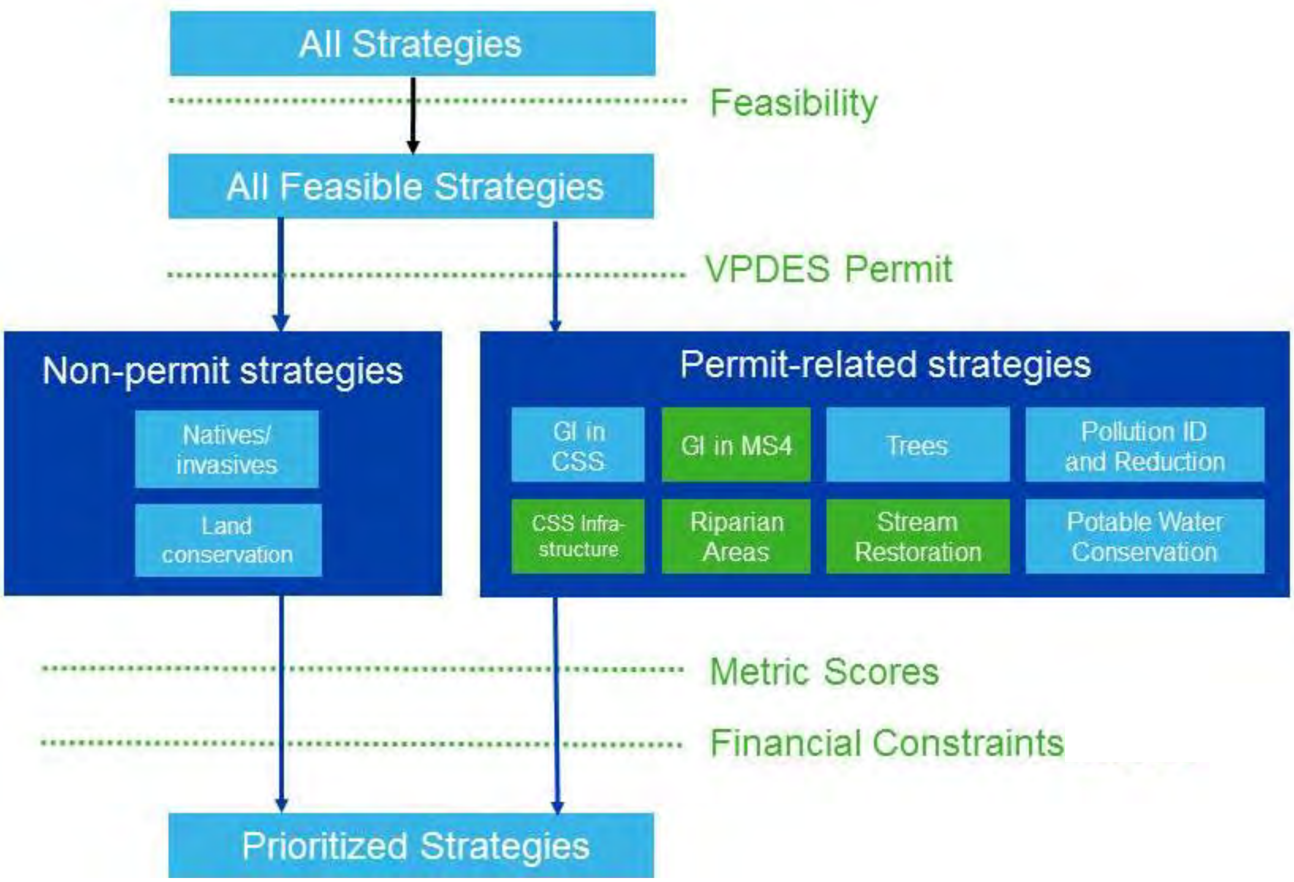

Figure 6.1. The process used for strategy evaluation

There are multiple factors at play that influence the selection of strategies. A strategy may do well with one factor, such as permit-related pollutant reductions, but not so well with others, like cost. As a result, the analysis of the various factors did not result in a clear and decisive outcome of one strategy that performed the best across all factors. What the strategy evaluation did determine was that all of the "pieces of the puzzle" needed to be evaluated collectively to achieve a complete picture of how well strategies achieve specific goals (Figure 6.2).

Figure 6.2. Puzzle piece conceptual model demonstrating how various factors fit together to inform the decision making process

Each of the "puzzle pieces" (other than Feasibility, which was discussed in Chapter 5) is discussed further below.

Strategy Scores

A comparison of the various strategies proposed through this stakeholder process was needed. To accomplish this, an Excel-based strategy scoring calculator was developed. This tool helped in the decision-making process by allowing the City and stakeholders to evaluate various alternatives by assigning scores to the alternative strategies.

The methodology used for this scoring calculator is a multi-objective decision analysis (MODA). Decision-making based on consideration of multiple goals/objectives and metrics is a widely documented research discipline. While referred to by a variety of terms in the literature, this decision-making approach is used to evaluate how well each of the alternative strategies (e.g., management practices, policy options) achieves a desired outcome (a decision-making problem, goal, etc.) through the use of metrics[7]. This approach also helps facilitate the involvement of diverse stakeholders by accounting for competing priorities and preferences in the decision-making process through inclusion of the weighting process (Saairkoski et. al. 2015).

Development of calculator-based strategy scores to support strategy evaluation includes the development of metrics that are tied to the goals/objectives. The development of these metrics is discussed below. Also discussed is how the analysis of individual metrics helped to answer specific questions related to strategy effectiveness. These metric-based strategy scores were then used in conjunction with other factors, like cost, to comprehensively evaluate strategies.

[7] There are a number of names for this approach in the literature, which share similar methodologies. These include: Multi-Criteria Decision Analysis, Multi Criteria Evaluation, Multi-Criteria Preference Analysis, Multi Objective Evaluation, Multi-attribute Decision Analysis, Multi-attribute Utility Analysis, etc.

Developing Metrics

An important component of strategy scoring is the development of metrics. While stakeholders and City staff dedicated significant time to the establishment of Integrated Planning goals and objectives, a standard of measurement was needed to evaluate how well the strategies achieved these goals and objectives and how well the strategies compared to one another.

Metrics:
Measurable properties by which efficiency, performance, or progress can be assessed

To accomplish this, a set of metrics was developed that includes a method of measurement. Table 4.2 provides examples of several metrics that were identified and how these are measured. Because metrics must be measureable, they are often quantitative. They may also be qualitative as long as there is a translation into a quantitative format. For instance, the "Stormwater Management Plan produced" in Table 6.1, is qualitative, but it is translated to a quantitative metric by incorporating a measuring scheme of a scale of 0 or 1.

Table 6.1 Example metrics and associated methods of measurement

Metric	Method of Measurement
Average yearly pollutant load reduction	Pounds of TN, TP, and TSS reduced Billion CFU of E.coli reduced
Percent increase towards meeting monthly geomean WQS compliance	Comparison of modeled E.coli concentration in the James River with the WQS standard
Riparian buffer restored/increased	Acres of riparian buffer
Partnerships implemented for Integrated Planning	Number of partnerships
Stormwater Management Plan produced	1=yes, 0=no
Amount of water conserved	Gallons

At least one metric was identified for each objective. An example is included in Table 6.2, which shows one of the Clean Water Planning goals. This goal includes several objectives (three of which are included here). Each objective is evaluated by at least one metric.

Table 6.2 Example of goal, objectives, metrics, and how metric is measured

Goal	Objectives	Metric	Measure of Metric
Protect and restore aquatic and terrestrial habitats to support balanced indigenous communities	Restore streams to improve, restore, and enhance native ecological communities.	Streams restored	Feet (of stream restored)
		Reduce stormwater volume discharging to streams	Millions of gallons
		Riparian buffers restored and/or increased	Acres (of buffer restored)
	Identify, protect, and restore critical habitats.	Habitat protected or restored	Acres (protected or restored)
	Enhance aquatic and terrestrial habitat connectivity.	Habitat connected by green corridor	Acres (included in "green corridor")

Appendix C includes the complete list of the goals, objectives, metrics, and Appendix D (the Excel-based Strategy calculator tool, discussed below) also includes the raw scores that were identified for each strategy.

Raw Scores for Metrics

Each strategy was then given a raw score for each metric. Table 6.3 takes the example from Table 6.2 a step further and shows how a raw score is assigned to a metric. These scores can come from sources, such as the Integrated Plan model (e.g., number of extra days of bacteria compliance), from the literature (e.g., nitrogen reduced by an infiltration-based stormwater BMP), or from stakeholder input (e.g., number of acres of conservation easements that can be added).

Table 6.3. Example of how raw scores are assigned to each metric

	Riparian Areas Strategy	MS4 Green Infrastructure Strategy	Stream Restoration Strategy
Goal: Protect and restore aquatic and terrestrial habitats to support balanced indigenous communities			
Objective: Restore streams to improve, restore, and enhance native ecological communities			
Metric: Streams restored (in feet)	0	0	2,500
Metric: Reduce stormwater volume discharging to streams (in millions of gallons)	3	30	0
Metric: Riparian buffers restored and/or increased (in acres)	10	0	6

Once the raw scores were input into the calculator tool they were normalized and weighted. Normalization was performed to account for the various units represented (acres, pounds, feet, etc.). The normalized, weighted scores for each of strategies were summed to produce one score for each strategy. These final scores allowed strategies to be compared to one another. The calculator tool (in

Appendix D) includes all of the formulas necessary for one to understand how these final scores are developed. Additionally, a call-out box on page 53, explains the concept of normalization further.

Strategy Analysis

As discussed above, there are multiple "puzzle pieces", or factors, that were taken into consideration in the analysis of strategies (Figure 6.2). The **Permit** puzzle piece represents the VPDES permit-related requirements that establish pollutant reduction targets by which the strategies were compared.

The Strategy Score "puzzle piece" involved using the calculator tool to evaluate **strategy scores** in several different ways. These analyses included evaluating:

- Permit-related metrics – metrics that related to total Nitrogen (TN), total Phosphorus (TP), total suspended solids (TSS) and bacteria were isolated in the calculator and scores associated with just these metrics were used to evaluate the effectiveness of strategies in reducing these pollutants of concern
- Standardization of strategies addressing permit-related metrics – strategies, which varied in size, were all standardized to 10 acres to compare these permit-related metrics in an "apples to apples" manner
- All metrics – including the full set of metrics associated with all of the objectives in addition to the pollutant-related metrics
- Standardization of all metrics – comparing how the same sized strategies (all 10 acres) address all metrics

The calculator tool was also tied to the **Strategy Cost** information. Metrics specific to pollutant reductions (e.g., pounds of pollutant removed by a strategy) were used to calculate Cost Effectiveness. Overall, strategy costs were then evaluated in association with Affordability.

Another puzzle piece, **Modeling Results**, provided the bacteria reductions associated with several strategies that were used as raw score inputs into the calculator. Modeling results also provided information pertaining to the relative nature of bacteria sources to the James River and tributaries.

Each of these specific analyses is discussed in more detail below.

The Permit

Establishing Targets

Stakeholders and City staff have dedicated significant time to the establishment of Integrated Planning goals and objectives as well as strategies to help ensure these are achieved. While stakeholder concerns ranging from pollutant reduction to habitat restoration and invasive species removal are all considered in the Clean Water Plan, it is essential to remember that there are VPDES permit-related requirements that must be addressed and therefore, these requirements are key drivers behind the Plan. Therefore, it is important to understand that these VPDES permit requirements are water quality-focused and this permit-driven approach inherently prioritizes efforts that help improve water quality in Richmond's waters. Determining the extent to which water quality needs to be improved and the targets that help guide these improvements is a key step in the strategy analysis. Once these targets are determined, the next step is to evaluate how the strategies themselves help the City best (efficiently and effectively) achieve these targets.

One pollutant the City must work toward reducing is bacteria. Table 6.4 includes the existing bacteria (*E.coli*) loads and the allowable pollutant loading (the Waste Load Allocation, or WLA) for the City's MS4 (as documented in the Bacteria TMDL Action Plan based upon the James River Bacteria TMDL) and for the CSO/WWTP discharges (as documented in the James River Bacteria TMDL). These loads and the WLAs are summed in this table to provide an overall bacteria reduction by watershed addressed by the TMDL.

Table 6.4. E.coli Bacteria reduction requirements for Richmond's WWTP/CSS and MS4 systems

	MS4			WWTP			CSO		
	Existing Load	WLA	Load Reduction Target	Existing Load	WLA	Load Reduction Target	Existing Load	WLA	Load Reduction Target
Bacteria (BCFU)	606,312	221,842	384,470	6,792	444,000	(437,208)	16,511,684	3,025,710	13,485,974

What Table 6.4 shows is that the MS4 and CSOs in particular are still the biggest sources of bacteria and will drive additional reductions. The WWTP is reducing bacteria efficiently. The existing bacteria load from the plant, therefore, is far below the WLA, which produces a "credit" for bacteria (this negative number is denoted by parenthesis around the load reduction target).

The City also has total Nitrogen (TN), total Phosphorus (TP), and total suspended solids (TSS) pollutant loading reduction targets driven by the Chesapeake Bay TMDL. TN and TP reductions are also reflected in the VPDES Watershed General Permit for Nutrient Discharges to the Chesapeake Bay. Table 6.5 identifies the WLA and reduction goals associated with the City's WWTP and its CSOs as well as with its MS4 program.

Table 6.5. TN, TP, and TSS reduction requirements for Richmond's WWTP/CSS and MS4 systems

	MS4			WWTP			CSO		
	Existing Load	Waste Load Allocation	Load Reduction Target	Existing Load	Waste Load Allocation	Load Reduction Target	Existing Load	Waste Load Allocation	Load Reduction Target
TN (lbs)	166,955	154,901	12,054	338,328	1,093,652	(755,324)	141,759	409,557	(267,798)
TP (lbs)	19,813	17,262	2,550	29,411	55,754	(26,343)	17,720	31,642	(13,922)
TSS (lbs)	6,327,579	5,223,204	1,104,375	361,031	847,754	(486,723)	2,303,581	3,396,550	(1,092,969)

Table 6.5 shows that the WWTP is very efficient in reducing these pollutants and resulting load reduction targets for Nitrogen, Phosphorus, and sediment are not only met, but exceeded.

As will be discussed in further in Chapter 9, the intent of the watershed-based integrated VPDES permit is to look at the City's source sectors collectively to determine greatest impacts. In an effort to do this, bacteria, nutrient and sediment targets for the MS4, WWTP, and CSOs are aggregated (Table 6.6).

Table 6.6. Aggregated annual load reduction targets

	Waste Load Allocation	Existing Load	Load Reduction Target
TN (lbs)	1,658,110	647,042	(1,011,068)
TP (lbs)	104,658	66,943	(37,715)
TSS (lbs)	9,467,508	8,992,191	(475,317)
Bacteria (BCFU)	3,691,552	17,124,789	13,433,236

These aggregated annual load reduction targets reflect the effectiveness of the WWTP in reducing nutrients and sediment in general. While this Clean Water Plan will still continue to emphasize additional reductions of these pollutants in the MS4 and its impacts to tributaries in particular, this information helps inform DPU as to where its most significant pollutant reductions are needed. This information will be taken into consideration in the following analyses and how this influences strategy prioritization.

Strategy Scores

Permit-Related Metrics

Permit-related metrics are defined as those that address TN, TP, TSS, or bacteria (the pollutants of concern). Through the population of the Excel-based strategy scoring calculator, each strategy was evaluated to determine what amount of, if any, pollutant reduction was achieved. Table 6.7 includes the strategies that are expected to result in reductions in permit-targeted pollutants associated with the Chesapeake Bay TMDL (TN, TP, and TSS) and bacteria TMDL (for compliance with recreational water quality standards). The values in Table 6.7 are excerpted from the strategy scoring calculator. How well each of these strategies addresses these pollutants is also conveyed in this table by color coding the cells based on the strategies that best address these pollutants of concern:

- **Green** – address all pollutants of concern (light green addresses fewer metrics)
- **Orange** – Address nutrients and sediments, but not bacteria
- **Red** – don't address any pollutants of concern, but can be used as supplemental strategies that can be incorporated as appropriate and as resources and opportunities allow

*Table 6.7. How strategies address pollutants of concern**

	Riparian areas	GI in MS4	GI in CSS	Stream restoration	Natives/ invasives	Trees	Land conservation	Water conservation	Pollution ID	CSOs / WWTP Infrastructure
Objective: Reduce nitrogen, phosphorus, and sediment in discharges to achieve VPDES permit requirements (Chesapeake Bay TMDL).										
Average yearly TN load reduction (lbs)	19	414	74	188	0	30	0	11	448	7,066
Average yearly TP load reduction (lbs)	4	90	16	170	0	4	0	1	162	903
Average yearly TSS load reduction (lbs)	1,081	42,397	7,393	75,013	0	447	0	422	57,893	116,843
Objective: Reduce bacteria levels to achieve VPDES permit requirements (local TMDL and water quality standards).										
Percent increase in monthly geomean WQS compliance	0	0	0	0	0	0	0	0	0	11
Average yearly E.coli load reduction (billion cfu)	83	3,531	40,642	0	0	0	0	0	0	3,551,112
Average yearly reduction in CSO events (number)	0	0	0	0	0	0	0	0	0	1
Average yearly reduction in CSO volume discharged (million gallons)	0	0	5	0	0	0	0	0	0	962

*(Associated with the goal: Manage wastewater and stormwater to improve the water quality and water quantity of ground water and surface water.)

The results of this comparison show the following:

- Strategies that address all pollutants including TN, TP, TSS and bacteria
  - CSO/WWTP Infrastructure
  - Green Infrastructure (in the MS4/CSS areas)
  - Riparian Areas
- Strategies that address TN, TP, TSS, but not bacteria
  - Stream restoration
  - Trees
  - Water conservation
  - Pollution identification

Additionally, strategies that can be implemented, but do not help achieve permit requirements include:

- Native/invasives
- Land conservation

The "raw" scores in Table 6.7 were then normalized and weighted (additional information on these processes is included on the call-out box on the following page). These values are included in Table 6.8.

*Table 6.8. Normalized and weighted scores of strategies in addressing pollutants of concern**

	Riparian areas	GI in MS4	GI in CSS	Stream restoration	Natives/ invasives	Trees	Land conservation	Water conservation	Pollution ID	CSOs / WWTP Infrastructure
Objective: Reduce nitrogen, phosphorus, and sediment in discharges to achieve VPDES permit requirements (Chesapeake Bay TMDL).										
Average yearly TN load reduction (lbs)	0.3**	6.8	1.2	3.1	0.0	0.5	0.0	0.2	7.4	116.0
Average yearly TP load reduction (lbs)	0.5	11.6	2.0	21.8	0.0	0.5	0.0	0.2	20.9	116.0
Average yearly TSS load reduction (lbs)	1.1	42.1	7.3	74.5	0.0	0.4	0.0	0.4	57.5	116.0
Objective: Reduce bacteria levels to achieve VPDES permit requirements (local TMDL and water quality standards).										
Percent increase in monthly geomean WQS compliance	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	87.0
Ave. yearly E.coli load reduction (billion cfu)	0.0	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	87.0
Average yearly reduction in CSO events (number)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.0
Average yearly reduction in CSO volume discharged (million gallons)	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	87.0
Score	1.9	61.4	12.9	99.4	0.0	1.5	0.0	0.8	85.7	696.2
Rank	**6**	**4**	**5**	**2**	**9**	**7**	**9**	**8**	**3**	**1**

*(Associated with the goal: Manage wastewater and stormwater to improve the water quality and water quantity of ground water and surface water.)

** All scores multiplied by 100 for clarification purposes. Total score may be off due to rounding.

Normalizing & Weighting Scores

The intent of the strategy scoring process is to produce a value that demonstrates how well each strategy addresses the metrics of interest. The metrics used to evaluate the strategies; however, can vary in the way they are measured (e.g., pounds of total Nitrogen reduced, acres of impervious surface treated, etc.). Because of the varying units represented, raw scores cannot simply be added together to obtain a score for each strategy. A normalization process is required to adjust these raw scores to a common scale.

To accomplish the normalization process, the raw score is divided by the maximum of the raw scores associated with that particular metric. In the example below, each of the numbers in the red box would be divided by 7,066 to produce the associated normalized scores for this metric.

Additionally, because the metrics may not all be of equal importance, various weights were also applied to them. In the example below TN reduction was considered most important and given a higher weight (50%) than the other metrics. Normalized scores are multiplied by the associated weight to produce a final weighted, normalized score. In the example below, each of the normalized scores in the orange box is multiplied by 50% to produce the associated values in the green box. A strategy's weighted, normalized scores are added together to produce a final score for that strategy. In the example below, Strategy B, with a score of 30, best achieves these four metrics.

Example scoring process

		Raw Scores			Normalized Scores			Weighted, Normalized Scores		
	Weight	Strategy A	Strategy B	Strategy C	Strategy A	Strategy B	Strategy C	Strategy A	Strategy B	Strategy C
Average yearly TN load reduction (lbs)	50%	19	11	7,066	0.003	0.002	1.0	0	0	1.2
Average yearly E. coli load reduction (BCFU)	20%	83	0	3,551,112	0	0	1	0	0	0.9
Impervious Surface reduced or treated (acres)	15%	2	5	0	0.4	1	0	6	15	0
Potable water consumption reduced (gallons)	15%	0	0	250	0	1.0	0	0	15	0
Total	100%							6	30	2.1

The normalized, weighted scores for each strategy are summed, which results in a final score for the strategy. The top ranked strategies for achieving key pollutant reduction include:

1. CSO/WWTP Infrastructure
2. Stream Restoration
3. Pollution Identification
4. GI in MS4

"Standardization" of Permit-Driven Metrics

As previously stated, the numeric targets of the strategies were based on the amount of DPU/PRCF land/resources available for that particular strategy. As a result, each strategy addresses a different amount of area (e.g., 10 acres of land for riparian area restoration vs. 104 acres of land in the MS4 for implementation of green infrastructure, etc.). To evaluate strategies in a "standardized" manner (all strategies being comparable in size to one another in an "apples to apples" manner), strategies were evaluated as if they would be implemented on 10 acres of land (Table 6.9).

It is important to note that the CSO/WWTP strategy is based on reducing the combined sewer overflow volume and frequency, which is not based on acreage of implementation. As such, this strategy cannot be standardized in this way and is not included in the analysis reflected in Table 6.9.

*Table 6.9. How "standardized" strategies address pollutants of concern**

	Riparian areas	GI in MS4	GI in CSS	Stream restoration	Natives/ invasives	Trees	Land conservation	Water conservation	Pollution ID
Objective: Reduce nitrogen, phosphorus, and sediment in discharges to achieve VPDES permit requirements (Chesapeake Bay TMDL).									
Average yearly TN load reduction (lbs)	19	40	41	327	0	4	0	22	1
Average yearly TP load reduction (lbs)	4	9	9	296	0	4	0	1	0
Average yearly TSS load reduction (lbs)	1,081	4,077	4,107	130,702	0	56	0	845	341
Objective: Reduce bacteria levels to achieve VPDES permit requirements (local TMDL and water quality standards).									
Percent increase in monthly geomean WQS compliance	0	0	0	0	0	0	0	0	0
Average yearly E.coli load reduction (billion cfu)	83	340	22,579	0	0	0	0	0	0
Average yearly reduction in CSO events (number)	0	0	0	0	0	0	0	0	0
Average yearly reduction in CSO volume discharged (million gallons)	0	0	3	0	0	0	0	0	0

*(Associated with the goal: Manage wastewater and stormwater to improve the water quality and water quantity of ground water and surface water.)

Table 6.10 shows the normalized, weighted scores for these strategies standardized across 10 acres. Again, note that the CSO/WWTP strategy is not included in Table 6.10 as it cannot be standardized across 10 acres of land.

*Table 6.10. Standardized strategies that have been normalized and weighted for pollutants of concern**

	Riparian areas	GI in MS4	GI in CSS	Stream restoration	Natives/ invasives	Trees	Land conservation	Water conservation	Pollution ID
Objective: Reduce nitrogen, phosphorus, and sediment in discharges to achieve VPDES permit requirements (Chesapeake Bay TMDL).									
Average yearly TN load reduction (lbs)	6.6	14.1	14.7	116.0	0.0	1.4	0.0	8.0	0.5
Average yearly TP load reduction (lbs)	1.5	2.8	3.0	116.0	0.0	0.2	0.0	1.1	0.0
Average yearly TSS load reduction (lbs)	1.0	2.4	2.5	116.0	0.0	0.0	0.0	0.8	0.3
Objective: Reduce bacteria levels to achieve VPDES permit requirements (local TMDL and water quality standards).									
Percent increase in monthly geomean WQS compliance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ave. yearly E.coli load reduction (billion cfu)	0.3	1.3	87	0.0	0.0	0.0	0.0	0.0	0.0
Average yearly reduction in CSO events (number)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average yearly reduction in CSO volume discharged (million gallons)	0.0	0.0	87.0	0.0	0.0	0.0	0.0	0.0	0.0
Score	9.4	22.5	195.8	348	0	1.6	0	9.9	0.8
Rank	**5**	**3**	**2**	**1**	**8**	**6**	**8**	**4**	**7**

*(Associated with the goal: Manage wastewater and stormwater to improve the water quality and water quantity of ground water and surface water.)

** All scores multiplied by 100 for clarification purposes

All Metrics

While evaluating key permit related pollutants is important, numerous other metrics were also identified for other goals and objectives (Appendix C). Table 6.11 shows the score (obtained from the strategy scoring calculator) for each strategy that takes all of the metrics collectively into consideration.

Table 6.11 – Scores and ranks of all feasible strategies – total acres/resources available

	Riparian	GI in MS4	GI in CSS	Stream Restoration	Natives/ Invasives	Trees	Land Conservation	Water Conservation	Pollution ID	CSO/ WWTP
Scores	54.90	57.53	39.88	47.82	43.10	44.80	42.02	45.00	35.29	46.22
Rank	2	1	9	3	7	6	8	5	10	4

The results of the scoring process (including all metrics and strategies) results in the following ranking of strategies:

1. Green Infrastructure in the MS4
2. Riparian Area Restoration
3. Stream Restoration
4. CSO/WWTP Infrastructure

"Standardization" of All Metrics

While these available acreages are very important for future implementation purposes, a "standardized" comparison of the strategies with regard to all other metrics was also performed. Again, this analysis assumed 10 acres of implementation for each of the strategies and, as discussed above, the CSO/WWTP strategy was not included in this standardized analysis as it cannot be evaluated on a 10-acre basis. The CSO/WWTP strategy is therefore evaluated separately below. Table 6.12 shows the scoring of the strategies if all were implemented on the same amount of acreage.

Table 6.12 – Scores and ranks of feasible strategies – 10 acres for each strategy

	Riparian	GI in MS4	GI in CSS	Stream Restoration	Natives/ Invasives	Trees	Land Conservation	Water Conservation	Pollution ID
Scores	66.87	55.46	57.67	67.74	44.44	43.83	46.49	56.33	36.27
Rank	2	5	3	1	7	8	6	4	9

The results of these scores produce in the following top-ranked strategies:

1. Stream Restoration
2. Riparian Area Restoration
3. Green Infrastructure in the CSS area
4. Water Conservation

Evaluation of CSS Infrastructure Projects

The CSS Infrastructure strategy was evaluated in previous sections as a whole, but this strategy consist of several different projects outlined in the LTCP, including:

- Installing wet weather interceptor in Lower Gillies to convey more flow to the WWTP
- Increasing WWT (wet weather treatment) at the WWTP to 300 MGD and expanding secondary treatment at the WWTP to 85 MGD
- Replacement of CSO 021 regulator and additional 2MG storage at CSO 021
- Expanding Shockoe retention basin by 15 MG to capture more overflow
- Disinfecting overflow at Shockoe retention basin (wet weather disinfection facility)

Each project was evaluated in isolation to determine individual impact on bacteria load reduction. These CSS "scenarios" are summarized in Table 6.13, below.

Table 6.13. Description of CSS Projects Evaluated by the Water Quality Model

CSS Scenario	CSS Project Name	CSS Project Description
Existing	Existing Conditions	Existing sewer conditions, including all LTCP Phase I and Phase II projects.
14-3	Baseline Conditions	Includes the currently funded projects: --CSO 028A & 028E disconnection --WWTP wet weather treatment up to 140 MGD
14-2	Gillies Conveyance	Lower Gillies Wet Weather Conveyance Interceptor to convey more flow to the WWTP
15-4	300 MGD Wet Weather Treatment	WWTP wet weather treatment up to 300 MGD
15-5	CSO 21 Replacement	Replacement of the CSO 21 regulator and additional 2MG storage
18-4	SRB Expansion	Shockoe retention basin (SRB) expansion to 15MG
18-5	SRB Expansion and Disinfection	SRB Expansion to 15MG and chlorine disinfection of the SRB discharge at CSO 06
19-3A	Full LTCP	All 10 Phase III projects, Full LTCP achieved.

Bacteria load reductions from each CSS scenario is shown in Figure 6.4, below.

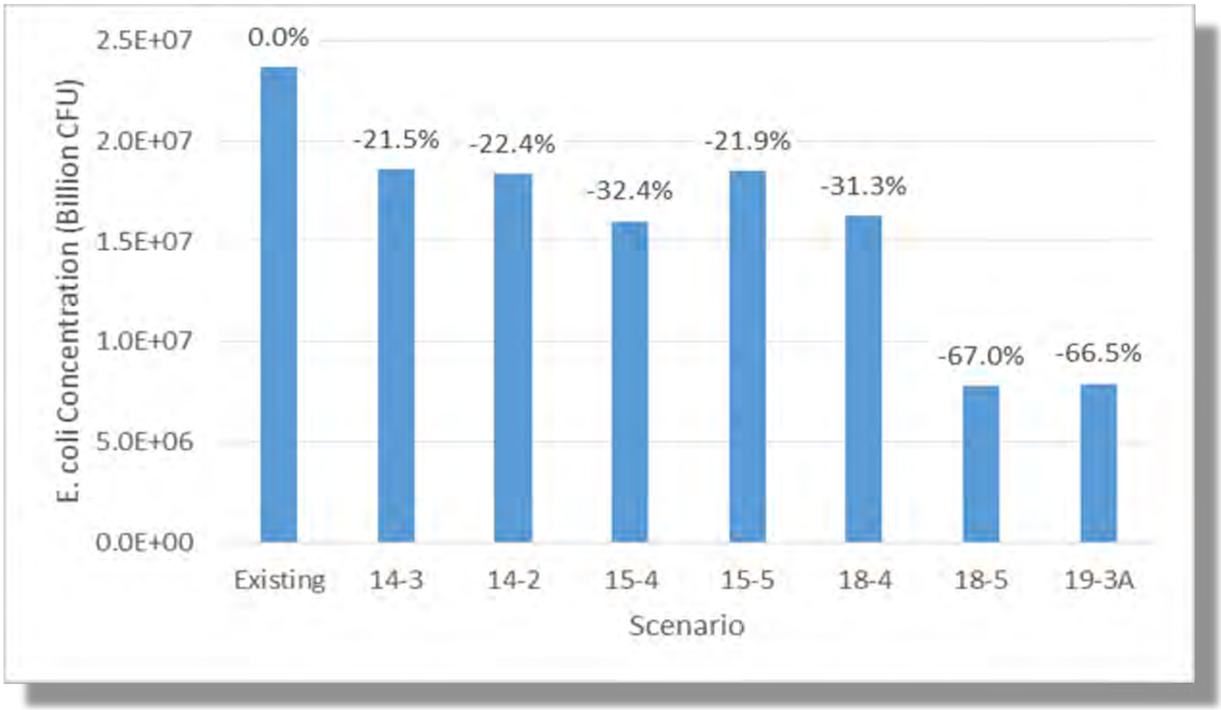

Figure 6.4 Bacteria load reductions from each CSS Infrastructure Project

Additional new projects, or variations to the existing projects, are currently being evaluated to determine if these alternative projects could accomplish similar or greater bacteria load reductions compared to the existing projects, and if this could be done in a more cost efficient way. Those alternative evaluations are currently ongoing, and include projects such as controlling discharge from CSO-040 and other combined sewer outfalls, and different types of disinfection for wet weather treatment at the wastewater treatment plant and at Shockoe retention basin.

Comparison of Targets with Load Reductions

The aim of the Integrated VPDES permit is to more efficiently control the discharge of pollutants from all DPU sources. In order to do this, it is necessary to look at the ultimate targets and all the sources together and assess where it is possible to get the greatest gains. It is also important to recognize not all pollutants will be assessed in the same way, different pollutants have different impacts. Some pollutants have far field effects and can be assessed based upon total load delivered while others must be looked at based on localized effects. For instance, an aggregate approach can be done for TN, TP, and TSS because the TMDL allows the targets to be assessed for the City as a whole to ultimately achieve improvements downstream to the Chesapeake Bay. The bacteria numbers can also be aggregated to show the overall scale of needed reductions, but it must be remembered that bacteria allocations exist for specific watersheds, and those need to be met at the local scale, rather than at the aggregate scale. These aggregated targets are depicted in Table 6.14.

Table 6.14. Aggregated Annual Load Reduction Targets

	Existing Load	Waste Load Allocation	Load Reduction Target
TN (lbs)	647,042	1,658,110	(1,011,068)
TP (lbs)	66,943	104,658	(37,715)
TSS (lbs)	8,992,191	9,467,508	(475,317)
Bacteria (BCFU)	17,124,789	3,691,552	**13,433,236**

While Table 6.14 shows (on an aggregated scale) targets for TN, TP, TSS are already met, bacteria still needs additional reductions in order to meet targets. These targets can be compared to the load reductions achieved by the strategies, shown previously in Table 6.6.

Costs

Financial constraints referred to in Figure 6.1 include the costs of the strategies and supporting actions and cost effectiveness of these strategies. Affordability is considered the overarching mechanism within which these elements can be paid for in an affordable manner by DPU. Each of these factors is discussed in more detail below.

Strategy Costs

The cost associated with the full implementation of the strategies included in Table 5.1 was also estimated (Table 6.15). For the purpose of estimating costs most consistently across strategies, the assumption was that the strategy would be implemented in the first year of the permit (capital costs) with maintenance being required for the strategy in years two through five of the permit.

Table 6.15. Cost of main strategies broken out by capital and maintenance

Main Strategy	Capital	O&M	Total
Riparian Areas	$900,000	$200,000	$1,100,000
Green Infrastructure in the MS4	$10,500,000	$2,000,000	$12,500,000
Green Infrastructure in the CSS	$2,600,000	$750,000	$3,350,000
Stream Restoration	$1,700,000	$1,200,000	$2,900,000
Native/ Invasives	$70,000	$95,000	$165,000
Trees	$1,600,000	$600,000	$2,200,000
Land Conservation	$ -	$ -	$ -
Water Conservation	$220,000	$ 50,000	$270,000
Pollution Identification & Reduction[8]	$16,385,000	$ -	$16,385,000
CSO Infrastructure[9]	$374,800,000	$17,400,000	$392,200,000
Total	**$408,775,000**	**$22,295,000**	**$431,070,000**

The cost of additional supporting actions was also estimated in Table 6.16.

[8] As street sweeping and catch basin clean-outs are ongoing efforts for the City, these activities are calculated for each of the five years of the permit.

[9] Note that the cost for the CSO Infrastructure strategy is over 30 years, while the costs of the other nine strategies are over five years.

Table 6.16. Cost of supporting actions

Supporting Actions	
Partnerships	$700,000
Monitoring, Assessments & Planning	$1,300,000
Incentives/ Credits	$1,250,000
Regs/ Ordinance/ Code	$ -
Outreach	$500,000
Total	**$ 3,750,000**

The source of all cost information as well as any assumptions that were made in association with the calculation of final cost estimates is discussed further in Appendix E.

Cost Effectiveness

While cost is important from the perspective of how it can be achieved within a certain budget, cost effectiveness of a particular strategy can be more informative because it provides an indication of the return on the investment. Cost effectiveness was evaluated for each strategy for the permit-driven metrics (TN, TP, TSS, bacteria) discussed above, and expressed as cost per unit pollutant removed. Cost effectiveness comparisons in Table 6.17 are also based on the strategies that included the fill size/acreage/ resources (again it should be noted that the Natives & Invasives strategy and the Land Conservation strategy are not included in this table because neither, as they are written, results in the reduction of these key pollutants).

Table 6.17. Pollutant reduction and associated cost effectiveness of strategies

	Riparian areas	GI in MS4	GI in CSO	Stream restoration	Trees	Water conservation	Pollution Identification	CSOs / WWTP Infrastructure
Average yearly TN load reduction (lbs)	19	414	74	188	30	11	448	7,066
Average yearly TP load reduction (lbs)	4	90	16	170	4	1	162	903
Average yearly TSS load reduction (lbs)	1,081	42,397	7,393	75,013	447	422	57,893	116,843
Average yearly E.coli load reduction (billion cfu)	83	3,531	40,642	0	0	0	0	3,551,112
Cost	$1,100,000	$12,500,000	$3,350,000	$2,900,000	$2,200,000	$270,000	$16,385,000	$392,200,000
Cost per pound TN removed	$58,902	$30,181	$45,270	$15,467	$72,158	$24,092	$36,597	$55,507
Cost per pound TP removed	$292,553	$138,687	$209,375	$17,059	$520,833	$195,744	$100,882	$434,293
Cost per pound TSS removed	$1,017	$295	$453	$39	$4,925	$639	$284	$3,357
Cost per billion E.coli removed	$13,190	$3,540	$82	--	--	--	--	$110

The green highlighted items in Table 6.17 identify those strategies that are most cost effective for the various pollutants.

Affordability

The intent of the Clean Water Planning process is to make sure that each dollar spent gets the greatest environmental benefit. While this is important to rate payers in general, it is additionally important because the City already has a large number of people who are below the poverty line and currently can't afford their utility bills. So, while the City was evaluating ways to make smart water quality decisions, it was also looking for ways to keep rates affordable.

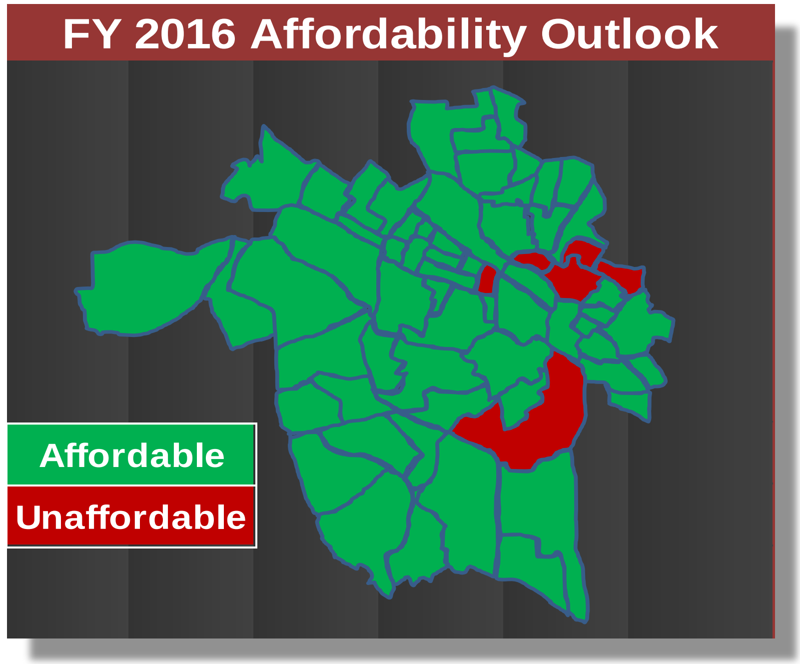

Figure 6.2 With current rates, those census tracks that cannot afford utility rates in 2016

While developing its Integrated Plan, DPU analyzed the impact annual spending would have on rates over time, and subsequently customer bills. This analysis was done to define and measure affordability, so that unaffordable bills and financial impacts can be mitigated to the greatest degree on an annual basis.

To accomplish this, DPU evaluated customer impacts on a localized level (at the census track level shown here) throughout the City by measuring bill impacts against various affordability and income metrics, like "living wages".

The results of this affordability analysis are summarized in Figure 6.2, demonstrating where rates are unaffordable by census tract. Between 2016 and 2045, the financial model shows the situation would get much worse (assuming rate increases remain at their current pace and economic conditions remain constant).

What this also shows is that if the City continues to attempt to comply with various water quality regulations with the "do everything, everywhere simultaneously" approach this is the probable outcome. Alternatively, the Clean Water Plan focuses strategic decisions for cleaner water faster, but in a more affordable way.

The budget within which strategies will be implemented within the Clean Water Planning effort have been set, or constrained, by affordability. It is important to note that a high cost of a given strategy may not take it off the table, but simply require it to be implemented over time or other strategies are prioritized ahead of it.

Strategy Prioritization

The various "pieces of the puzzle", discussed above, were used to understand how to best prioritize activities for implementation. As each of these analyses tells only a piece of the story, it is important to look at these analyses collectively. What these analyses have shown is that no one strategy consistently scores the highest or performed the best across the analyses, however, several strategies consistently performed well (a summary of the analyses are included in Table 6.18; green highlighted information depicts those that consistently score highest).

To allow for the consideration of multiple factors in determining priorities, it was determined that rather than ranking 10 strategies individually, that strategies would be grouped into one of three tiers based on effectiveness (Figure 6.3). Tier 1 includes those strategies that best address metrics associated with the pollutants of concern (TN, TP, TSS, bacteria) as well as the non-pollutant related metrics. These strategies were also the most cost effective. Tier 2 also addressed pollutant and non-pollutant related metrics, but not as efficiently or cost effectively as those in the Tier 1 grouping. Tier 3 includes those strategies that do not address the pollutants of concern.

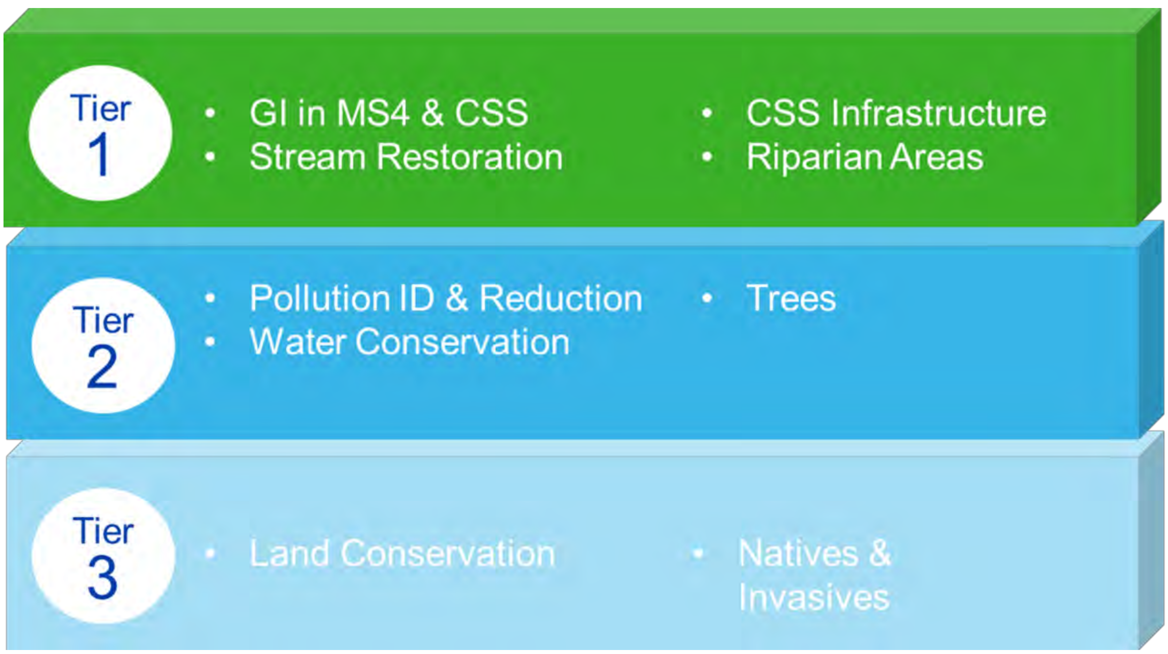

Figure 6.3. Organization of strategies into tiers for prioritization

It is important to note that while select strategies may be *prioritized* it does not mean that the remaining strategies will be disregarded. Implementation of these strategies will be assessed based on additional resources available to DPU or priorities and resources available from other City departments or other partners.

It is also important to note that this analysis was done at a high level. As DPU moves toward implementation and conducts a more refined evaluation of strategies, there may be modifications to this prioritization. For instance, the Green Infrastructure strategy includes bioretention, green roofs, permeable pavement, engineered tree boxes, rain barrels, and stormwater pond retrofits. If other green infrastructure practices are identified as alternatives, details, such as cost, amount of pollutant reduction, and how the practices achieves other metrics, will all be taken into consideration.

Table 6.18 Summary of Strategy Analysis and Strategy Prioritization

Rank	Pollutants of Concern Metrics	Pollutants of Concern Metrics: Standardized*	All Metrics	All Metrics: Standardized*	Cost Effectiveness (TN)	Cost Effectiveness (TP)	Cost Effectiveness (TSS)	Cost Effectiveness (bacteria)
1	**CSO Infrastructure**	**Stream restoration**	**GI in MS4**	**Stream restoration**	**Stream restoration**	**Stream restoration**	**Stream restoration**	**GI in CSS**
2	**Stream restoration**	**GI in CSS**	**Riparian areas**	**Riparian areas**	Water conservation	Pollution ID and reduction	Pollution ID & reduction	**CSO Infrastructure**
3	Pollution ID & reduction	**GI in MS4**	**Stream restoration**	**GI in the CSS**	**GI in MS4**	**GI in MS4**	**GI in MS4**	**GI in MS4**
4	**GI in MS4**	Water conservation	**CSO Infrastructure**	Water Conservation	Pollution Identification	Water conservation	**GI in CSS**	**Riparian areas**
5	**GI in CSS**	**Riparian areas**	Water Conservation	**GI in MS4**	**GI in CSS**	**GI in CSS**	Water conservation	Water conservation
6	**Riparian areas**	Trees	Trees	Land Conservation	**CSO Infrastructure**	**Riparian areas**	**Riparian areas**	
7	Trees	Pollution ID & reduction	Natives/ invasives	Natives/ invasives	**Riparian areas**	**CSO Infrastructure**	**CSO Infrastructure**	
8	Water Conservation	Natives / invasives	Land Conservation	Trees	Trees	Trees	Trees	
9	Natives/ invasives	Land Conservation	**GI in the CSS**	Pollution Identification				
10	Land Conservation		Pollution ID and reduction					

*WWTP/CSO strategy cannot be evaluated on a 10-acre basis so it is not included herein

7. Implementation Program

As discussed in Chapter 5, high-level strategies to achieve goals and objectives were developed to include quantifiable targets that DPU can work towards implementing (e.g., 10 acres of riparian buffer restoration, implementation of 104 acres of green infrastructure in the MS4 area of the City, etc.). An important part of this Clean Water Plan is developing an approach that can help the City implement these strategies in the most efficient and cost effective manner possible.

Framework Planning

In order to most efficiently and effectively implement its IWPM Plan, DPU will use a "Framework Planning" approach. The Framework Planning approach provides a methodology that ties together different strategies (and, subsequently, site-specific projects) and, where possible, aligns these strategies with other City or stakeholder-driven initiatives.

This Framework Planning approach is intended to be:

- A comprehensive and action-oriented blueprint for near- and long-range decision making
- A planning guide for the implementation of a set of strategies and serves to create a "framework" around multiple other efforts (e.g. Master Plan, guidelines for new/existing development, other City planning efforts, etc.) to guide planning in a cohesive way
- Designed for flexibility and choices that will enable different entities (City Departments, partners, etc.) to act both collaboratively and independently, over different periods of time, but in a coordinated way

The goal of the Framework Planning approach is to identify and sequence a blend of activities that yield the greatest environmental benefit (as measured by identified metrics) in the most cost-effective (and affordable) manner.

Framework Planning Process

As discussed in previous chapters, the Clean Water Planning process involved the development of goals and objectives, and high-level strategies that could meet these goals and objectives. For implementation purposes, these strategies will be translated into projects (e.g., 104 acres for the Green Infrastructure in the MS4 strategy could be implemented as 50 engineered tree boxes, 10 acres of permeable pavers, etc., which will, in total, drain 104 acres).

As depicted in Figure 7.1, strategies are prioritized (into Tiers, as discussed in Chapter 6) (#1), but they are still disparate strategies (#2). An example is the Green Infrastructure in the MS4 area strategy (which targeted 104 acres, 44 acres of which were estimated to include bioretention). Assuming each of these bioretention facilities drains one acre, 44 facilities would then be implemented across the City's MS4 area. Implementing these facilities in a piecemeal approach would still meet the target of implementing 44 acres and would still achieve pollutant load reductions estimated for these facilities.

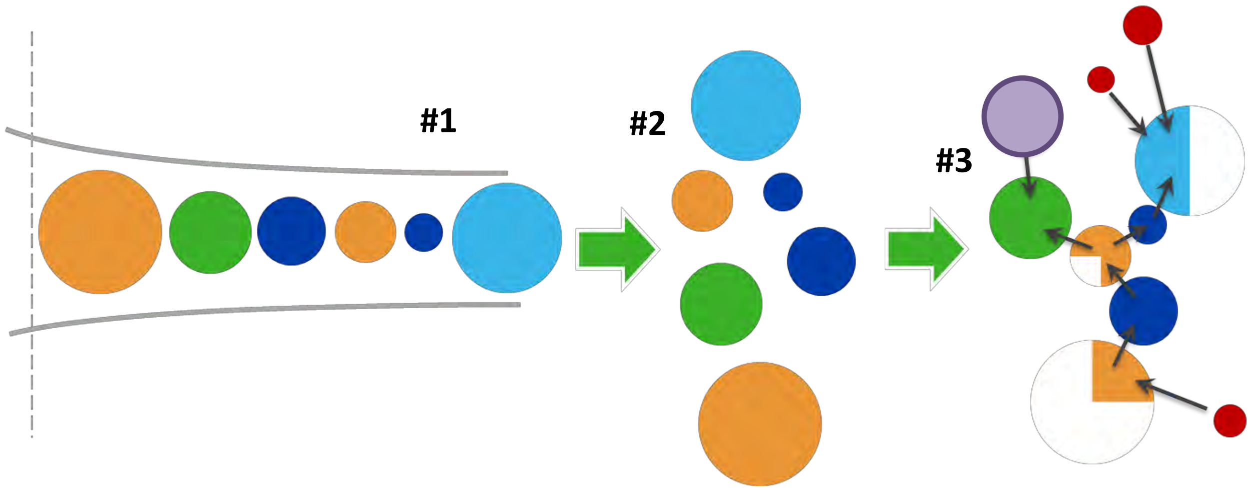

Figure 7.1 Framework Planning includes the interface of various elements together in the landscape in a way that makes the most sense for implementation.

Alternatively, DPU and its stakeholders can look collectively at the City for not only where the opportunities are for implementing bioretention, but where these practices can be implemented within the context of a more comprehensive planning and coordination effort under a Framework Planning umbrella. This Framework Planning process provides the structure for implementation of strategies/projects in a more integrated and cohesive way by leveraging opportunities with other city-led projects such as, for example, Richmond's Riverfront Plan, or stakeholder efforts such as, for example, EnRichmond's tree planting efforts (shown with the red and purple circles in Figure 7.1, #3). The Framework Planning process may also lead to the identification of new ideas and opportunities that can be pushed forward by DPU itself.

While DPU recognizes that some implementation may need to occur in a piecemeal fashion, its goal, where feasible, is that Framework Planning will drive implementation of the strategies. Framework Planning will meet the objectives and goals of the Clean Water Plan, while at the same time supporting and leveraging the overall growth and planning at the City or Stakeholder level.

An example of a Framework Planning-based clustered project is depicted in Figure 7.2, which is included in Arkansas' Conway Urban Watershed Framework Plan (2016). This example depicts Green Streets and parks that tie together the implementation of various types of green infrastructure while addressing other community needs, such as traffic calming, inclusion of recreational opportunities, and expanding parking. Figure 7.3 shows another example from the Conway Urban Watershed Framework Plan, which includes transportation corridors (streets and trails) and recreational amenities with riparian area restoration and green infrastructure. Additional detail on the Conway Framework Plan is included in the Case Study below, and provides additional context about what Framework Planning includes, and is consistent with the Clean Water Plan Framework Planning approach.

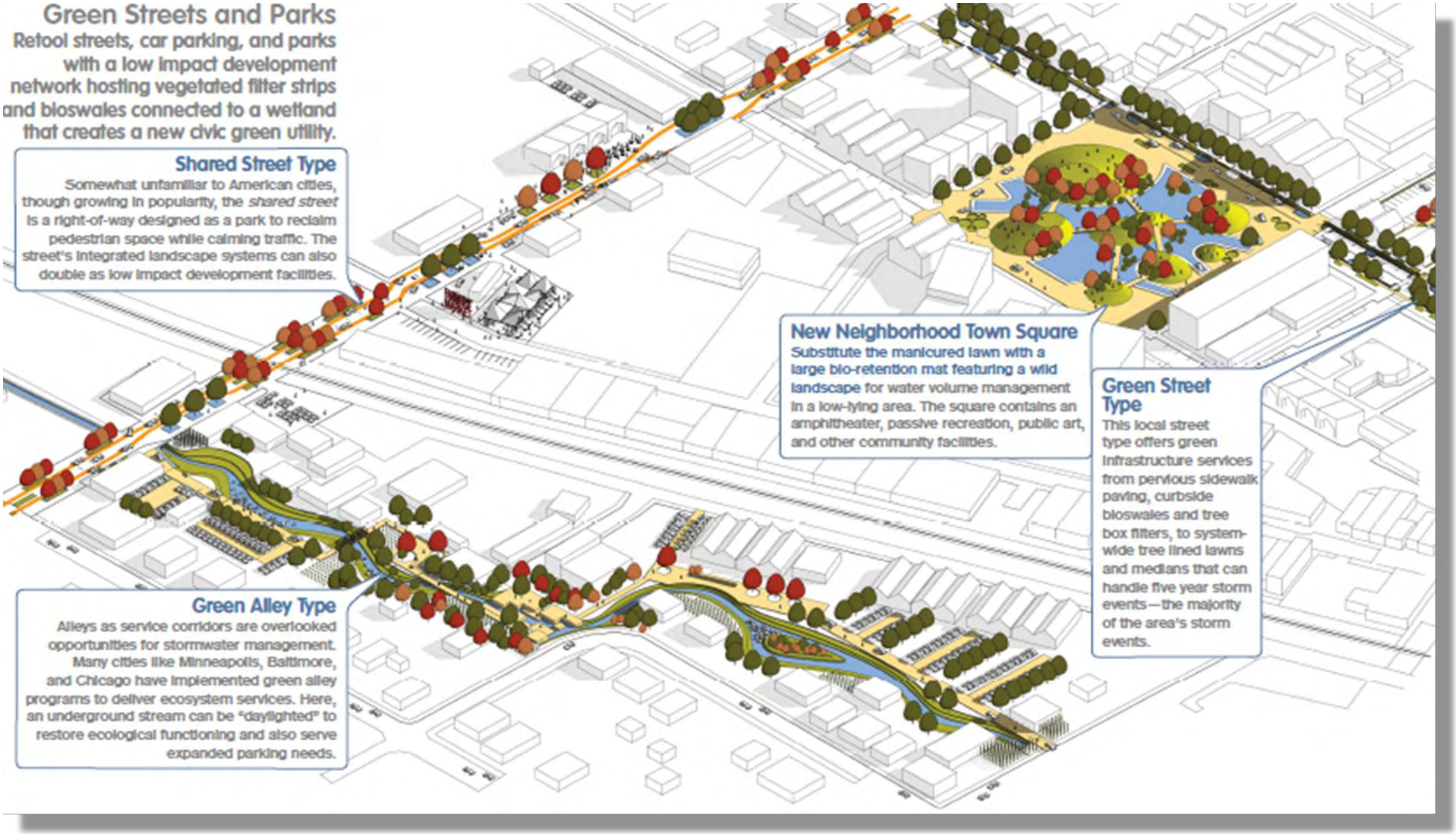

Figure 7.2. Example from the Conway Urban Watershed Framework Plan that shows how multiple strategies (green infrastructure, trees, riparian areas, natives/invasives) can be implemented in holistic way that also addresses other City priorities (traffic calming, recreation, beautification, etc.)

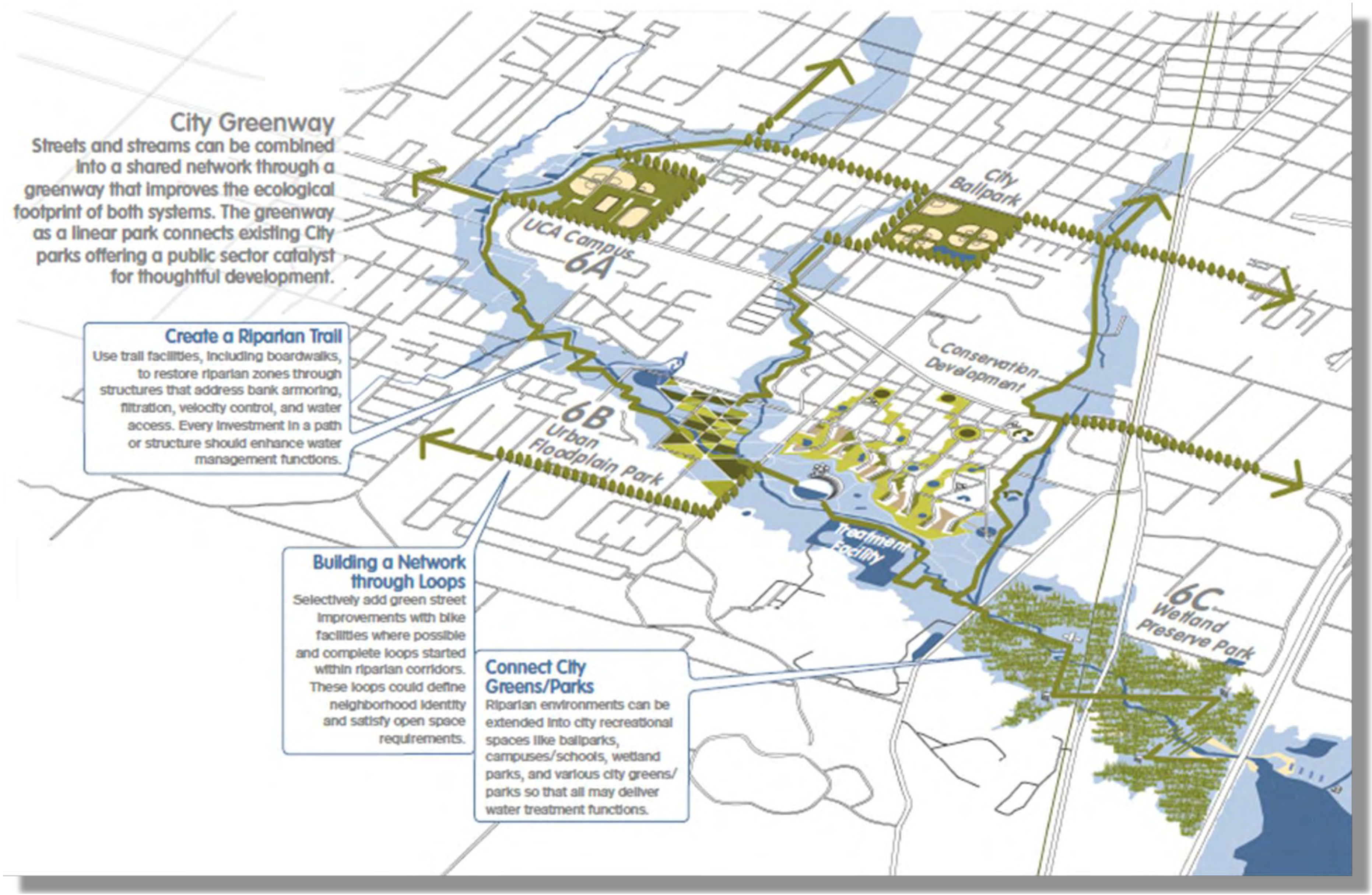

Figure 7.3. Example from the Conway Urban Watershed Framework Plan that shows how Greenways can incorporate strategies like green infrastructure and riparian area restoration with transportation corridors, parks, etc.

Case Study on Urban Framework Planning: Conway, Arkansas

An excerpt from the Conway Urban Watershed Framework Plan

The Framework Plan operates evolutionarily through a set of retrofit types that are incremental, contextual, and successional. The Framework Plan is incremental, relying on participation from various interests— public, private, or a combination thereof—to develop projects as funding and opportunity permit. Projects can be implemented step-wise and successively across various fronts in the urbanized area. Unlike the master plan which is totalizing and shows only a climax condition, the Framework Plan can be pioneered beginning with modest cumulative efforts that cohere from shared ecological design practices.

The Framework Plan is contextual, working through landscape architectural adaptations responsive to local ecologies and urban water problems. Soft engineering accounts for local soils, and vegetative and wildlife communities in place-based solutions that substitute for universal metrics and costly "over-engineered" outcomes driven by worst-case scenarios. The goal is to deliver ecological services through installing sustainable soft infrastructure. Soft engineering's use of adaptive management lessens long-term maintenance burdens associated with hard-engineered infrastructure.

The Framework Plan is successional, understanding that cities are not built at once and that pioneer stages of development are rudimentary as they minimize start-up costs. The Framework Plan works initially through tactical demonstration projects, which if approved after assessment, can be mainstreamed into future projects and policies. This way the city or project developer can evaluate new practices without committing permanently to an untested development and business model. Cities do not have to retool policies without the chance to pursue due diligence. Stakeholders in decision-making, including the city and the area's new watershed alliances (e.g., the Lake Conway-Point Remove Watershed Alliance), can collaborate as learning communities removing adversarial relationships so redolent in municipal planning processes. Without demonstration projects, conventional development approaches will remain entrenched despite the presence of more value-added approaches.

The Framework Plan places Conway ahead of the curve in addressing the greatest ongoing challenge to planning: development of urban form in human-dominated ecosystems. More cities are tasking urban infrastructure with regeneration of diminished ecosystems to support livable communities. Besides solving for water management problems like flooding, the collateral benefits of implementing the plan include greater livability, sustained economic development, improved community resilience to disruption and shocks, and exemplary beauty in the civic realm that creates enduring value and symbolism.

(University of Arkansas Community Design Center 2016)

The Framework Planning approach includes the following elements that are discussed further below:

1) Data and information gathering
2) Identification of potential opportunities
3) Prioritization
4) Plan development
5) Implementation

Data and Information Gathering

A significant data gathering effort was undertaken early in the City's Clean Water Planning process with the development of the Watershed Characterization Plan and Water Quality Model that helped characterize Richmond's watersheds and the James River and tributaries. The type of data that was collected for these two efforts included, for example, impervious surfaces, impaired waterways, City-owned properties, existing stormwater BMPs, and water quality sampling data. The Framework Planning process will facilitate the identification of additional information deemed important to the City and stakeholders, including information such as, for example, ongoing or planned restoration projects or watershed-scale initiatives, places (parks, neighborhoods) that draws people in, and areas challenged by socio-economic issues. DPU initiated discussion of such information at its March 21, 2017 Technical Stakeholder meeting (Figure 7.4). This initial meeting included discussion of what stakeholders felt were existing needs or challenges in the City. This included not only water quality-related issues, but transportation or other socially-driven challenges.

Figure 7.4. Initial Technical Stakeholder brainstorming session on challenges and opportunities to be considered in the Framework planning process

Figure 7.5 depicts examples of other data types that will be looked at collectively through this process, including location of parks (or lack thereof), bike paths, priority conservation areas, commercial areas targeted for revitalization, etc.

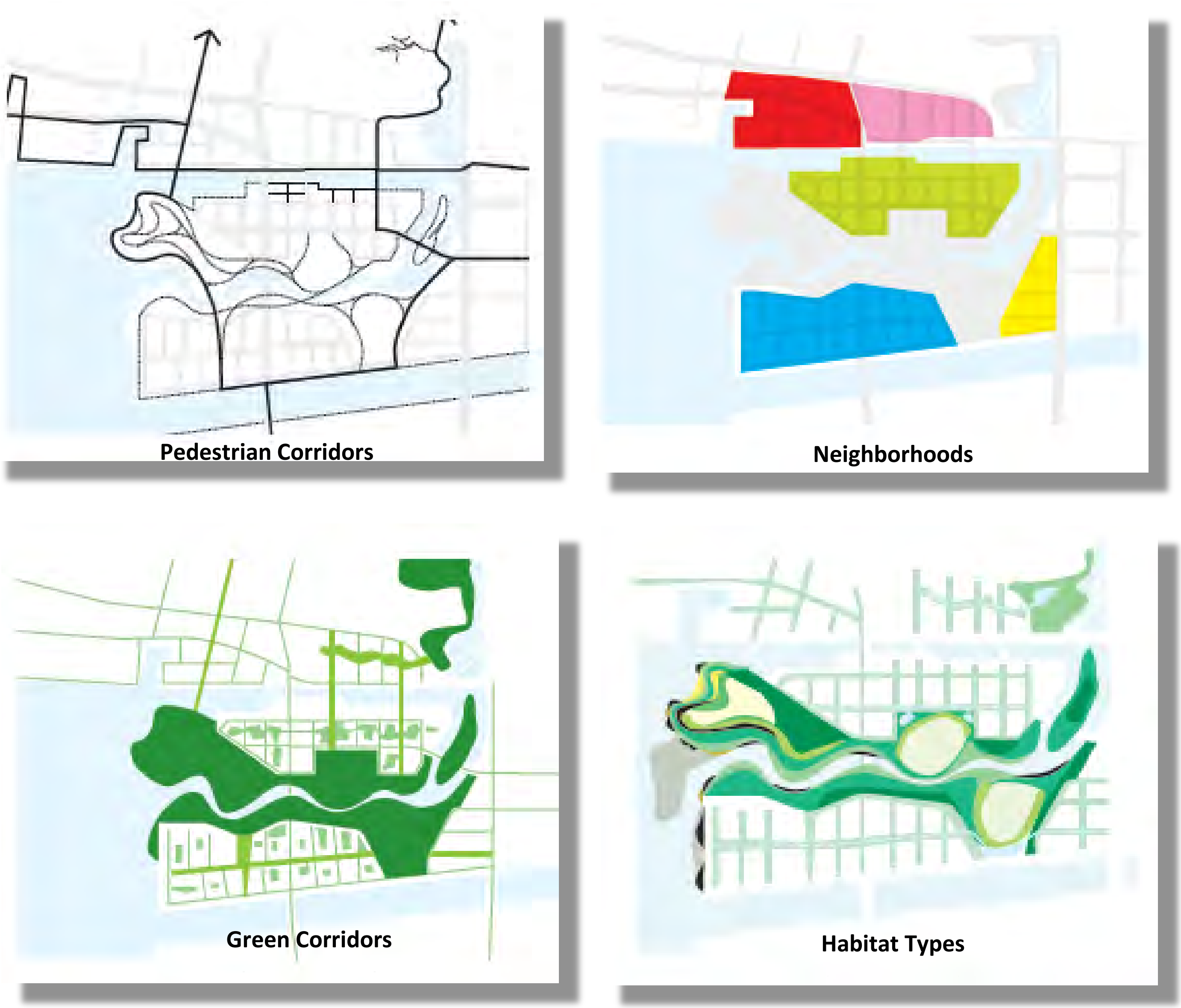

Figure 7.5 Examples of data types that will be considered within the Framework Planning Process

Several additional brainstorming meetings are scheduled to occur with Technical Stakeholders over the course of this project. Additionally, DPU will meet with other City departments to discuss opportunities for collaboration that will allow DPU to not only address its goals and objectives, but those of the City as a whole.

Identification of Potential Opportunities

As meetings with stakeholders and City staff continue, they are expected to evolve from identifying available information, concerns, and areas of interest within the City, to evaluating and assessing this information, and ultimately identifying areas of potential opportunities where strategy implementation could occur through the leveraging of planned or existing initiatives.

For example, a stream, such as Goodes Creek requires bacteria reductions per the James River bacteria TMDL. In this same watershed, there are also Commercial Area Revitalization Effort (CARE) neighborhoods (yellow areas in Figure 7.6) that could be targeted for tree planting or implementation of green infrastructure for beautification purposes. Additionally, GIS analysis has identified stretches of Goode Creek as having deficient stream buffers (pink lines within the circled area in Figure 7.6). DPU and

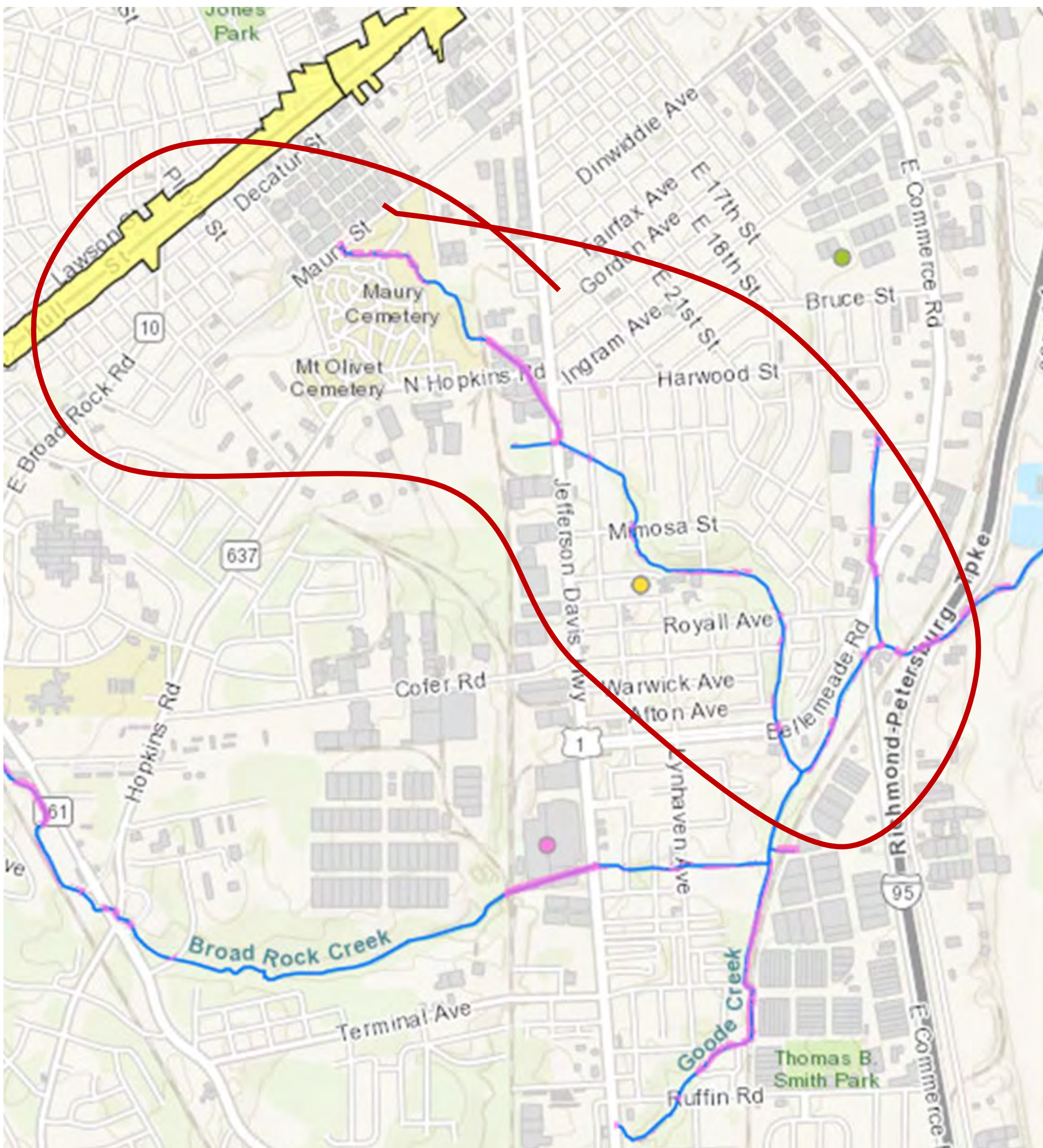

Figure 7.6. ArcGIS online map depicting the region near Goode Creek that contains City park property (Maury Cemetery), CARE neighborhoods (yellow), and buffer deficient streams (pink)

its stakeholders could identify potential project clusters such as these for additional evaluation of opportunities for strategy implementation.

Prioritization

Once data and information have been assessed and opportunities for projects or project clusters have been identified, these must be prioritized for further analysis and subsequent implementation. Regardless of projects being implemented piecemeal or in an integrated manner, there may continue to be diverging priorities driving implementation. A key element of this Framework Planning effort will involve identifying criteria by which these projects or project clusters are prioritized. This criteria development process will involve discussions with Technical Stakeholders over the summer of 2017. Several examples of criteria that may be used to evaluate projects or project clusters include if they:

- Address priority pollutants (and how much)
- Address other metrics identified by stakeholders (and how much)
- Address public health concerns
- Can be enhanced by partner resources (staff, funding, etc.)
- Include an educational component
- Address the social or economic elements of the Triple Bottom Line (Figure 7.7)
    - Are environmental justice concerns addressed?
    - Are lower SES neighborhoods targeted?
- Account for the City's Affordability Analysis
    - Can it be implemented with existing resources or does it require additional funding?
- Have stakeholder support

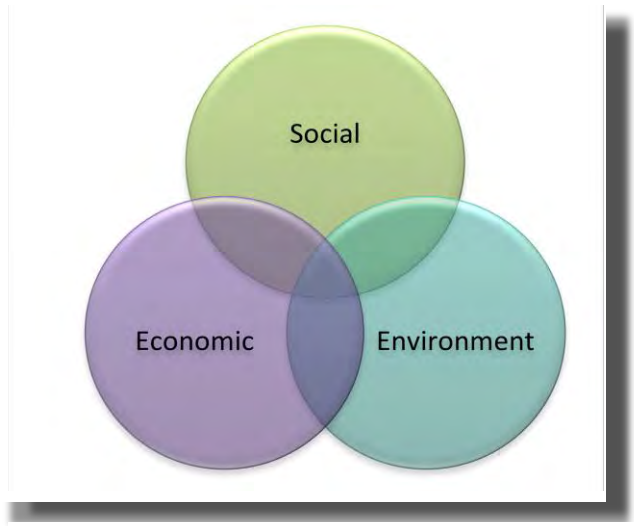

Figure 7.7 Elements of the Triple Bottom Line

Based on the number of criteria met, the projects/project clusters will be sorted into "very high", "high", "medium", and "low" priority projects. Additional detail on this prioritization process will be developed over the summer of 2017.

Plan Development

The Framework Planning process and the identification and prioritization of projects and project clusters will be documented in the Framework Plan. The Framework Plan will also demonstrate how the projects and project clusters will meet the goals and objectives of the Clean Water Plan, including the numeric targets of the strategies.

Schedule

The Framework Plan will reflect efforts to be implemented over the course of the five year permit cycle. While most of the strategies that have been developed for the Clean Water Plan are based on a five year timeframe, other, more resource intensive projects, such as those related to the CSO Infrastructure strategy, may require a longer time frame for full implementation. NPDES permits typically allow flexible compliance schedules for meeting the state WQS. These schedules can be as long as necessary to achieve the water quality objectives. The federal regulations specifically require the schedule in the permit to achieve limits “as soon as possible.”

Funding

An appropriate level of funding will be important to the success of the City’s approach to integrated planning on a watershed basis. The various programs involved in this planning process (i.e., stormwater, wastewater, CSOs, drinking water) have funding mechanisms available to them. Specific project funding will be developed concurrently with the development of the City’s annual budget cycle. DPU’s funding sources will be evaluated to determine the anticipated costs, funds available, and any anticipated funding gaps. Overall, it will be imperative that implementation takes into account the findings of the City’s affordability analysis, which is expected to be finalized in 2017.

Implementation

The framework planning process will lead to the identification and prioritization of projects or project clusters that the City will fund for implementation. The sum of these projects will be consistent with the high level strategies defined in the Clean Water Plan.

There are several important concepts that will be taken into account through implementation. For instance, it is envisioned that implementation will occur incrementally over the course of the permit cycle (e.g., 10 acres of riparian buffers will not necessarily be restored all at once or within only one project, but may be addressed through the implementation of several projects/project clusters). Additionally, it may be determined that once more refined analysis is performed during or prior to the design/build phase of a project, that a particular project or project element cannot be achieved in its entirety. Flexibility is incorporated into implementation through adaptive management. If it is found that one strategy cannot be implemented in whole or in part, DPU will work to identify an alternative approach to achieving the same or similar pollutant reductions and other identified goals and objectives.

Implementation of projects, particularly those that involve stakeholders or other City departments, will require significant coordination. In addition to regular Technical Stakeholder meetings to provide updates on progress, DPU will convene a workgroup of those organizations involved in these implementation efforts. As projects are implemented, associated benefits (pollutant reductions, area treated, other metrics addressed) will be tracked as well. Measuring progress made under the Clean Water Plan as a result of project implementation is discussed further in Chapter 8.

8. Measuring Progress

Once targets have been established and strategies have been identified to address watershed goals, an approach must be developed to monitor and measure progress made in association with these implementation efforts. As the City's implementation moves forward, measuring progress will include determining if goals have been met, if progress has been deemed sufficient, or if changes should be made within the program to try to improve the level of progress made.

Determining the level of progress that has been made as a result of the City's investments is a key element to the success of the Clean Water Plan and its ultimate support by the public, stakeholders, and elected officials. Measuring progress; however, can be complex. Targets may be established at various scales (i.e., site scale, sub-watershed, watershed, city scale). Implementation actions can also include a wide range of options including structural and non-structural practices as well as practices that address various source sectors (i.e., stormwater, wastewater, non-point sources). As a result, the approach used for measuring progress under the City's program must be flexible enough to account for these variations in scale and options that will be employed to mitigate pollutants and meet the City's goals.

Measuring progress will be done in a holistic manner based on data from the City's monitoring programs, modeling efforts, and other programmatic information (e.g., implementation targets, such as miles of stream buffers restored per year or number of residents reached by outreach efforts). Each of these elements is outlined in Table 8.1 and is discussed further below.

Table 8.1. Monitoring activities and associated outcomes implemented under the Clean Water Plan

	Activities	Outcomes
Water Quality Monitoring	Instream water quality, biological (e.g., macroinvertebrates), CSO and WWTP discharge monitoring	Progress made toward pollutant reduction targets in permit
		Progress toward achieving WQS (e.g., measure improvement in aquatic life designated use)
		Identify sources, stressors, or pollutants of concern
		Identify trends over time
	BMP monitoring	Effectiveness of specific BMPs or source reduction efforts
		Progress toward achieving WQS (e.g., measure improvement in aquatic life designated use)
Programmatic Monitoring	Tracking strategy implementation	Progress made toward strategy implementation goals (e.g., acres of green infrastructure implemented)
		Progress made in pollutant reduction through strategy implementation (e.g., pounds of TN reduced through green infrastructure implemented)

		Progress made toward pollutant reduction targets identified in permit
Modeling	Receiving water, CSS, and watershed modeling and analysis	Progress made in bacteria WQS compliance
		Progress made in bacteria load reduction
		Progress made in reduction of CSO events or volume discharged

Each element of this process to evaluate Clean Water Plan progress will occur on a regular/annual basis over the course of the permit. Reporting on each of these elements will occur annually per VPDES permit requirements. At the end of the permit cycle a more comprehensive review of the progress made within this integrated planning framework will be compiled and included with the next VPDES permit application.

Water Quality Monitoring

As part of the watershed characterization effort, described in Chapter 3, historical water quality monitoring was compiled and evaluated including:

- James River monitoring carried out by VCU and other agencies
- In-stream monitoring of streams like Gillies Creek and other small tributaries within the city
- End-of pipe monitoring of CSO and WWTP discharges
- Data on other sources of pollution within the City

These data were organized and incorporated into a GIS-based geo-database. These water quality data were used to assess spatial and temporal trends, identify data gaps, and provide the water quality monitoring data needed to assess baseline conditions. Once implementation of the projects and programs in the Clean Water Plan has commenced, newly collected monitoring data can be used to evaluate changes from these baseline conditions.

Monitoring Program Development

Drivers behind the development of a monitoring program are often the regulatory requirements specifying monitoring objectives or collection of specific data elements. For DPU, these requirements will stem from the VPDES permit. As the Clean Water Plan and associated integrated watershed-based VPDES permit is finalized, DPU will assess its existing monitoring program to determine if it will provide the data needed to achieve the objectives of the permit. Examples of monitoring objectives include:

- Assess spatial and temporal trends of monitoring sites along the James River and its tributaries
- Evaluate the performance of specific BMPs or source reduction efforts
- Evaluate the health of the City's waterbodies
- Identify or evaluate parameters of concern
- Identify or evaluate potential sources of stressors
- Assess progress toward permit targets

Permit-driven objectives along with the identification of any additional data needs will ultimately determine the monitoring design. For instance, to evaluate stressors in a watershed, targeted monitoring would be conducted upstream and downstream of a key source(s). Monitoring could include sampling during different environmental conditions (e.g. dry and wet weather, high and low flow, seasonal effects), and point source and BMP flow and quality sampling. Conducting biological and habitat assessments also provide links between instream conditions and pollutants.

Alternatively, to evaluate the overall health of the City's waterbodies, a probabilistic monitoring design would be developed that includes multiple randomly selected sites throughout the City. This approach would allow DPU to show overall conditions and, as Clean Water Plan implementation occurs over time, how integrated planning is benefitting the City's waterbodies.

In addition to DPU's own objectives, the City may want to determine if other local stakeholders have monitoring objectives that complement its own. Broader coordination can result in the development an integrated monitoring program that could broaden the scope of the monitoring plan while identifying efficiencies to reduce resources directed at monitoring efforts.

Programmatic Monitoring

As a number of the City's watersheds reach past Richmond's borders and are impacted by sources outside the City's control, water quality monitoring efforts alone will not necessarily provide an accurate representation of the City's progress in achieving the goals and objectives of the Clean Water Plan. In addition to water quality monitoring, a programmatic approach will be evaluated to determine its effectiveness.

As discussed in Chapter 4, an extensive effort was undertaken to develop goals and objectives for this Clean Water Plan as well as strategies that would achieve these goals and objectives. Tracking these strategies to measure progress will occur in several ways.

Tracking Strategy Implementation Targets

Each strategy was written to include quantifiable targets for implementation (e.g., acres of green infrastructure, acres of riparian area restored, miles of stream reengineered, etc.). Evaluating the extent to which the strategies are being implemented and targets are being met will be an important mechanism for tracking progress. If targets are not being met or strategies are not being implemented, the City will evaluate why this is the case and determine if other alternatives are available that will result in achieving the same or similar progress towards goals and objectives.

Strategies are comprised of multiple implementation efforts (e.g., all of the projects that would result in 104 acres of green infrastructure implementation in the MS4 area). DPU will continue to use several tools to track these projects. Currently, a database is used to track practices as they are implemented. The City's existing GIS will also serve as the basis for this tracking effort.

Tracking Strategy Pollutant Reductions

Tracking the anticipated pollutant reductions associated with these strategies will also be an important component of measuring progress of the Clean Water Plan. EPA's Chesapeake Bay Program (CBP) has established pollutant reduction credits for many of the stormwater BMPs proposed in association with the Clean Water Plan strategies. To ensure consistency with the CBP and the targets established for the City through the Chesapeake Bay TMDL, these BMP credits will be used as the basis for tracking of pollutant reductions through implementation of strategies.

As strategies are implemented, associated pollutant reductions for total nitrogen, total phosphorus, and total suspended solids will be calculated. These credits will be tracked in a geodatabase, which will allow for the geolocation of associated projects within the City's various watersheds.

While the Chesapeake Bay TMDL pollutants have established pollutant reduction credits assigned to various practices, bacteria, the other key pollutant in this Clean Water Plan does not. As a result, bacteria reductions achieved through strategy implementation will be based on literature values as well as the results of modeling efforts (discussed further below).

Comparing Pollutant Reductions to Targets

As discussed previously in Chapter 6, pollutant reduction targets (see Table 6.6) will be included in the City's VPDES permit. Tracking of progress toward these targets will help assess strategy implementation in the various watersheds[10]. This will help DPU determine if sufficient progress is being made, if larger implementation efforts are required, if more funding is necessary, or if additional partners are needed to increase implementation. To help make these determinations, funding and other staff resources and amount of stakeholder participation will be evaluated in comparison to implementation of programs and practices and, ultimately to environmental improvements. Based on Clean Water Plan evaluation, modifications will be made to the program as part of the Plan's adaptive management approach.

Evaluating pollutant reductions as well as locations of these reductions within the City will help DPU not only determine if targets are being achieved, but if various watersheds or sections of the City should receive additional focus for implementation.

Modeling

The Modeling Framework will continue to be used as needed to evaluate the water quality improvements related to the implementation of projects and strategies. Metrics that will be evaluated by the Modeling Framework include progress made in bacteria WQS compliance, progress made in overall bacteria load reduction, and progress made in reducing CSO events or volume discharged. The quantification of these metrics will be used as part of the programmatic monitoring efforts (as discussed in the previous section).

[10] While water quality monitoring will be used, in part, to evaluate progress toward achieving targets, EPA's CBP promotes tracking of progress through credits applied to various implementation types. This approach will also be used to evaluate Clean Water Plan progress.

9. Next Steps

The Clean Water Plan has resulted in a comprehensive understanding of the City's watersheds and associated water resources. This includes an understanding of the pollutant sources and stressors within the City; the monitoring data that has been collected to date, as well as where additional data area needed; and the characteristics of the watersheds, such as soils and impervious surfaces. Additionally, the Clean Water Planning process has identified the goals and objectives and associated metrics that will guide the City moving forward. It also includes a plan for identifying control projects and programs that can be updated and adapted throughout the plan's implementation.

The next step is to use the Clean Water Plan to develop a watershed-based VPDES permit. Watershed-based permitting has been long supported by EPA and allows multiple pollutant sources to be managed under one permit. For Richmond, these pollutant sources are CSO, wastewater, and stormwater via the MS4 and direct drainage. The Clean Water Plan provides the planning framework and strategies to manage these sources and prioritize control projects based on their improvements to local waterways. Therefore, the Plan will be included in the VPDES permit as a source of data and provide information to be included in the "Special Condition" section related to BMPS to be implemented and additional monitoring to be done to track progress. The Clean Water Plan will also be included in the Permit Fact Sheet as an information source.

Once the watershed-based VPDES permit is issued to the City, next steps include implementing the projects and programs in the Clean Water Plan and conducting monitoring and modeling to measure progress towards the goals of the plan. While this first permit cycle will include targets consistent with the strategies identified in the planning process, continued implementation will be a long-term process that will span multiple five-year VPDES permit cycles. Therefore, the Clean Water Plan will require updating for each successive VPDES permit using the adaptive management approach described in the previous section. Future VPDES permits will be pursued as watershed-based permits until the Clean Water Plan is fully implemented.

The City will also continue to engage stakeholders to inform them of activities and associated progress towards the goals of the Clean Water Plan, and solicit their input on Plan updates. This engagement process will likely be simplified now that the considerable effort to develop the initial Plan has been completed.

More information on EPA's perspective on watershed-based permitting as it pertains to a watershed-based VPDES permit for the City is provided in the following section to illustrate the consistency between its requirements and the Clean Water Plan elements.

Adaptive Management

The adaptive management approach to water resources and regional wastewater management is increasingly recognized as the most appropriate and economically efficient way to identify problems, assess alternative solutions, and implement targeted corrective actions. The adaptive management approach has been, and will continue to be, implemented during each step of the Clean Water Planning process.

Adaptive management will be critical for the success of Richmond's plan as any new data collected through the course of this effort will need to be reviewed on a regular basis and used to refine/modify the Clean Water Plan so it is up-to-date and accurate. An adaptive management approach will also be a key component of the framework the City will use to monitor the progress made through the Clean Water Plan. As mentioned above, assessment of progress will involve periodic comparison to the various targets established through previous steps of this process.

While strategies include targets, the Clean Water Planning process includes an adaptive management component that provides flexibility should some unforeseen issue arise regarding a particular strategy. For example, it may be determined over time that green infrastructure in the MS4 is only feasible on 80 acres (rather than 104 acres), or it may be riparian area restorations will require more implementation on private land than originally calculated. In such situations, the City will have to evaluate ways to expand other strategies/opportunities to work toward achieving the Clean Water Plan's goals and objectives. This may include expanding other strategies so that a similar pollutant reduction is accomplished or measures of additional metrics are reached. Alternatively, as implementation moves forth, stakeholders or additional Departments within the City may participate more than originally planned. This could add resources, expand implementation, and potentially result in efficiencies that can further streamline the Clean Water Plan effort.

Adaptive management can also be informed by the monitoring conducted by the City. If water quality monitoring data are not showing expected improvements, the Clean Water Plan can be modified to increase levels of implementation, accelerate implementation schedules, alter BMP types planned for the watershed, etc. For example, a watershed where BMPs have been implemented, but in which the water quality or biological communities do not show improvement, may need additional implementation efforts. Alternatively, upstream water quality monitoring (e.g., from outside the City's boundaries) may show that the water quality upstream is also not meeting WQS, which may explain the lack of improvement despite BMP implementation. In contrast, improved water quality or functioning of biological communities may show that the implementation has been successful. It should be emphasized, however, that BMP implementation often results in a significant (years, decades) lag time in instream response to this implementation. This will be taken into consideration when evaluating progress. An alternative situation may occur where WQS are not being met, but a local biological community is no longer impaired. In such an instance, a use attainability analysis (UAA) may be warranted and would offer an alternative to expending money and resources to implement projects in areas that are not causing exceedance of the WQS.

While adaptive management will play a key role in keeping the City's planning efforts on track, it should be noted that implementation of a sufficient amount of control to meet the City's goals may take many years. Once controls are implemented, it may take even more time for in-stream benefits to be measurable, especially in the biological community or habitat conditions. The tracking framework will take long-term implementation into account and will be reflected within the tracking of targets.

Watershed-based VPDES Permit

The intent of the Clean Water Plan is to feed into an Integrated VPDES permitting process. The CWA (§ 402) established the NPDES permit (VPDES in Virginia) as the primary tool for controlling point source discharges, and therefore municipal discharges. An integrated approach would then allow the City to address all of its regulatory requirements (stormwater, CSOs, wastewater) as well as source water protection within the same plan thereby providing better and more efficient coordination of requirements.

Watershed-based permitting is an integrated approach to developing VPDES permits for multiple point sources within a defined geographic area (watershed boundaries).

The primary difference between this and the traditional approach to permitting is the consideration of watershed goals and the impact of multiple pollutant sources and stressors, including nonpoint source contributions, to receiving waters.

For many years, the EPA has supported and encouraged a watershed approach to addressing water quality problems. The approach is very flexible so watershed-based permitting can encompass a variety of activities ranging from synchronizing permit issuance, review and renewal of NPDES permits within a basin, to developing water quality-based effluent limits using a multiple discharger modeling analysis. One key component in the overall watershed-based permitting process is the integration of programmatic requirements. The watershed-based permitting framework provides the structure for examining a specific area and all of the stressors within that area, data related to the stressors and water quality goals, and prioritizing actions based on those data.

US EPA Support of Watershed-based Permitting

As discussed in more detail in Richmond's Methodology for Integrated Watershed Management (2014), EPA developed several guidance documents upon which the City has based its approach for Watershed-based permitting. These guidance documents include:

- Committing EPA's Water Program to Advancing the Watershed Approach (2002)

- Watershed-based National Pollutant Discharge Elimination System (NPDES) Permitting Implementation Guidance (2003)

- Watershed-based NPDES Permitting Technical Guidance (2007)

Additionally, as described in EPA's 2003 Watershed-based Permitting Policy:

> *A holistic watershed management approach provides a framework for addressing all stressors within a hydrologically defined drainage basin instead of viewing individual sources in isolation. Within a broader watershed management system, the watershed-based permitting approach is a tool that can assist with implementation activities. The utility of this tool relies heavily on a detailed, integrated and inclusive watershed planning process. Watershed planning includes monitoring and assessment activities that generate the data necessary for clear watershed goals to be established and permits to be designed to specifically address the goals.*

This Clean Water Plan provides the mechanism for identifying goals and pollutant sources that may impact the goals. This Plan also provides the framework for consolidating DPU's sources (MS4, CSO, WWTP) together and determining the best distribution of investment in these sources to produce the greatest environmental gain.

The watershed-based permitting process provides the tools to apply resources to protect the goals and serves as the mechanism to drive integrated planning in the City. The permit will include a "Special Condition" that will recognize specific components of the Clean Water Plan. The permit will require data collection that will serve to support the evaluation of program effectiveness. The permit will also include controls (limits or pollutant reduction targets) that look collectively at DPU's various sources and allow the City to work toward the goal of greater environmental benefit.

This approach was successfully demonstrated with the issuance of the watershed-based permit to Clean Water Services in Oregon. The permit provided for trading between point and nonpoint sources to address temperature issue in the receiving water. Additionally, the Neuse River Compliance Association holds a permit for discharges from 20 WWTPs in the watershed. These entities all share a collective nutrient limits that they must achieve collectively.

In the case of Richmond, a single permit will be appropriate given the discharges are all controlled by DPU. Regardless of format, the permit will focus on watershed needs.

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Appendix 1. Modeling Report

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1 Executive Summary

1.1 Introduction

In 2014, the City of Richmond began a multi-year effort to develop an Integrated Water Resources Management Plan (herein after called the RVA Clean Water Plan). The goal of this plan is to achieve improvements to water quality that will help the city meet its regulatory obligations under the Clean Water Act (CWA). Part of the Clean Water Plan involves developing strategies for the coordinated management of the City's water utilities, including wastewater treatment, drinking water treatment, stormwater runoff, combined sewer overflows (CSOs), and sanitary sewer overflows (SSOs), all of which are assets that are typically permitted and managed separately. By holistically considering all of the City's water utilities in the development of the Clean Water Plan, the City will be more efficient and cost-effective with their ratepayer-funded resources, and provide greater benefit to local waterways than the traditional siloed approach used for permitting and management.

A key step towards the development of the Clean Water Plan was the development of a water quantity and quality modeling framework. The purpose of the modeling framework is to quantify present day bacteria (*Escherichia coliform [E.coli]*) loads and concentrations in the James River and to predict future bacteria loads and concentrations under the RVA Clean Water Plan-related strategies. The modeling framework also allowed for the quantification of discharge flows and volumes, as well as the occurrence of CSO events. Additionally, the modeling framework provides a platform for comparing the CSO reduction projects included in the City's CSO Long Term Control Plan (LTCP) against alternative CSO reduction projects that may provide similar benefits but at a reduced cost.

The purpose of this report is to document the development, calibration, and application of these models.

1.2 Model Development

Three models were used to achieve the modeling objectives, and together they comprise the modeling framework (Figure 1-1). These three models include:

- A watershed model to simulate flow and bacteria loads from contributing areas of tributaries to the James River within the greater Richmond area, as well as from Richmond's Municipal Separate Storm Sewer System (MS4), but excluding the combined sewer system (CSS) service area. This model was developed using the EPA Storm Water Management Model (SWMM) software.
- A collection system model to simulate flow and bacteria loads from the CSS. The CSS model is an existing model that is used by the City of Richmond for Wastewater Master Planning to support implementation of the CSO Long Term Control Plan and to prepare the Annual CSS Reports. This model was developed using the EPA SWMM software, and was adapted for use in this study.
- A receiving water quality model that computes bacteria concentrations in the James River resulting from the various sources of bacteria to the river. The outputs of the watershed and CSS models are used as inputs to the receiving water quality model. The receiving water quality model was developed using the EPA-supported Environmental Fluid Dynamics Code (EFDC) software.

Water quality data were used to inform the development and calibration of the models. Section 2.2 contains detailed figures showing the extent and key features included for each model.

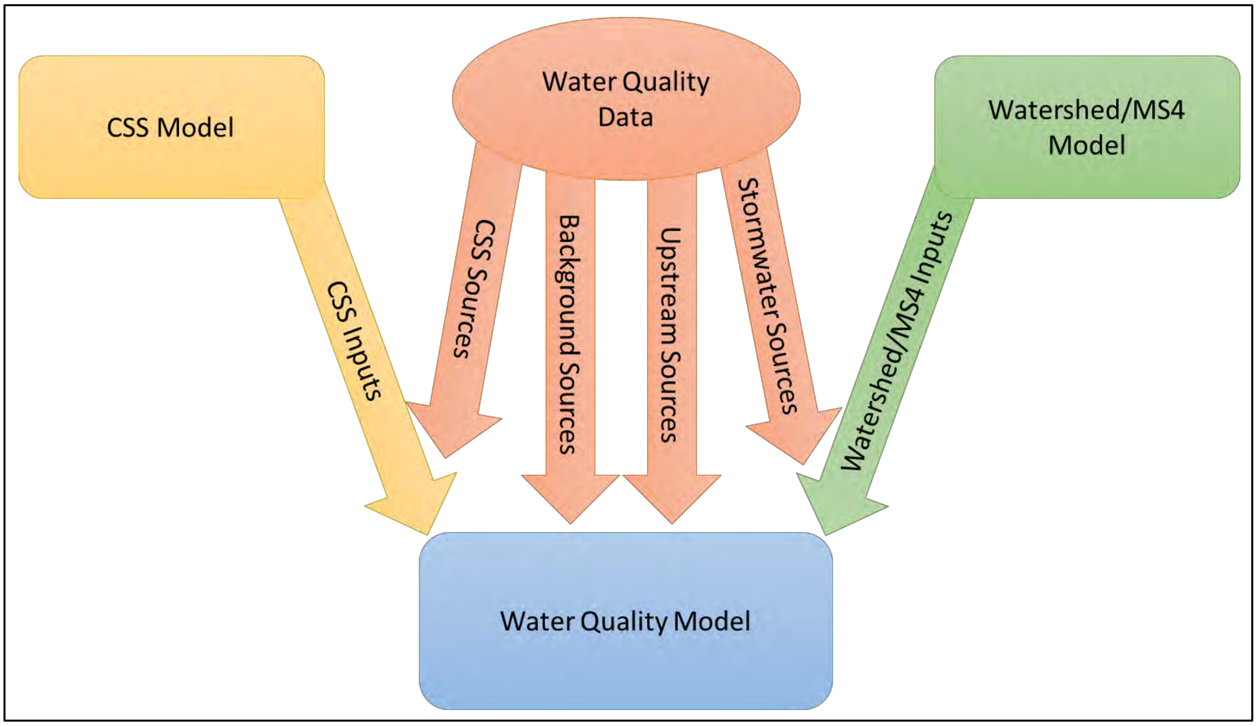


Figure 1-1: Modeling Framework Schematic

1.3 Model Calibration

- Model calibration is the process of adjusting model parameters and assumptions within defensible ranges to achieve reasonable agreement between modeled and observed environmental conditions. The calibration process demonstrated that the modeling framework is sufficiently well calibrated to support the following modeling objectives:
- Design the modeling framework to provide a reliable and reasonably complete accounting of bacteria sources to the James River;
- Develop the modeling framework using sufficiently complete and accurate site specific data;
- Calibrate the models using reasonable assumptions consistent with the site data, literature, and professional judgment;
- Achieve a level of model accuracy that is adequate to support decision making;
- Apply the models for a period including a wide range of common environmental conditions (i.e. river flow and precipitation conditions); and,
- Evaluate and synthesize model output to interpret major sources of current bacteria water quality impairment and to forecast future bacteria water quality conditions.

1.4 Model Application

After the water quality modeling tools were developed and calibrated, they were jointly applied to assess water quality benefits associated with the selected strategies. For this purpose, the model was applied for a 3-year simulation period, 2011 through 2013, that includes an average rain year (2011), a dry year (2012, less than normal precipitation), and a wet year (2013, more than normal precipitation). To date, the model has been applied to evaluate the following conditions or strategies:

- Current conditions: Best representation of current conditions, and includes all the combined sewer system improvement projects that were included in Phase I and Phase II of the CSO Long Term Control Plan.
- Baseline Conditions: represents the current conditions, plus all the currently funded Phase III CSS improvement projects from the LTCP.
- Green Infrastructure in the MS4 Area Strategy: represents the baseline conditions, plus the implementation of 104 acres of green infrastructure on city-owned area in the MS4.
- Green Infrastructure in CSS Area Strategy: represents the baseline conditions, plus the implementation of 18 acres of green infrastructure on city-owned area in the CSS area.
- CSS Infrastructure Strategy: Implementation of CSS projects included in the LTCP: represents the baseline conditions, plus all the remaining unfunded Phase III collection system improvement projects from the LTCP.

The sequencing of the modeling applications is shown in the figure below.

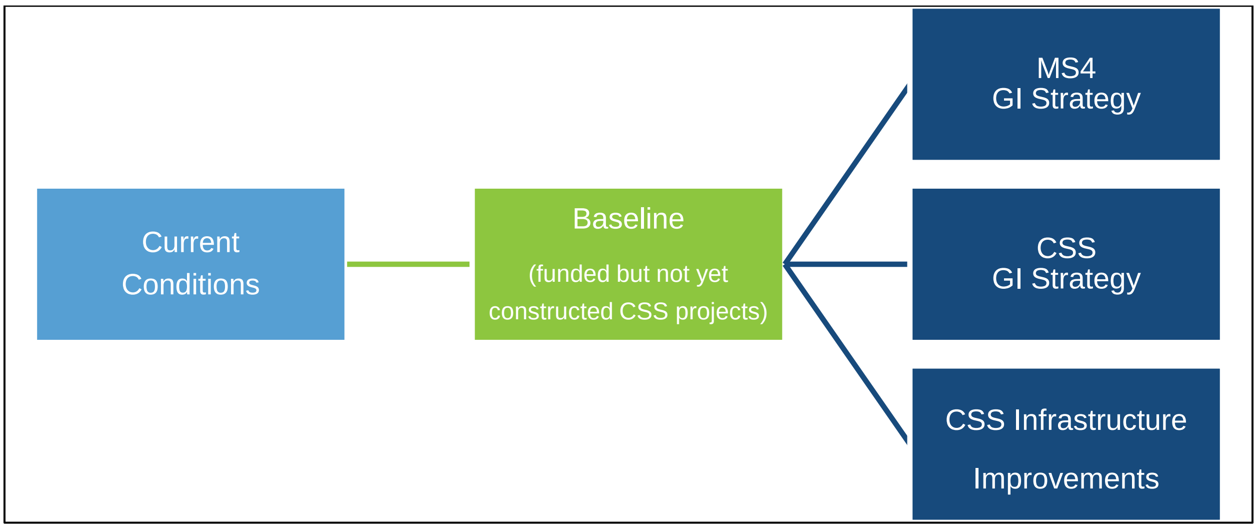


Figure 1-2: Sequencing of Model Applications

These strategies were evaluated using several metrics related to bacteria reduction, including:

- Bacteria load reduction from combined sewer and tributary discharges (which can include pollutant loads from the City's MS4), expressed as billion CFU per year
- Overall average percent increase in monthly geometric mean (geomean) water quality standard (WQS) compliance in the James River at the downstream city limit
- Reduction in number of CSO events per year
- Reduction in CSO volume, expressed as million gallons per year

These water quality benefits were then entered into an Excel-based strategy scoring calculator tool that integrates the benefits of strategies across a wide range of Goals and Objectives. More information on the strategy calculator can be found in Appendix D of the RVA Clean Water Plan. Water quality benefits were also assessed on a monthly basis relative to the two existing water quality standards: a monthly geometric mean standard and a statistical value threshold (STV) standard.

1.5 Major Model Findings

Major findings of the water quality modeling are as follows:

- Current *E.coli* bacteria water quality standards are sometimes exceeded in the James River in Richmond.
- The two largest contributors to exceedances of WQS are sources upstream of the City of Richmond and CSOs.
- Eliminating the City of Richmond bacteria sources alone would not achieve compliance with WQS in the James River.
- Reducing CSOs via the RVA Clean Water Plan strategies would improve compliance with WQS.

1.6 Future Use of Model

The Modeling Framework will continue to be used as needed to evaluate the water quality improvements related to the implementation of projects and strategies. Additionally, it is anticipated that the modeling framework will be applied during the summer and fall of 2017 to evaluate alternative CSS reduction projects that may provide similar benefits to the LTCP projects, but at a reduced cost. Metrics that will be evaluated by the Modeling Framework include progress made in bacteria WQS compliance, progress made in overall bacteria load reduction, and progress made in reducing CSO events and volume discharged.

2 Introduction

In 2014, the City of Richmond began a multi-year effort to develop an Integrated Water Resources Management (IWRM) Plan (herein after called the RVA Clean Water Plan). The goal of this plan is to achieve improvements to water quality that will help the city meet its regulatory obligations under the Clean Water Act (CWA). Part of the Clean Water Plan involves developing strategies for the coordinated management of many of the City's water utilities, including wastewater treatment, drinking water treatment, stormwater runoff, combined sewer overflows (CSOs), and sanitary sewer overflows (SSOs), all of which are assets that are typically permitted and managed separately. By holistically considering all of the City's water utilities in the development of the Clean Water Plan, the City will be more efficient and cost-effective with their ratepayer-funded resources, and provide greater benefit to local waterways than the traditional siloed approach used for permitting and management.

A key step towards the development of the RVA Clean Water Plan was the development of a water quantity and quality modeling framework. The purpose of the modeling framework is to quantify present day bacteria (*Escherichia coliform [E.coli]*) loads and concentrations in the James River and to predict future bacteria loads and concentrations under the Clean Water Plan-related strategies. The modeling framework also allowed for the quantification of discharge flows and volumes, as well as the occurrence of CSO events. The purpose of this report is to document the development, calibration, and application of these models.

2.1 Model Purpose, Objectives, and Functions

The purpose of the modeling framework is to quantify present day *E.coli* concentrations in the James River and to predict future *E.coli* concentrations under management strategies that were developed by the city and stakeholders. The following modeling objectives supported the attainment of this project goal:

- Design the modeling framework to provide a reliable and reasonably complete accounting of *E.coli* sources to the James River;
- Develop the modeling framework using sufficiently complete and accurate site specific data;
- Calibrate the models using reasonable assumptions consistent with the site data, literature, and professional judgment;
- Achieve a level of model accuracy that is adequate to support decision making;
- Apply the models for a period including a wide range of common environmental conditions (i.e. river flow and precipitation conditions); and,
- Evaluate and synthesize model output to interpret major sources of current water quality impairment and to forecast future water quality conditions.

The following report documents how these objectives were achieved through the process of selecting, developing, calibrating, and applying the water quality modeling framework.

2.2 Model Selection

Three models, which comprise the Modeling Framework (Figure 2-1), were used to achieve the modeling objectives. These three models include:

- A watershed model to simulate flow and *E.coli* loads from contributing areas of tributaries to the James River within the greater Richmond area, as well as from Richmond's Municipal Separate Storm Sewer System (MS4), but excluding the combined sewer system service area;
- A collection system model to simulate flow and *E.coli* loads from the combined sewer system (CSS); and
- A receiving water quality model that computes *E.coli* concentrations in the James River resulting from the various sources of *E.coli* to the river.

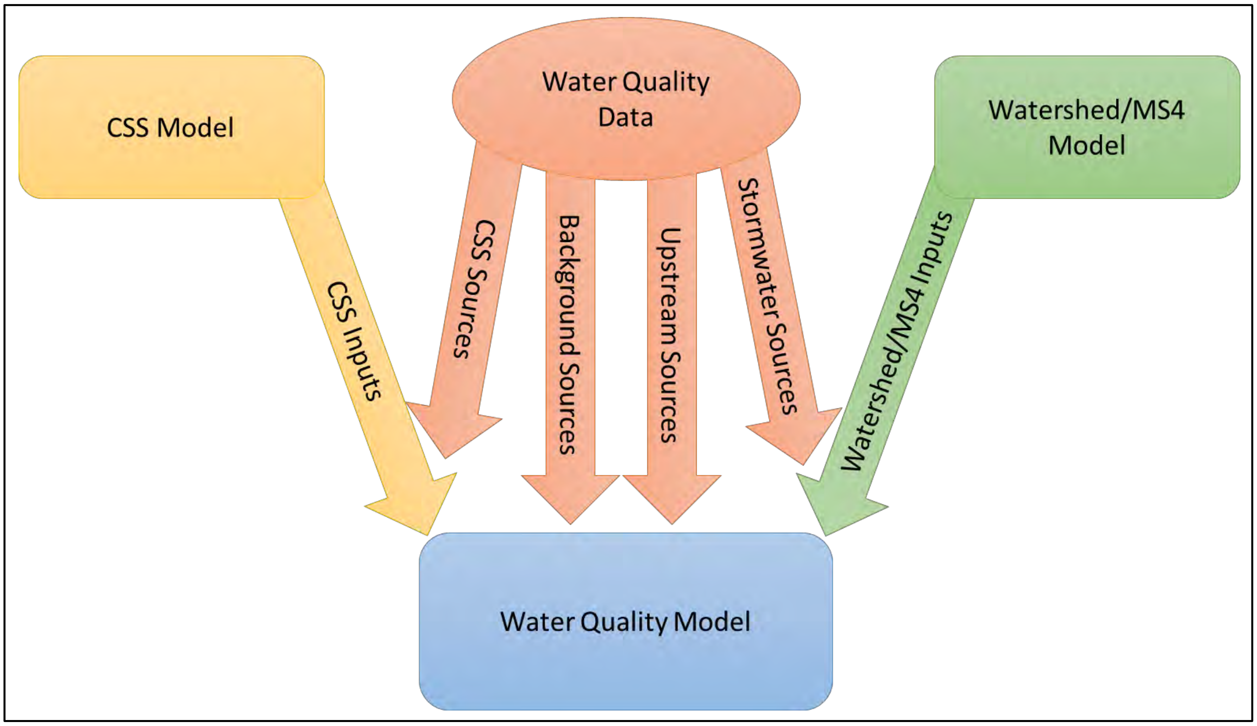


Figure 2-1: Modeling Framework Schematic

2.2.1 Watershed Model

Many watershed model software packages are available and these models vary in their recognition by USEPA and their applicability to the James River and its tributaries. The watershed model framework applied for this project is EPA Storm Water Management Model (SWMM), which is supported by the USEPA and has been successfully applied by the project team at similar sites and for related purposes. SWMM is a dynamic rainfall-runoff simulation model used for single event or continuous simulation of runoff quantity and quality from primarily urban areas (USEPA, 2015). Additionally, the CSS model was also developed using the SWMM software, so choosing SWMM for the watershed model provides consistency.

A variety of enhanced SWMM platforms are available that integrate the EPA SWMM software with user friendly interfaces and GIS capabilities. For this project, PCSWMM, developed by Computational

Hydraulics International (CHI), was used. The watershed model was developed using SWMM engine version 5.1.010, which is consistent with the version used for the CSS model.

2.2.2 CSS Model

The combined sewer system (CSS) model used for this study is based on the Wet Weather Combined Sewer (WWCS) model developed by Greeley and Hansen (GH) to support Richmond's wastewater collection system master planning, Long Term Control Plan (LTCP) implementation, and combined sewer system annual reporting. The CSS model is based upon the EPA Storm Water Management Model (SWMM) framework and uses the SWMM engine version 5.1.010. The model is operated within the PCSWMM environment.

2.2.3 Receiving Water Quality Model

The receiving water quality model was developed based on the EFDC modeling framework (Environmental Fluid Dynamics Code). This model has been applied to support numerous CSO water quality projects and is suitable for representing hydrodynamic conditions occurring in the James River, including the transition from riverine to estuarine conditions, and low head dam hydraulics. EFDC is a state-of-the-art finite difference model that can be used to simulate hydrodynamic and water quality behavior in one, two, or three dimensions in riverine, lacustrine, and estuarine environments (TetraTech 2007a, 2007b). The model was developed by John Hamrick at the Virginia Institute of Marine Science in the 1980s and 1990s, and it is currently maintained under support from the USEPA. The model has been applied to hundreds of water bodies, including Chesapeake Bay and the Delaware River.

The EFDC model is both public domain and open source, meaning that the model can be used free of charge, and the original source code can be modified to tailor the model to the specific needs of a particular application. As a result, EFDC provides a powerful and highly flexible framework for simulating hydrodynamic behavior and water quality dynamics in the James River.

2.3 Model Extent

The model extent defines the spatial or geographic boundary to which the model applies. The extents of the three models are described further below.

2.3.1 Watershed Model

The watershed model incorporates watersheds for 23 tributaries that contribute flow to the portion of the James River that falls within the receiving water quality model extent, and is shown in Figure 2-2 below. The tributaries represented in the watershed model were selected based on two criteria: they have been classified as impaired for *E.coli* on the 2014 VADEQ 303(d) list, or they are expected to contribute significant flows or *E.coli* loads to the James River receiving water quality model. Key features represented in the model include time-variable meteorology, watershed land use and land cover, topography (slopes), land use based pollutant loading, CSO flows and *E.coli* loads (simulated with the CSS model) to tributaries, and basic stream network geometry. The area serviced by the combined sewer system was excluded from the watershed model, as this area is represented in the CSS model. The final watershed model includes 44 square miles within the City of Richmond and 133 square miles outside the city.

2.3.2 CSS Model

The City of Richmond Collection System model simulates all sanitary flows from areas that are connected to the wastewater treatment plant as well as surface runoff from within the combined area. The model is described in the Wastewater Collection System Master Plan (Greeley and Hansen, 2015), and includes the following major features, as shown in Figure 2-3:

- The model contains 227 subsheds, including 99 subsheds representing 44,346 acres of sanitary area and 128 subsheds representing 11,523 acres of combined area. Storm water runoff from the sanitary areas is included in the watershed model.
- The total length of sewer pipes in the model is 235,683 ft. (44.6 miles) distributed over 1,020 individual pipe elements with diameters between 12 inches and 120 inches.
- The model represents all currently active CSO outfalls (29) plus the WWTP outfall used to discharge treated effluent.
- The model represents the Shockoe Retention Basin as well as the Hampton – McCloy Storage Tunnel.

2.3.3 Receiving Water Quality Model

The James River receiving water quality model extends from South Gaskins Road upstream of the Richmond city boundary, to Osborne Park downstream of the Richmond city boundary. The upstream limit of the model was chosen to be just upstream of Richmond's city limits. The downstream limit was chosen to be downstream of Cornelius Creek and near a frequently sampled water quality station. Twenty three miles of the James River are represented in the model with average grid cell dimensions of 140 feet wide and 340 feet long. Each grid cell spans the average depth of the river within their cell boundary. Six cells typically span the width of the river. Key features represented in the model include upstream James River flows; low head dams; the James River Falls near downtown Richmond, runoff; base flow, and *E.coli* loads from tributaries and MS4 areas; the City wastewater treatment plant, CSO discharges and *E.coli* loads; and tidal conditions in the Lower James River. Several of these features are shown in Figure 2-4.

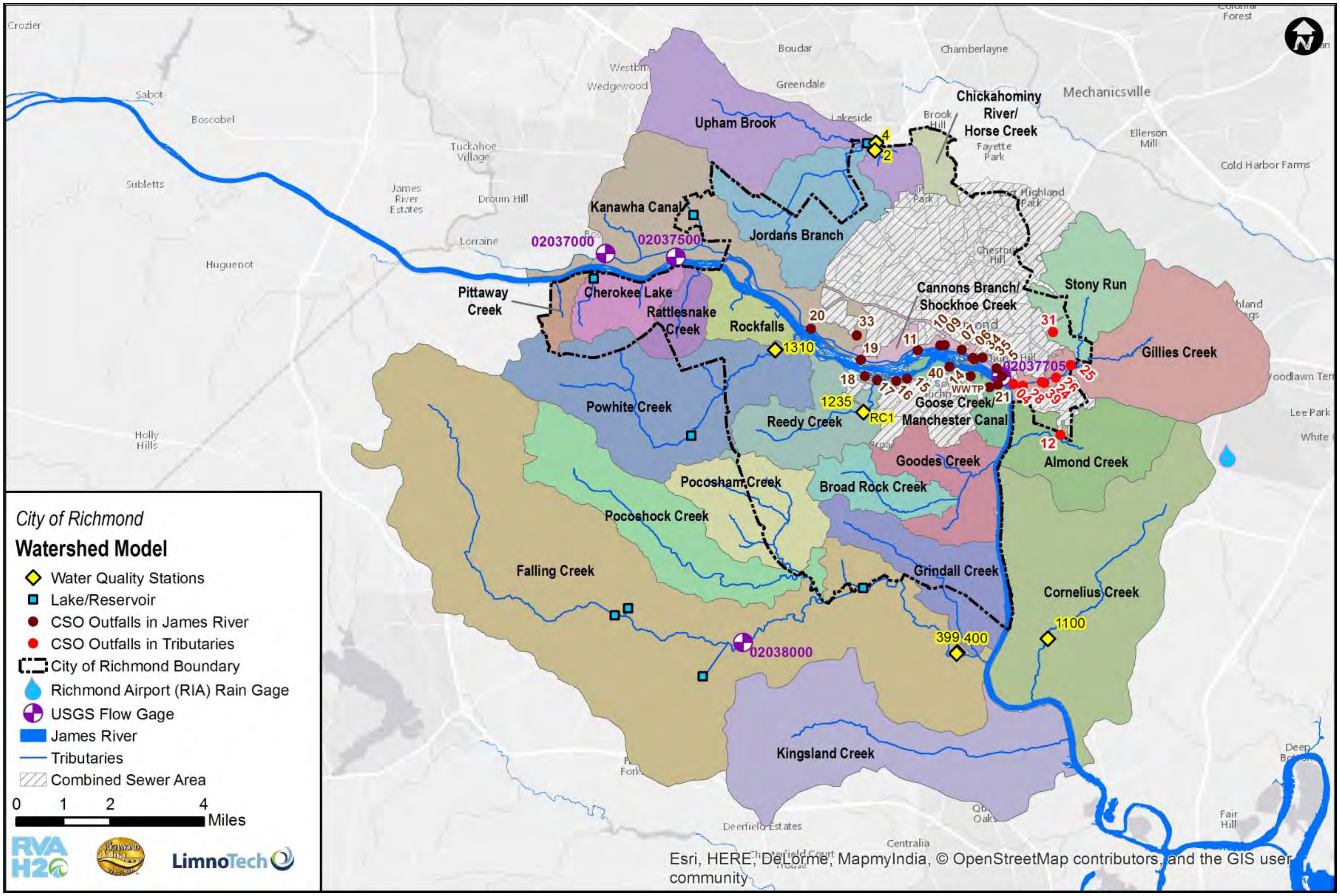


Figure 2-2: Extent and Key Features of the Watershed Model

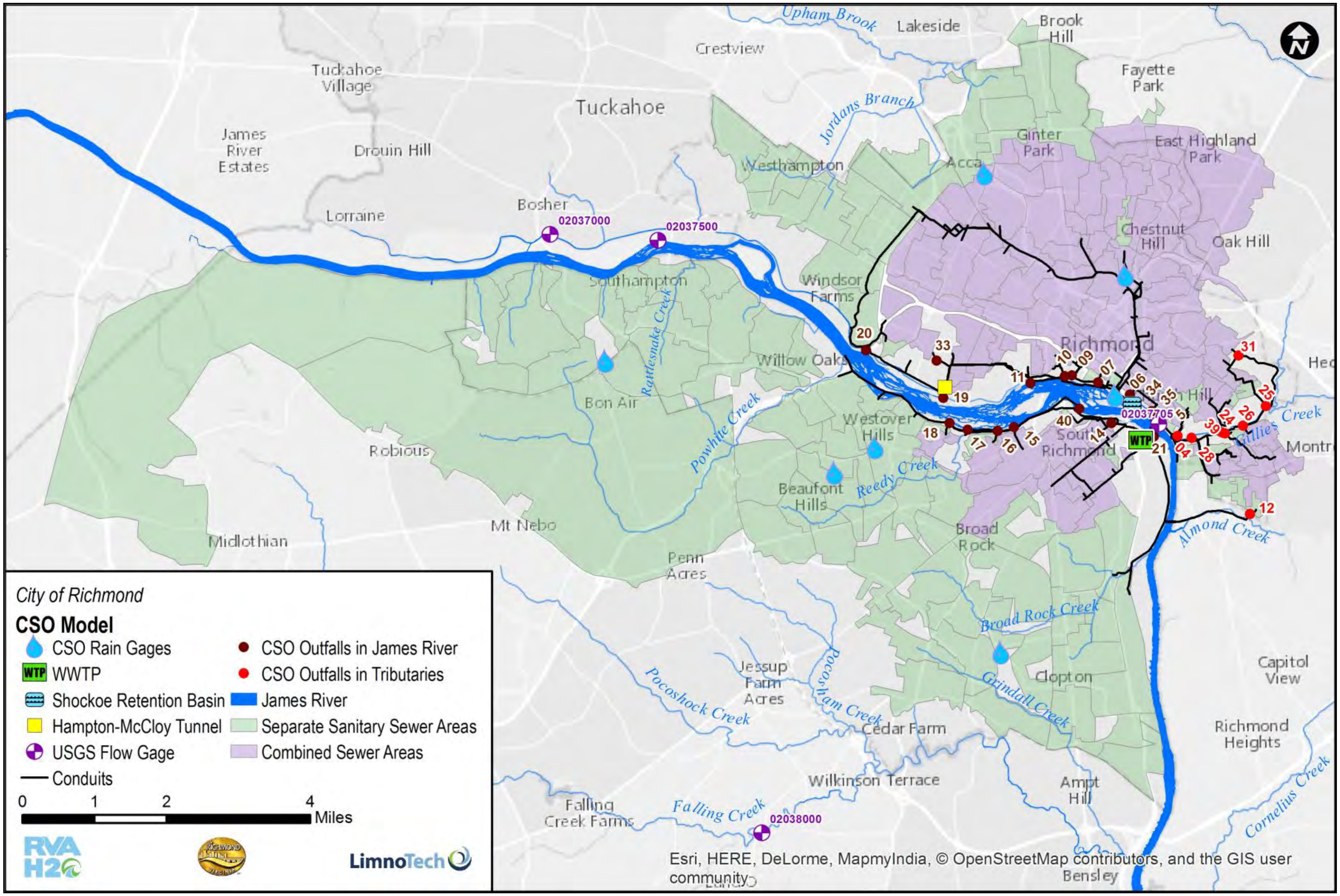


Figure 2-3: Extent and Key Features of the Richmond CSS Model

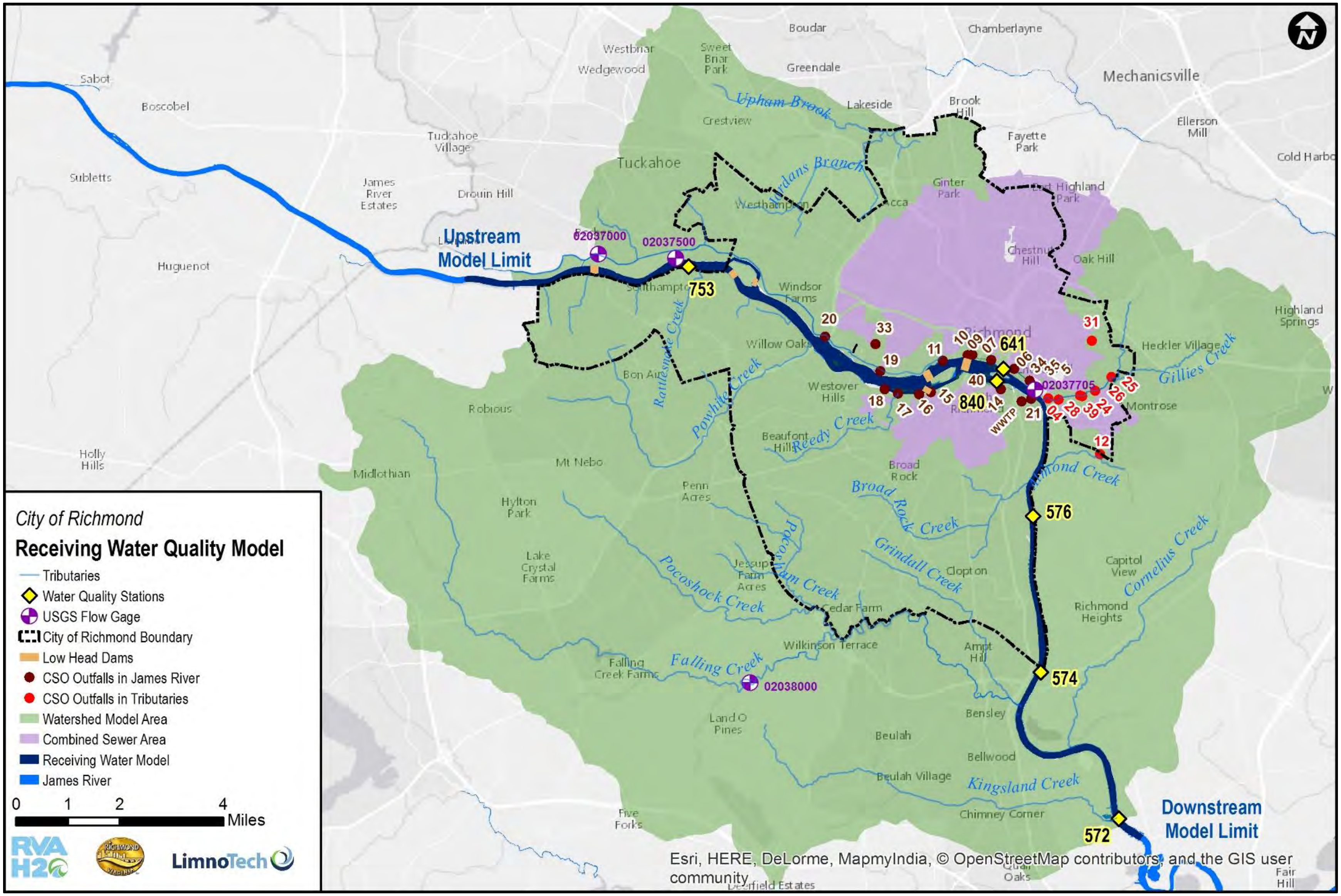


Figure 2-4: Extent and Key Features of the Receiving Water Quality Model

3 Model Development

Model development is the process of configuring a model to represent certain conditions of interest (e.g. combined sewer overflows, or bacteria concentrations) at a particular site. The model development process for the James River water quality modeling framework included definition of 1) important physical and chemical processes, 2) model inputs and assumptions influencing the modeled processes, 3) the spatial extent of model calculations, and 4) the time span of model calculations. This process is described below for each of the three components of the modeling framework.

3.1 Watershed Model

The Richmond watershed model consists of a set of subcatchments (representing the hydrology of the system) that are connected to a network of streams and impoundments (representing the hydraulics of the system). During wet weather events, runoff and associated pollutants are transported from the subcatchments to the stream network, and ultimately discharge to the James River (representing water quality in the system). To set up the watershed model in SWMM, processes influencing the system's hydrology, hydraulics, and pollutant transport must first be characterized. Several different types of data are needed to properly develop a SWMM model. These data characterize the properties that affect the hydrology and hydraulics of a SWMM model. The processes that were modeled and the relevant data that were collected and analyzed for the purpose of setting up the Richmond watershed model are described below.

3.1.1 Process Model Selection

The first step in model development is determining what hydraulic and water quality processes should be included. SWMM is capable of modeling six processes: rainfall/runoff, infiltration, snow melt, groundwater, flow routing, and water quality. To meet the objectives of this model four of these processes were used: rainfall/runoff, infiltration, flow routing, and water quality. It was assumed that snow melt typically does not generate significant runoff in the Richmond area. The contribution of groundwater to stream flow was approximated using a baseflow time pattern for select model nodes, so explicitly modeling groundwater was unnecessary.

3.1.2 Hydrology

3.1.2.a Subcatchments

The 23 tributary watersheds (Figure 2-2) were divided into smaller subcatchments through interpretation of a digital elevation model (DEM), political boundaries, and consideration of culverts, major roads, and water quality stations.

For several watersheds, delineated subcatchments existed from previous modeling efforts by Greeley and Hansen for the Richmond Stormwater Master Watershed Plans (Greeley and Hansen, 2012-2014). For these watersheds, the Greeley and Hansen delineations were re-evaluated using the above considerations, and the subcatchment boundaries were adjusted to meet the needs of this modeling effort. In total, the watershed model is comprised of 427 subcatchments.

To simplify model characterization, some subcatchments located outside of the Richmond city limits were replaced with inflow time series when data was available. Four subcatchments in the upstream portion of the Kanawha Canal watershed were replaced with data from USGS gage #02037000, which had an instantaneous flow time series available from 2007-2015.

3.1.2.b Meteorology

SWMM requires two meteorological inputs: a precipitation time series to generate runoff, and temperature data to calculate evaporation. Complete time series for precipitation (hourly and daily), daily minimum temperatures, and maximum temperatures were available at Richmond International Airport (RIA) from 1949 through current condition. All meteorological data at RIA were obtained from the National Centers for Environmental Information[1] (NCEI) which is operated by the National Oceanic and Atmospheric Administration (NOAA).

3.1.2.c Baseflow

Baseflow comprises the majority of stream flow during extended periods of dry weather, and can be estimated from measured flow data time series. The only gaged tributary within the model extent is in the upper portion of the Falling Creek watershed (USGS 02038000, Figure 2-2), so the flow record from this gage was used to approximate baseflow for all tributaries within the model. Using 30 years of flow data (1965-1994), monthly 7Q10 flows were calculated using methods from Risley et al (2008). These values were then normalized to watershed area (in mi^2) and applied to subcatchments that contribute to the streams and creeks that are included in the watershed model (Figure 3-1).

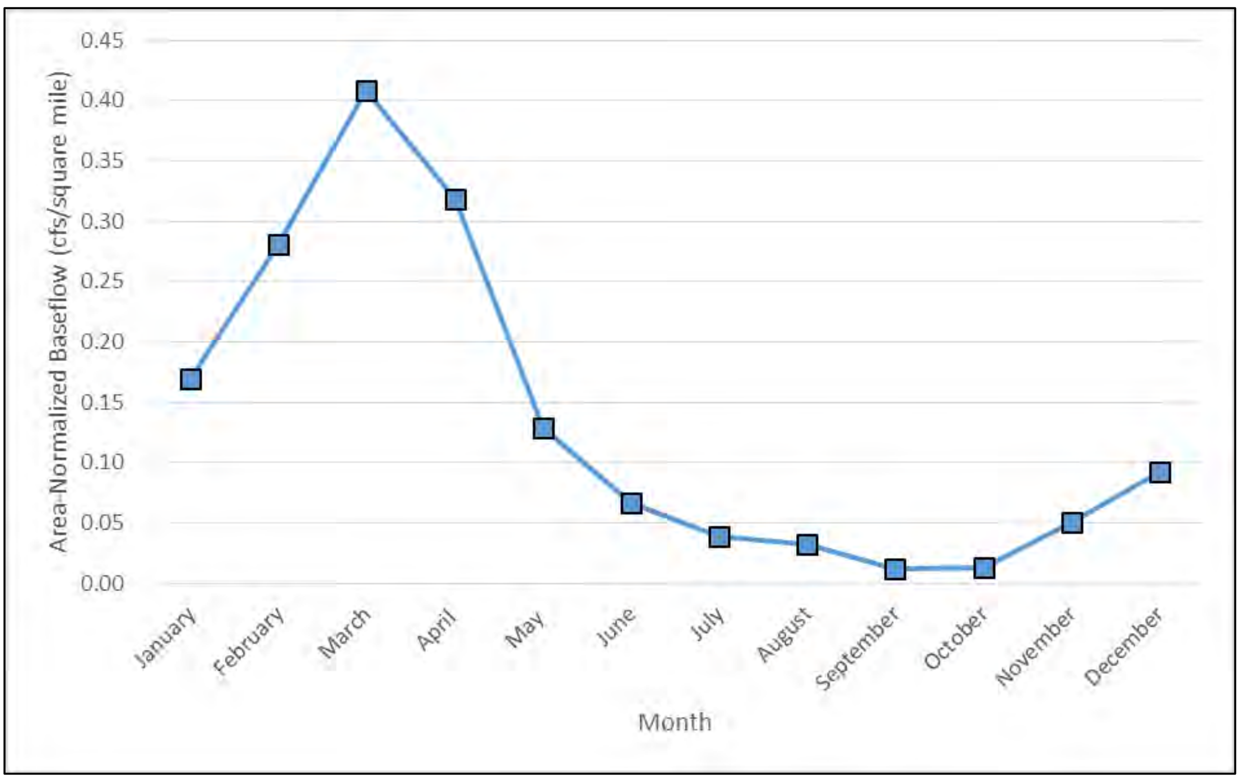


Figure 3-1: Monthly Baseflow Values Used in the Watershed Model

[1] Formerly the National Climatic Data Center (NCDC). In 2015 NCDC merged with the National Geophysical Data Center (NGDC) and the National Oceanic Data Center (NODC).

3.1.2.d Soil infiltration

SWMM offers several methods for soil infiltration (listed in order of increasing complexity): Curve Number, Horton's, and Green-Ampt. The Green-Ampt method requires site-specific knowledge to characterize infiltration parameters, which were not readily available for this project. Therefore, the Horton method was selected for the watershed model. Horton's method uses a set of parameters that defines the maximum infiltration rate, the minimum infiltration rate, the decay rate for changing from maximum to minimum infiltration rates, a recovery rate for changing from minimum to maximum infiltration rates, and an overall maximum infiltration volume. These parameters are determined based on the hydrologic soil groups that are present in the watershed model extent.

The hydrologic properties of soils influence the how quickly and how much precipitation is converted to runoff. In general, soils can be classified by hydrologic soil group (HSG). There are four basic HSGs, called HSG A, HSG B, HSG C, and HSG D. Soils in group A have the lowest runoff potential, while soils in group D have the greatest runoff potential (Mockus et al., 2004). These four basic classifications can then be broken down into dual classifications such as A/D or B/D. Dual classifications represent soils that are classified as group D because of a high water table, making them behave as though they have a high runoff potential. However, if the water table were lowered, these soils would have a lower runoff potential (such as group A or B).

To characterize the soils within the model extent, data were downloaded from the Soil Survey Geographic (SSURGO) database provided by the National Resources Conservation Service (NRCS). A wide range of HSGs are represented within the SWMM model extent (Table 3-1). In addition to the four standard categories (HSG A through D), several dual classifications are also represented. These dual classifications were assumed to be undrained, and were therefore assigned the same soil properties as HSG D. There were also nine soil types with no official hydrologic soil group classification (Table 3-2). Based on the descriptions provided by NRCS, it was assumed that most of these unclassified soils were poorly drained and would have a high potential for runoff (Mockus et al., 2004). Therefore, they were assigned the same soil properties as HSG D.

The soil infiltration parameters associated with each HSG were estimated from tables provided in the *User's Guide to SWMM 5* (James et al., 2010). An average minimum and average maximum value from the suggested range was used for the infiltration rate. In the absence of detailed soil data, the decay constant and drying time were assumed to be the same for all soil types within the model extent, and a maximum infiltration volume was not specified.

Table 3-1: Description of hydrologic soil groups within watershed model extent

Hydrologic Soil Group	Description	Area (mi^2)	% Total
A	Soils with low runoff potential	17.9	9.1%
A/D	Soils with high runoff potential unless drained. Otherwise classified as HSG A.	0.4	0.2%
B	Soils with moderately low runoff potential	75.8	38.7%
B/D	Soils with high runoff potential unless drained. Otherwise classified as HSG B.	20.0	10.2%
C	Soils with moderately high runoff potential	30.3	15.5%
C/D	Soils with high runoff potential unless drained. Otherwise classified as HSG C.	10.9	5.6%
D	Soils with high runoff potential	5.5	2.8%

Table 3-1: Description of hydrologic soil groups within watershed model extent			
Hydrologic Soil Group	**Description**	**Area (mi^2)**	**% Total**
Unknown	See Table 3-2	33.0	16.8%
Water	N/A	2.2	1.1%
	TOTAL	**196.0**	**100.0%**

Table 3-2: Description of the "Unknown" Hydrologic Soil Group within watershed model extent			
Hydrologic Soil Group	**Soil Type**	**Area (mi^2)**	**% Total**
Unknown	Urban land	20.1	10.2%
Unknown	Udorthents-Dumps complex, pits	6.7	3.4%
Unknown	Udorthents, loamy, borrow pits	0.2	0.1%
Unknown	Udorthents, loamy	1.4	0.7%
Unknown	Gravel pit	2.2	1.1%
Unknown	Udorthents, clayey	0.001	0.0%
Unknown	Borrow pit	0.004	0.0%
Unknown	Orthents-Udults-Mine pits complex	0.4	0.2%
Unknown	Made land	2.0	1.0%
	TOTAL	**33.0**	**16.8%**

3.1.2.e Impervious Area and Slope

Percent impervious area and percent slope strongly influence the amount of precipitation that becomes stormwater runoff. Large amounts of impervious area and/or high slopes can lead to high-volume and "flashy" runoff. To estimate median percent impervious area for each subcatchment, a percent impervious area raster was downloaded from National Land Cover Database (NLCD) (Xian et al., 2011). Percent slope for each subcatchment was estimated using the National Elevation Dataset (NED) (Gesch et al., 2002).

3.1.2.f Additional Subcatchment Parameters

In addition to the major subcatchment parameters listed in the sections above, there are five additional parameters that were characterized for each subcatchment: Manning's n coefficient for overland flow over pervious and impervious areas, depression storage for pervious and impervious areas, and percent of impervious area with zero depression storage. These parameters can be used to adjust the shape and the timing of the hydrograph. For simplicity, these parameters were set to constant values for all subcatchments. The values were selected based on literature values from the SWMM5 manual (James et al., 2010)

Table 3-3: Additional SWMM Subcatchment Parameters			
Parameter	**Value**	**Description**	**Source**
Manning's n for overland flow over impervious area	0.018	Average value	Mc Cuen et al. (1996)
Manning's n for overland flow over pervious area	0.25	Dense grass	Mc Cuen et al. (1996)
Depression storage for impervious area	0.075	Average value for impervious surfaces	ASCE (1992)
Depression storage for pervious areas	0.15	Average value for lawns	ASCE (1992)
Percent of impervious area with no depression storage	25%	Default value in SWMM	

3.1.3 Hydraulics and Routing

SWMM offers three methods for routing water through the stream network (listed in order of increasing complexity): steady flow, kinematic wave, and dynamic wave. Dynamic wave was selected for the routing portion of the model. The dynamic wave model can account for channel storage, backwater, entrance/exit losses, flow reversal, and pressurized flow. The dynamic wave model allows for more complex flow conditions than the other routing methods, but requires the use of smaller computational time steps, so choosing this method generally increases the model run times. Theoretically, it produces more accurate results.

3.1.3.a Stream network

Modeling efforts focused on tributaries within the watershed model extent that are currently impaired for bacteria or have active or planned stream restoration projects. Some of these streams originate outside of the city of Richmond, but flow through the city. Two types of small, intermittent streams were not explicitly modeled: unimpaired tributaries within the City of Richmond and unimpaired tributary streams outside the City of Richmond. Unimpaired small tributaries within the city limits were omitted largely because there were no data on stream geometry or characteristics. Upon visual inspection of aerial photography, it was noted that most of these waterbodies were ditches. The small, intermittent streams outside the city were omitted because they are not within Richmond's service area.

The network of streams modeled was developed using two sources. Hydrography data were acquired from the National Hydrography Dataset (NHD Plus), which is developed by USEPA Office of Water and the US Geological Survey (USGS) (USEPA, 2005). This dataset includes nationwide spatial information about a variety of waterbodies, including streams, rivers, lakes, and ponds. NHD Plus was modified using a digital elevation model developed from LiDAR mass points. Modifications of the NHD Plus flow lines were made to align with the lowest nearby digital elevation model (DEM) elevation and with aerial photographs.

The DEM was also used to characterize irregular transects for each section of the stream channel. Using the DEM, one transect was drawn for each subcatchment in the model. Each transect was drawn at a location that was considered to be most representative of the stream channel within a subcatchment.

3.1.3.b Infrastructure

The modeling of culverts was limited to structures that were located on modeled tributaries. Culvert data were provided by the City of Richmond for portions of the watersheds within the city limits. Culvert locations and geometry were estimated for culverts located outside of the city. An initial estimate of culvert geometry was based on aerial photos from Bing maps and the DEM. Initial estimates were then adjusted during calibration under the assumption that culverts were designed to avoid flooding roadways.

The hydrology calibration process revealed that lakes and reservoirs significantly influence the timing of peak flows and their magnitudes. Nine lakes and impoundments were identified through the NHD dataset and subsequently modeled within the model extent, including Cherokee Lake, Cornelius Creek Lake, Falling Creek Reservoir, Gregory's Pond, Lower Beaver Pond, Lower Young's Pond, Rock Creek Park Lake, Upper Lake Bexley, Upper Young's Pond, and Westhampton Lake. When possible, data for these impoundments, associated weirs, and spillways were obtained from the US Army Corps of Engineers (USACE, 1979-1981). Otherwise, impoundment, weir, and spillway characteristics were estimated from aerial photographs, 2-ft contours created from Light Detection and Radar (LiDAR) data, and the DEM. Two conditions constrained the hydraulic behavior of impoundments in the model. First, impoundments were assumed to have a minimum constant water depth that was equal to the primary spillway elevation. Second, it was assumed that lakes and impoundments did not regularly overflow their banks. This seemed like a reasonable assumption because several of the impoundments are surrounded by buildings. If an impoundment regularly flooded in the model, the depth of the storage node was increased and the stage-storage curve was linearly extrapolated.

3.1.4 Water Quality

3.1.4.a Land use/land cover

For water quality modeling in SWMM, land uses must be defined in order to assign pollutant loading. To characterize land use within the model extent, land use data were acquired from the National Land Cover Database (NLCD). The data are generated by the Multi-Resolution Land Characteristics (MRLC) consortium and provided in a raster data format with a spatial resolution of 30 meters (MRLC 2016). NLCD 2011, the most recent version of this dataset, was used to characterize land use in the SWMM model (Homer et al., 2011).

The NLCD also provides data on percent impervious area (Xian et al., 2011), and this dataset was modified and used to estimate the median percent impervious area for each subcatchment. The modification of these data was necessary because the initial model runs during the hydrology calibration process underestimated gaged flows. This discrepancy was discovered through a watershed-scale analysis comparing NLCD impervious cover and a planimetric impervious layer provided by the City of Richmond. It revealed that the NLCD impervious layer underestimated the median percent impervious area, especially in less urban areas. A linear regression was used to develop a relationship between the two datasets and to adjust the NLCD impervious area to better match the planimetric data from the City. After the initial adjustment, the percent impervious area for each subcatchment was adjusted downward by 15%, in order to account for impervious areas that are not directly connected to a waterway or storm sewer. This is standard practice in watershed modeling because runoff from unconnected impervious areas typically first flow onto pervious areas where infiltration can occur, and any excess is then routed to the stream or storm sewer. Because the amount of directly connected impervious area is not known, this adjustment factor was used as a calibration parameter.

3.1.4.b Pollutant loading

In the watershed model, pollutants enter the tributaries in three ways: runoff from the tributary watersheds, baseflow, and CSO overflows. Build-up of pollutants on the watershed and their subsequent wash-off during runoff events are the dominant mechanisms for pollutant loading into tributaries. Pollutant concentrations in baseflow is effectively a calibration parameter that is set for consistency with dry weather pollutant data in the streams. CSO overflows to the tributaries are estimated using combined sewer model output and event mean concentrations (as described below in Section 3.3).

During dry weather periods, pollutants accumulate on subcatchments through a process called build-up. The two parameters that govern build up are the build-up rate, which is the rate at which pollutant accumulates on a subcatchment (expressed in units of cfu/acre/day), and the maximum buildup, which is the maximum amount of pollutant that can accumulate on a subcatchment (expressed in units of cfu/acre). Both of these parameters are represented in the model as a function of land use. To assign reasonable build-up rates and maximum build up to each land use, a review of literature values from across the country was conducted (see tables below). Literature values were not available for all land uses in the model, so in the absence of available data, the build-up parameters for the most similar land use were assigned. Initial model runs used the median build-up rate and the median of maximum build-up for each land use. These parameters were then were fine-tuned during calibration, using the 25th and 75th percentiles as reasonable limits on the range of potential values.

Table 3-4: Land Use Build-Up Rates (cfu/acre/day) Used in the Watershed Model

Land Use	Count	Q1	Median	Q3
Developed - High Intensity	21	6.24E+07	1.27E+09	2.12E+09
Developed - Low Intensity	12	8.13E+07	1.65E+09	2.60E+09
Developed - Medium Intensity	14	9.09E+07	1.50E+09	2.60E+09
Developed - Open Space	8	2.31E+08	1.57E+09	7.81E+09
Undeveloped	32	1.09E+08	1.43E+09	9.62E+09
Forest	9	5.07E+06	8.52E+06	1.41E+08

Table 3-5: Maximum Build-Up Rates Used in the Watershed Model

Land Use	Count	Q1	Median	Q3
Developed - High Intensity	7	9.57E+09	1.06E+10	1.41E+10
Developed - Low Intensity	4	1.06E+10	1.14E+10	3.44E+11
Developed - Medium Intensity	5	5.33E+09	1.02E+10	2.33E+11
Developed - Open Space	4	1.03E+10	1.40E+10	1.75E+11
Undeveloped	9	1.53E+09	2.95E+10	8.51E+10
Forest	5	1.53E+09	1.53E+09	1.67E+09

During wet weather periods, pollutants are depleted from subcatchments and delivered to streams through a process called wash-off. Similar to build-up, the amount of pollutant that washes off during a runoff event is dictated by land use-specific wash-off rate called the event mean concentration (EMC). EMCs for each land use were informed by a literature review. Runoff will continue to generate pollutant load until the available source of pollutant build-up has been exhausted. Literature values were not available for all land uses in the model, so in the absence of available data, the build-up parameters for the most similar land use were assigned. Initial model runs used the median EMC for each land use, and were then were fine-tuned during calibration, using the 25th and 75th percentiles as reasonable limits.

Table 3-6: Landuse Based E.Coli EMC Values Used in the Watershed Model

NLCD 2011	*E.coli* (CFU/100 mL)		
Cultivated Crops	1,945	8,440	26,567
Pasture/Hay	2,682	3,989	28,102
Forest	380	504	565
Wetlands (Woody/Herbaceous)	565	10,339	10,756

Table 3-6: Landuse Based E.Coli EMC Values Used in the Watershed Model			
NLCD 2011	***E.coli* (CFU/100 mL)**		
Developed - Open	2,479	2,479	25,856
Developed - Low Intensity	3,157	15,294	29,723
Developed - Medium Intensity	4,480	5,620	15,527
Developed - High Intensity	884	3,700	11,000

An *E.coli* baseflow concentration was assigned at each model location where baseflow was added. A literature review of urban TMDLs was conducted to determine a reasonable range of values. Initial model runs used the median *E.coli* concentration of 50 CFU/100 mL, which was then were fine-tuned during calibration, using the 25th (28 CFU/100 mL) and 75th (599 CFU/100 mL) percentiles as reasonable limits. The assigned baseflow *E*.coli concentration is the same for each tributary, and is a constant value over time.

CSO flows from the CSS model and *E.coli* concentrations were added to more accurately reflect water quality within CSO-impacted tributaries. There are eight CSOs that overflow into two tributaries in the model: Gillies Creek and Almond Creek. Inflow time series for these eight CSOs were generated by the CSS model. EMCs were assumed for the CSO discharges and were based on previous work on typical fecal coliform concentrations for CSOs in Richmond. The fecal coliform values were then adjusted to represent *E.coli* concentrations using the VADEQ translator (Lawson, 2003). An *E.coli* EMC of 205,000 CFU/100 mL was used for seven of eight CSOs in Gillies Creek. An EMC of 215,000 CFU/100 mL was used for the remaining Gillies Creek CSO and the one CSO in Almond Creek. Further information on the values selected for the CSO EMCs can be found in Section 4.1.

3.1.4.c In-Stream Decay Rate

In-stream bacteria fate and transport processes include die-off, settling to and resuspension from the streambed. The net effect of these processes are represented in the model through the use of a first-order decay rate. Typically, all of the streams in a modeled system will have the same decay rate, with the resulting losses of bacteria in each waterbody varying as a function of travel time through the stream network. An initial in-stream decay rate was set to 1.0/d based on the initial decay rate estimated in the 2010 James River TMDL (MapTech, 2010). This parameter was then adjusted during calibration. The decay rate was varied incrementally between 0.5/d and 2.0/d during the calibration phase.

3.2 CSS Model

The combined sewer system (CSS) model used for this study is based on the Wet Weather Combined Sewer (WWCS) model developed to support Richmond's Long-Term Control Plan Re-Evaluation (Greeley and Hansen, 2002). This CSS model was recalibrated and revised by Greeley and Hansen (GH) between 2010 and 2015 as part of the Wastewater Collection System Master Plan (Greeley and Hansen, 2015). This version of the CSS model is currently used by the city to produce the Combined Sewer System Annual Reports. This CSS model relies on boundary forcings (operating rules, observed flow time series and control decisions) that makes it unsuitable for hindcasting extended time periods and modeling CSS operational alternatives.

The primary SWMM processes and parameters used in the CSS model are similar to the ones described in Section 3.1 above with the exception that the CSS model does account for evapotranspiration as part of the rainfall - runoff process and does not include any internal system pollutant loading (pollutant EMC are assigned to the outfall discharge only). During the CSS model calibration process, 7 local rain gages were used while the NCDC gage at Richmond Airport was used for the IRWMP, due to limited data availability and reliability of the 7 local rain gages.

To prepare the CSS model for use in this study, it was reviewed and modified by Brown and Caldwell, as described in the "CSO Model Review and Advancement Strategy" technical memorandum by Brown and Caldwell (Brown and Caldwell, 2016). As part of this work, the following major changes and modifications were done:

- Reduction of the number of pipe elements to focus on the main interceptor network and improve model stability. This reduced the number of model pipes from 2,357 to 1,019.
- Definition of standard operating procedures for the WWTP by replacing the flow boundary condition, which required an observed plant influent time series with a simple outflow pipe limited to the plant capacity (e.g. 75 MGD for the model calibration)
- Definition of standard operating rules to control the major facilities like the Shockoe Retention Basin and eliminating the need of an external time series forcing for flow boundary condition at this location.
- Elimination of various inactive control rules
- Reduction of the number of subcatchments (and receiving nodes) by deleting those that flow to the neighboring county collection system
- Reduction of the number of unit hydrographs describing the baseflow I & I conditions

These changes were necessary in order to be able to run the model in hindcast mode for a long-term continuous period, and in order to operate the model for evaluating CSS alternatives.

3.3 Receiving Water Quality Model

Site specific data supported the development of both the hydrodynamic and water quality components of the EFDC receiving water model. Bathymetric data from the current FEMA Flood Insurance Study (FEMA, 2014) and from a USACE survey of the estuarine reach (USACE, 2013) were averaged over the model grid. In the upper, riverine reach, a cross-sectional average bed elevation was computed for each row of grid cells. In the lower, estuarine reach, a DEM was computed from the detailed USACE elevation data and averaged over the model grid. The modeled James River bed elevation profile is illustrated in the figure below.

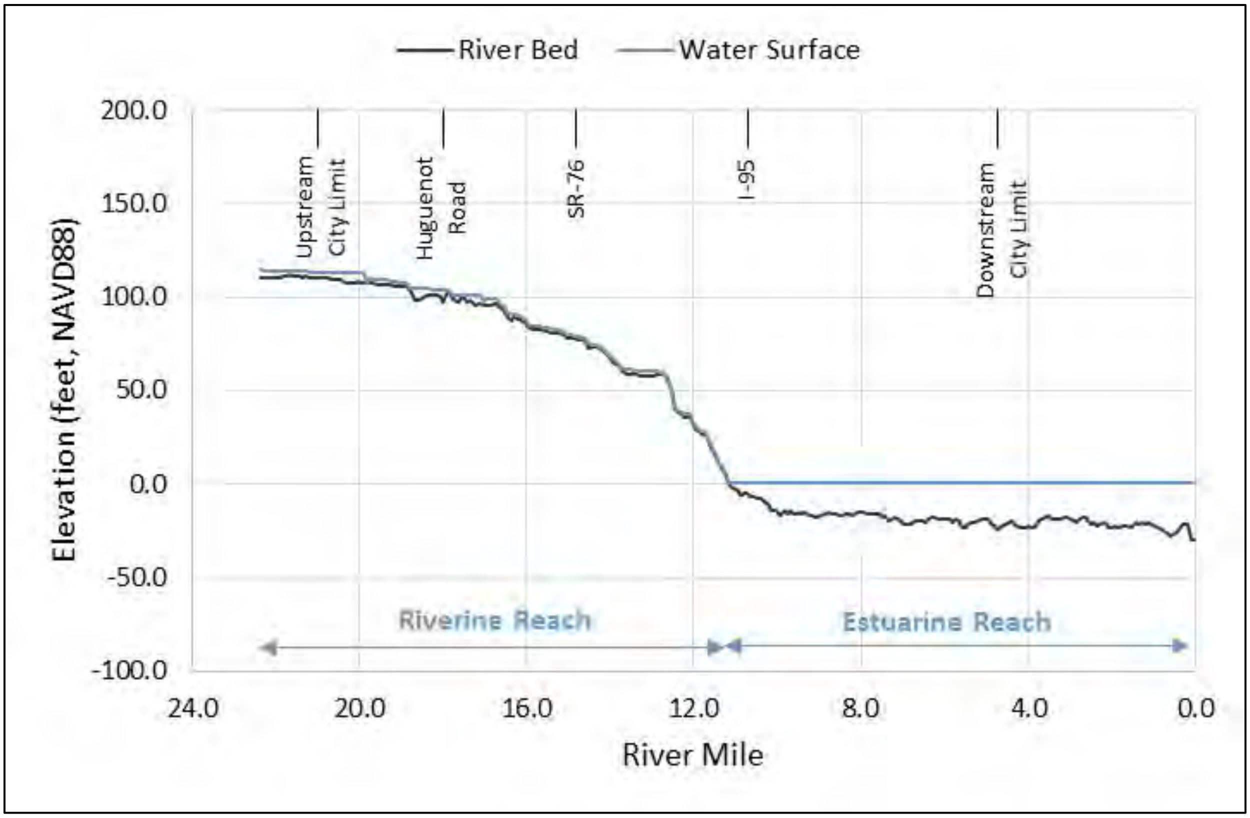


Figure 3-2: James River Elevation Profile

Tidal water levels from USGS Station #02037705 (James River at City Locks at Richmond, VA) were applied at the downstream boundary and the model was calibrated to adjust for the change in water levels between the gauging station and the downstream model boundary. This calibration, which is described in Section 4, accounts for differences in timing (phasing) of the tides between the two locations, and differences in non-tidal water levels associated with river flows.

Upstream James River flows from USGS Station 02037500 (James River near Richmond, VA) were directly applied at the upstream model boundary. For days when *E.coli* were sampled near the upstream boundary, these data were directly inputted to the model. For days when *E.coli* data were unavailable, upstream James River *E.coli* concentrations were estimated based on sampling data from a station at Huguenot Bridge. 112 samples at this location collected between 2011 and 2013 were used to develop a regression of flow and *E.coli* using the USGS LOADEST software package.

LOADEST is a program for "estimating constituent loads in streams and rivers" (USGS, 2017). The figure below illustrates the predicted relationship between James River flow and *E.coli* concentrations upstream of Richmond. The regression equation is as follows:

$$a_0 + a_1 * \ln Q + a_2 * lnQ^2 + a_3 * \sin(2pi * dtime) + a_4 * \cos(2pi * dtime)$$

Where:

- a_0, a_1, a_2, a_3, and a_4 are constants equal to 3.17, 1.27, 0.41, -0.79, and -0.04 respectively,
- Q is streamflow (cubic feet per second), and,
- dtime is time relative to the center time (days)

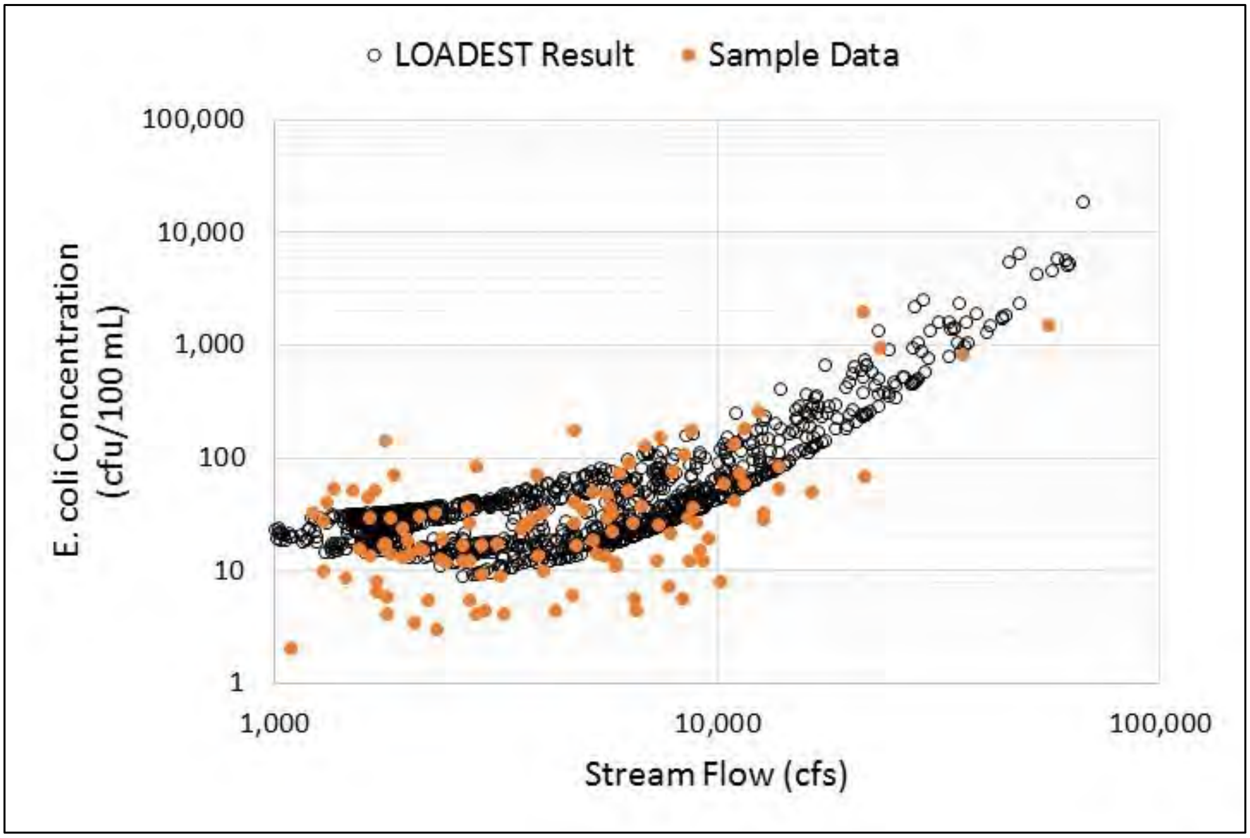


Figure 3-3: Regression of James River flow and *E.coli* concentration

Flows and *E.coli* concentrations associated with MS4 and watershed areas, and CSO discharges were computed from the watershed and CSS models, respectively. Flows and concentrations from the watershed model were input to EFDC at an hourly interval. Flows from the CSS model were input to EFDC at a five-minute interval due to the faster response time of the combined sewer system to rainfall relative to the watershed.

Fecal coliform event mean concentrations (EMCs) were previously calculated (and accepted by VADEQ) for the CSO discharges during the development of the Long Term Control Plan. These EMCs were calculated based on CSO outfall monitoring at several CSOs (Greeley and Hansen, personal communication, 11/15/2016). For this modeling effort, fecal coliform EMC concentrations were converted to *E.coli* concentrations using the VADEQ translator (Lawson, 2003). Table 3-7 summarizes the original fecal coliform EMCs and the translated *E.coli* values.

Consistent with the Long Term Control Plan, all influent to the WWTP was assumed to have an *E.coli* concentration of 235,000 CFU/100mL. It was assumed that influent receiving full treatment would result in an effluent concentration of 126 CFU/100 mL, consistent with the effluent concentration guidelines in the VAPDES permit (#VA0063177). For model application scenarios in which WWTP wet weather flow upgrades are proposed, effluent discharge concentrations were estimated based on the methods described in Section 5.

Table 3-7: Summary of fecal coliform and *E.coli* CSO EMCs				
CSO Districts	CSO Drainage Areas			
	Outfall Serial No.	Outfall Location	Fecal Coliforms (#/100 mL)	*E.coli* (#/100 mL)
South Side James River Park	018	42nd Street	986,775	318,000
	017	Reedy Creek	986,775	318,000
	016	Woodland Heights	986,775	318,000
	015	Canoe Run	986,775	318,000
	040	CSO-1 OUT/SSJRP	986,775	318,000
North Side James River Park	011	Park Hydro	437,343	150,000
	010	Gambles Hill	437,343	150,000
	009	Seventh Street	437,343	150,000
	(008)[a]	(Sixth Street)[a]	437,343	150,000
	007	Byrd Street	437,343	150,000
	(036)[b]	(Virginia Street)[b]	437,343	150,000
Manchester Area (WWTP Area)	014	Stockton Street	86,266[d]	34,000
	013	Maury Street	86,266[d]	34,000
	021	Gordon Avenue	86,266[d]	34,000
Gillies Creek	005	Peach Street	612,230	205,000
	002	Orleans Street	612,230	205,000
	004	Bloody Run	612,230	205,000
	003	Nicholson Street	612,230	205,000
	(023)[c]	(Old Fulton Street Bridge)[c]	612,230	205,000
	024	White and Varina Streets	612,230	205,000
	025	Briel Street and Gilles Creek	612,230	205,000
	026	1250 feet east of Government Road	612,230	205,000
	(027)[c]	(Williamsburg Road and Gillies Creek)[c]	612,230	205,000
	028	800' North of Nicholson Street	612,230	205,000
	035	25th and Dock Streets	612,230	205,000
	039	550 feet Downstream from Government Road	612,230	205,000
Shockoe Creek	006	Shockoe Creek	315,369[d]	111,000
	034	19th and Dock Street	315,369[d]	111,000
Remote Locations	020	McCloy Street	647,000	215,000
	019	Hampton Street	647,000	215,000
	033	Shields Lake	647,000	215,000
	012	Hilton Street	647,000	215,000
	031	Oakwood Cemetery	647,000	215,000

4 Model Calibration

Model calibration is the process of adjusting model parameters and assumptions within defensible ranges to achieve reasonable agreement between modeled and observed conditions. Model parameters and assumptions are set to the extent possible based on site specific data. However, in some cases, calibration is necessary because site specific data are either limited or unavailable. The calibration process fine-tunes these parameters, within reasonable bounds, to improve model calculations.

4.1 Calibration Data

The calibration process relies heavily on site-specific data to guide the tuning of model inputs. Site specific data support identification of important spatial patterns or time trends in environmental conditions. These patterns often lend insights into the processes or sources most strongly influencing environmental conditions. In this way, the model calibration process involves interpreting site data to understand and bring the model into agreement with important conditions. Site data vary in their capacity to support such an interpretation depending largely on their quantity and locations. The following sections describe the site specific data available for calibration of the modeling framework and also describe the interpretation of these data.

4.1.1 Watershed Model

4.1.1.a Hydrology

The hydrology calibration for the watershed model relied on data from Falling Creek (USGS #02038000), which was the only continuous flow and water depth gage within the modeled area (

Figure 2-2). Daily average flow data was available from 1955-1994. It was assumed that calibrated parameters related to in-channel roughness, overbank roughness, and impervious area would be similar between Falling Creek and the remainder of the watershed. This assumption seems reasonable based on a comparison of key watershed characteristics that influence runoff, including impervious area, slope, and soil infiltration, in Falling Creek versus the other model subcatchments. This comparison is shown in the table below.

Table 4-1: Median value of key runoff parameters in Falling Creek compared to the rest of the model subcatchments

Key Runoff Parameter	Median Value in Model Subcatchments	Median Value in the Falling Creek Subcatchment
% impervious area	26%	22%
% slope	5%	7%
Min infiltration	2.5	2.7
Max infiltration	0.161	0.178

4.1.1.b Water quality

The selected water quality calibration period was calendar years 2011 through 2013. This time period had the greatest quantity of sampling data available and the greatest range of *E.coli* results, including high values that would be indicative of wet weather source impacts. Seven stations on five different tributaries were chosen to evaluate the water quality calibration (Table 4-2). Station selection was based on the quantity of available data during the calibration period, the proximity of the station to the mouth of the stream, distribution of stations in the model extent, and the size of the tributary. Stations near stream mouths were selected because they more accurately reflect the total *E.coli* load delivered to the James River for each tributary. Stations representing a varied spatial distribution and a variety of sizes were selected to evaluate the robustness of the calibrated parameters.

Table 4-2: Water quality monitoring stations used for watershed model calibration

Tributary	Station ID	*E.coli* Data (#)
Falling Creek	399/400	30
Cornelius Creek	1310	15
Powhite Creek	1100	12
Upham Brook	4	14
Upham Brook	2	7
Reedy Creek	1235/RC1	6

Similar to the hydrology calibration, the water quality calibration was limited by the available data. Because of the data limitations, the water quality calibration was viewed not so much as a definitive calibration, but as a reasonable estimate of tributary loads and their timing so that calibration of the James River receiving water quality model could move forward. If necessary, the watershed model calibration would be revisited if the results from the receiving water quality model indicated it was necessary. The final calibration of the watershed model would be considered complete once the water quality calibration of the James River model was complete. After initial tuning of the watershed model water quality parameters, tributary *E.coli* loads were passed forward to the James River receiving water model. The effect of these tributary loads on James River water quality was assessed through calibration of the James River model which is further described in 4.4.

Water quality data in the tributaries were limited in their capacity to describe wet weather conditions. Most of the data collected appeared to be sampled during dry weather periods, a time when *E.coli* concentrations are expected to be low. Additionally, for almost all stations, samples were collected once per day, and therefore do not capture the temporal variability of bacteria (also known as the "pollutograph") that is expected during a rainfall event.

4.1.2 CSS Model

The CSS model was calibrated by Greeley and Hansen in 2015 during the initial model development as described in the CSS model documentation of the Waste Water Collection System Master Plan (Greeley and Hansen, 2015). The calibration was done using monitoring data from 16 flow meters, 7 rain gauges, and one river level sensor near outfall CSO 06 (Figure 2-3). The monitoring period lasted 11 months, from July 2012 to June 2013. Several issues related to the metering were identified in the report, and not all data collected was suitable to be used for model calibration. Ten (10) wet weather events were selected from the monitoring period to perform the wet weather calibration.

4.1.3 Receiving Water Quality Model

The hydrodynamic calibration period for the James River receiving water quality model was calendar years 2011 through 2013. This is the same period used for the water quality calibration, and includes a wide range of James River flow conditions. Data from two USGS stations supported the hydrodynamic model calibration: one in the riverine reach (Station 02037500 at Huguenot Bridge) and one in the estuarine reach (Station 02037705 at the City Locks). Data from the riverine USGS station quantify the change in stream depth and velocity with river flow. Data from the estuarine USGS station quantify the amplitude and phasing of tidal water levels.

The water quality calibration period for the James River receiving water model was calendar years 2011 through 2013. As shown in Figure 4-1, this period contains nearly the greatest density of sampling data in the James River. It also represents a typical range of flow and precipitation conditions. While calendar year 2010 had the highest sample count, several of the samples resulted in non-detected *E.coli* concentrations so they were less informative for the model calibration.

Data from the six locations with the greatest quantity of samples with detectable *E.coli* concentrations guided the calibration. Three of these locations occur in the riverine reach and three occur in the estuarine reach. One station (#753) is upstream of all Richmond sources, two are near downtown Richmond and are influenced by CSOs (#641 and #840), and the remaining three are downstream of CSOs and beyond Richmond (#576, #574, and #572). These stations are shown in Figure 2-4.

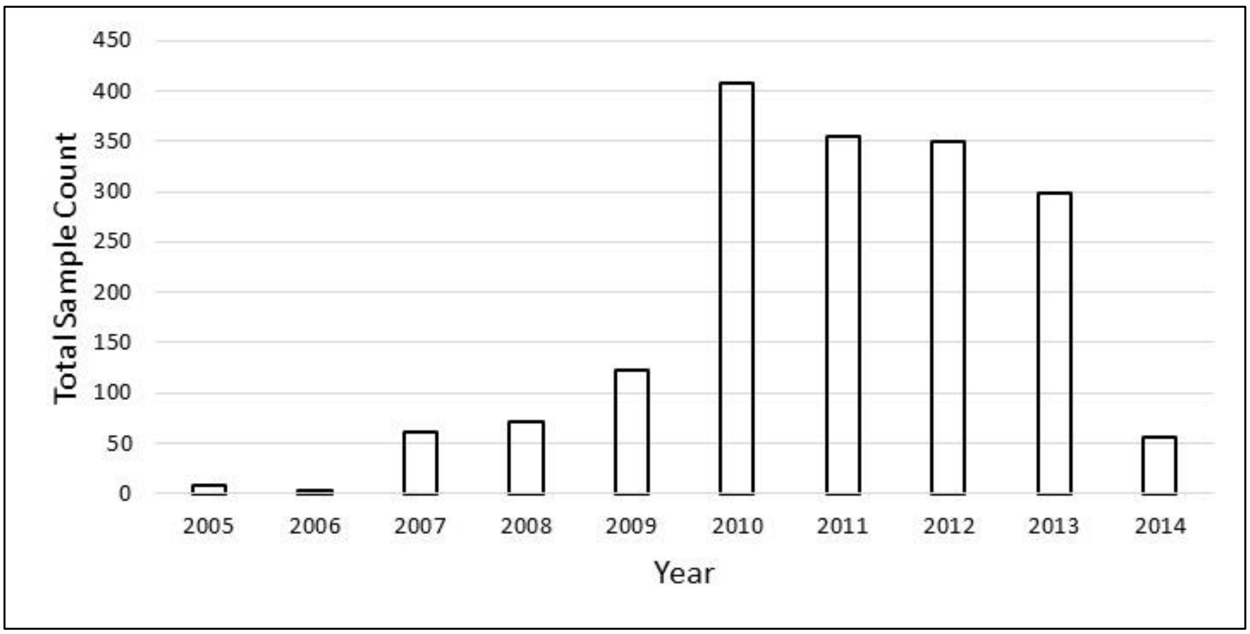


Figure 4-1: James River E.coli Water Quality Sample Count by Year

The calibration data were analyzed to identify patterns in water quality along the James River that would guide model calibration. Three significant observations were made. First, dry weather *E.coli* concentrations increase significantly moving from the upstream most station at Huguenot Bridge (station

753) to the downtown area (station 840).

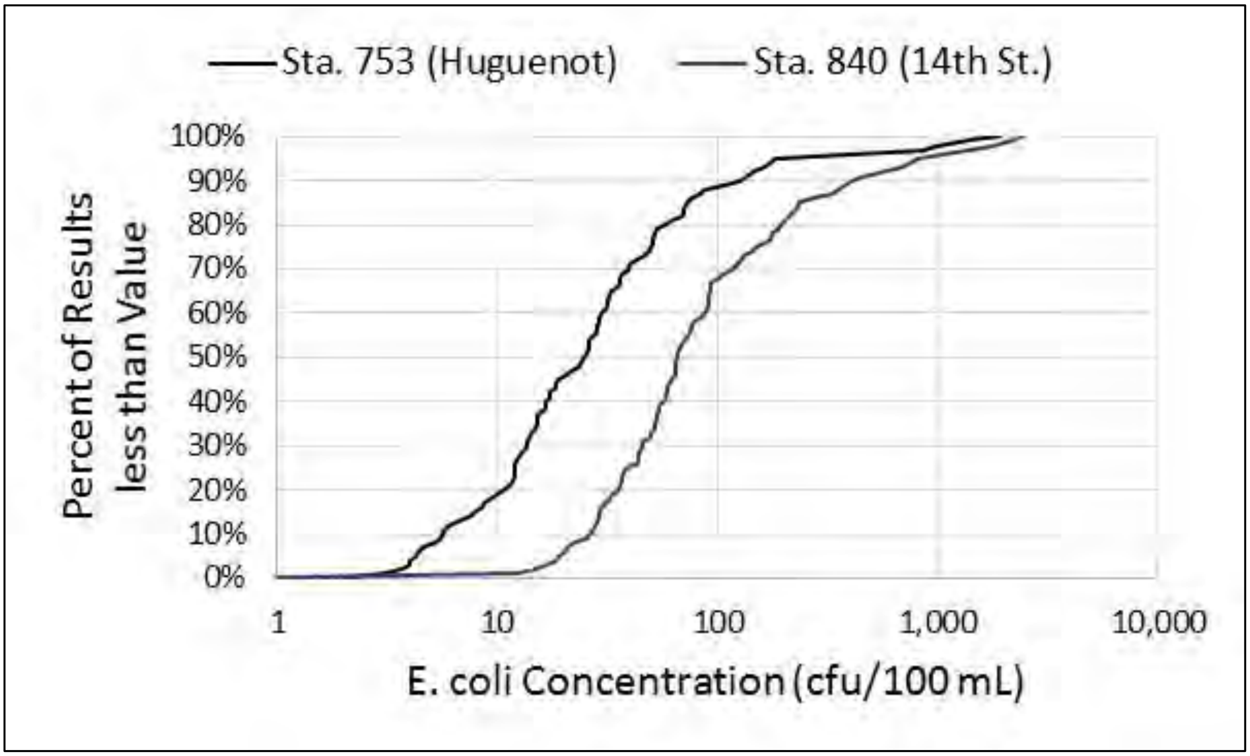


Figure 4-2 compares cumulative frequency distributions (CFDs) at the upstream station and a station near downtown. Median (50th percentile) *E.coli* concentrations increase from 25 to 66 CFU/100 mL, indicating a significant persistent source of *E.coli* to the river between these locations.

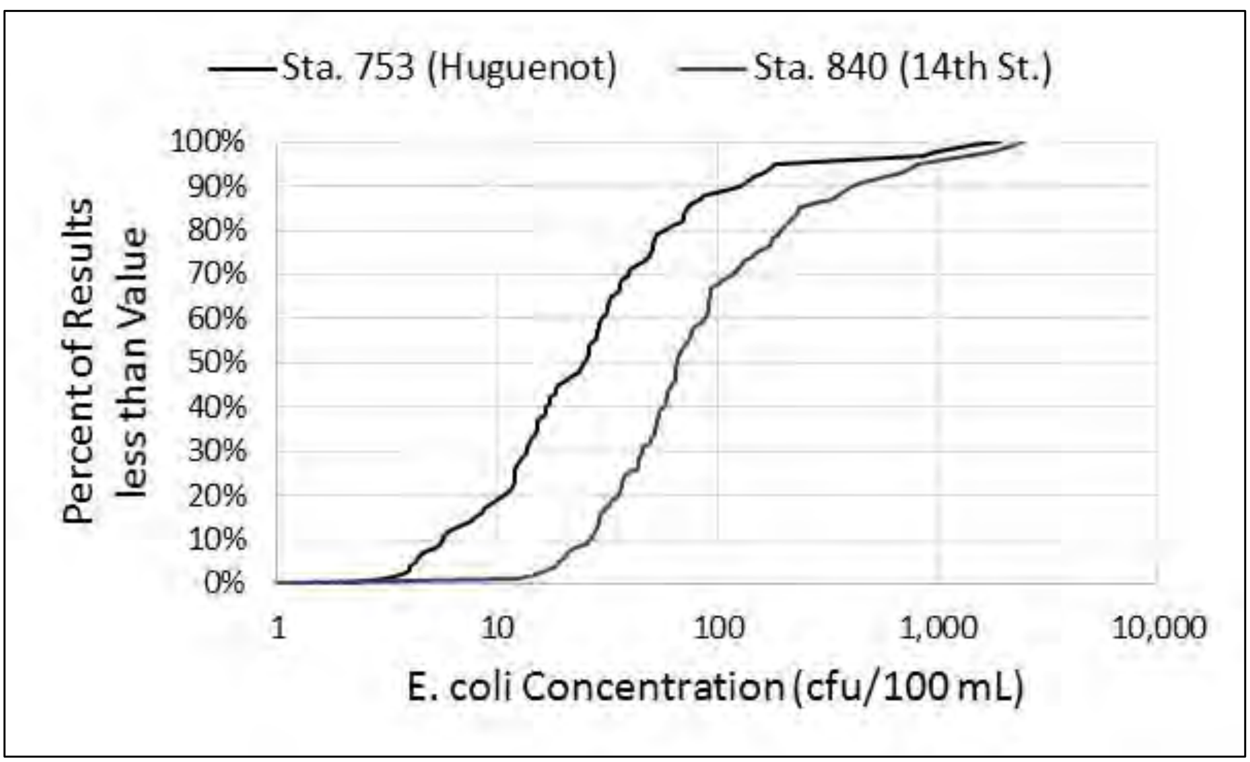


Figure 4-2: Increase in *E.coli* Concentrations from Huguenot Bridge to 14th St. Bridge

Second, *E.coli* concentrations are similar among station 840 on the south side of Mayo Island at 14th Street and stations 576, 574, and 572 which occur farther downstream in the estuarine reach.

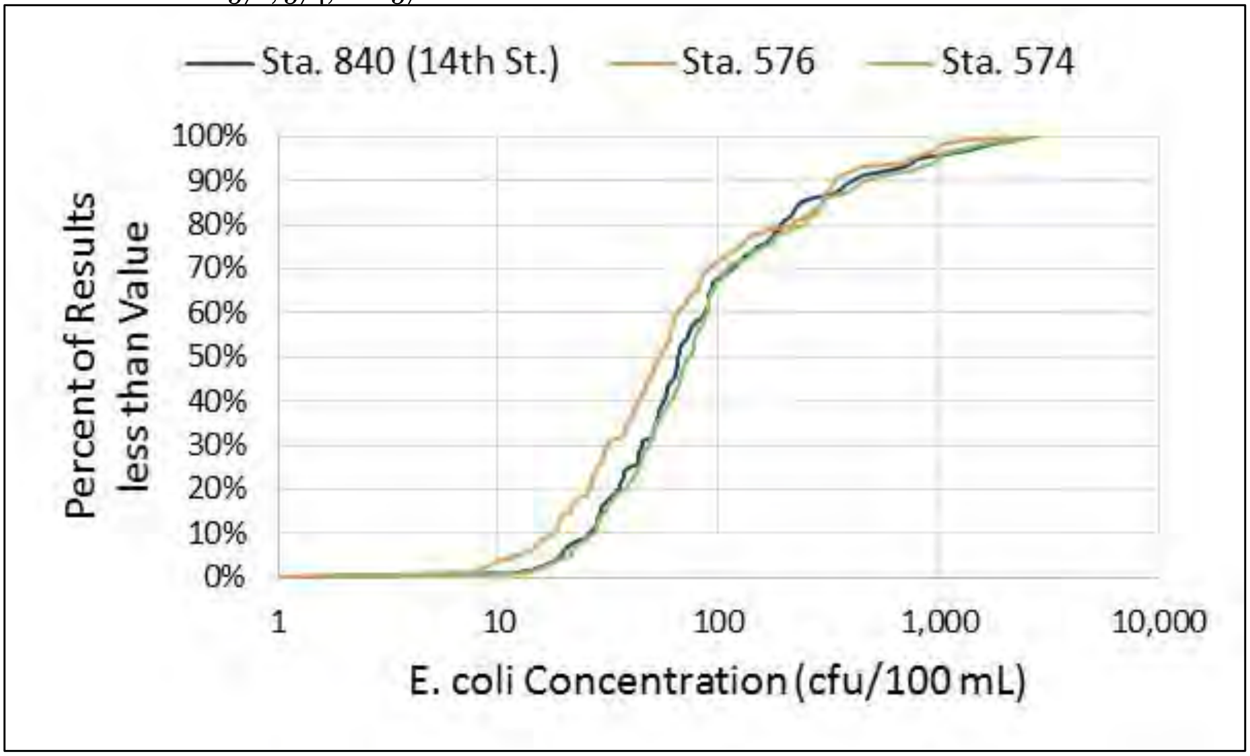


Figure 4-3 compares the cumulative frequency distributions (CFDs) among these stations. Similarities in the *E.coli* concentrations among these stations indicate that, most of the time, additional pollutant loads downstream of station 840 and on the north side of Mayo Island are small relative to the upstream *E.coli* load. Similarity in *E.coli* concentrations at these three locations also indicates that in-stream losses of bacteria are minor between stations 840, 576, and 574. Median (50th percentile) E.coli concentrations at stations 840, 576, and 574 are 66, 74, and 55 CFU/100 mL respectively.

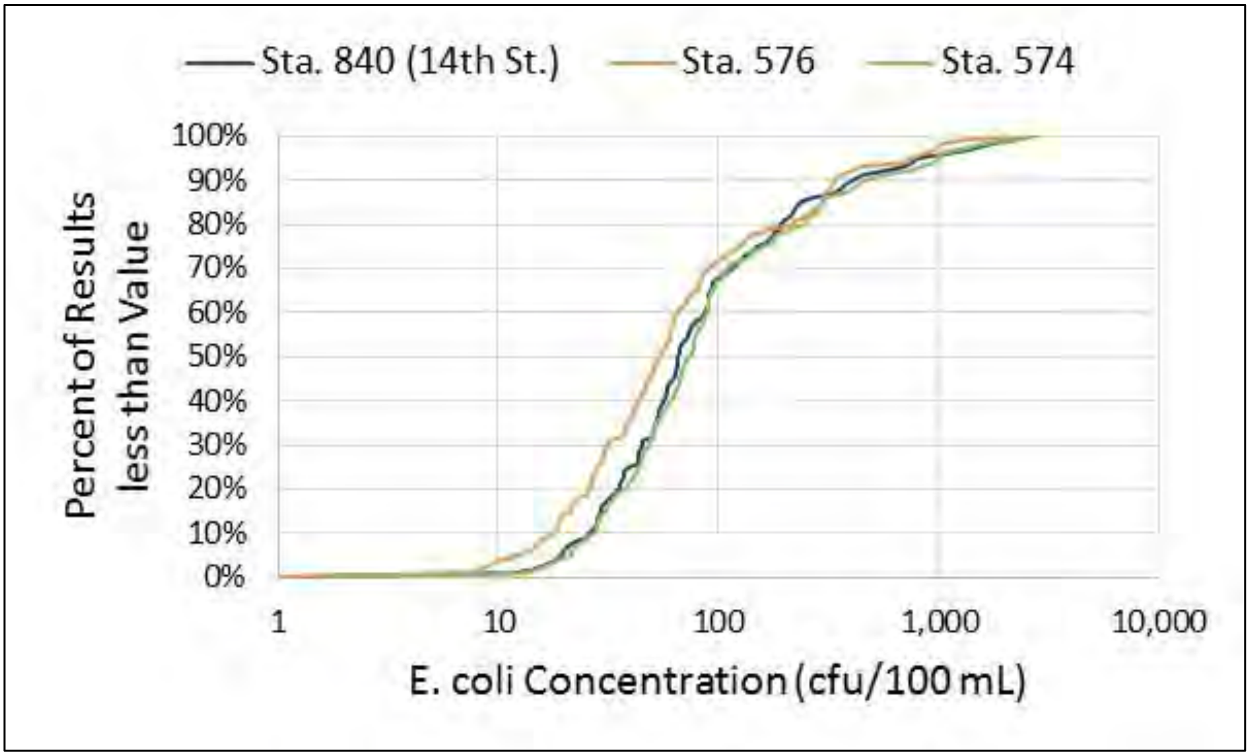


Figure 4-3: Similarity in *E.coli* Concentrations among Stations 840, 576, and 574

Third, *E.coli* concentrations at station 641 are significantly higher than at stations 840, 576, 574, and 572 and are assumed to be unrepresentative of ambient conditions on the north side of the island. If these data were representative of the total flow north of the island, then *E.coli* concentrations at downstream stations would be higher than data at station 841 on the south side of the island. Given the similarity in concentrations between stations 841, 576, and 574, it is assumed that samples at station 640 are not representative of the broader river flow north of the island. Samples at this location were taken within a protected embayment that receives discharge from CSO 06 (Shockoe Retention Basin discharge). The protected embayment may have flow properties different from the main section of James River (e.g. sheltered location, stagnant water, little flushing from the James River, direct CSO discharge) that may relate to the unrepresentatively high *E.coli* concentrations observed there.

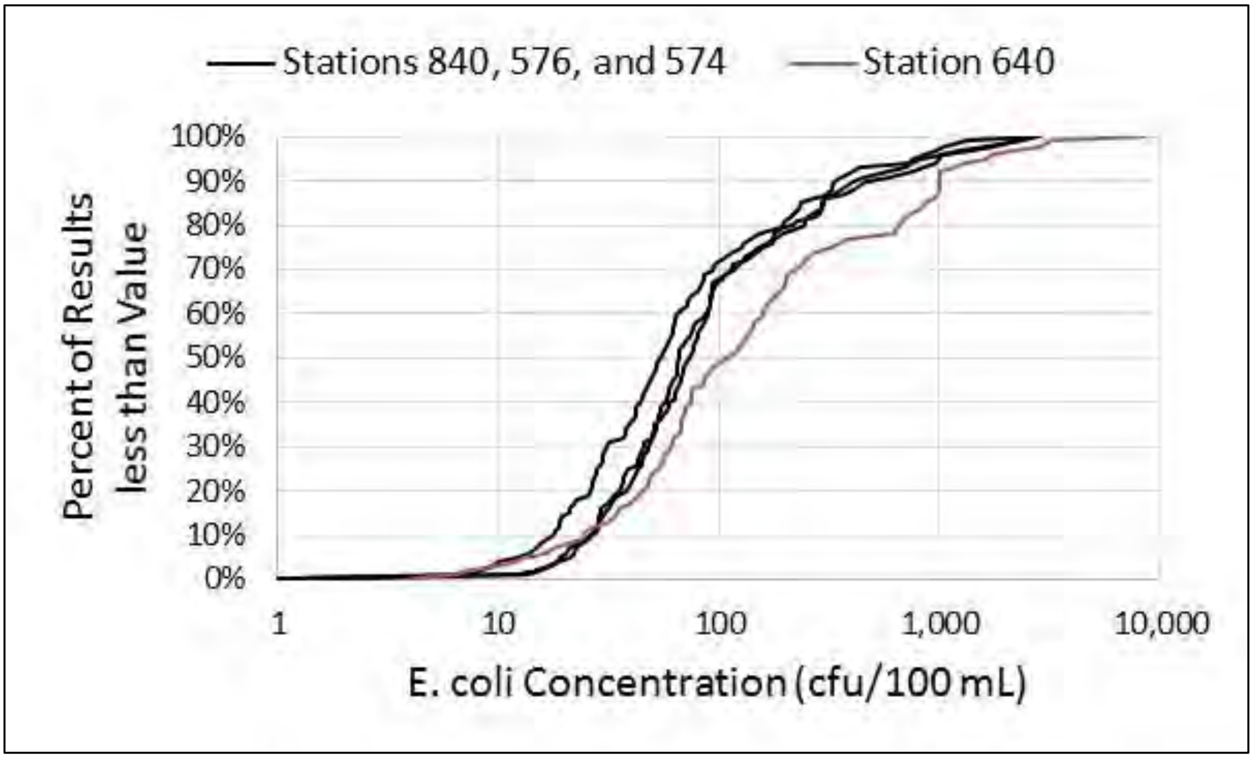


Figure **4-4** illustrates differences between *E.coli* concentrations at station 640 and the surrounding stations.

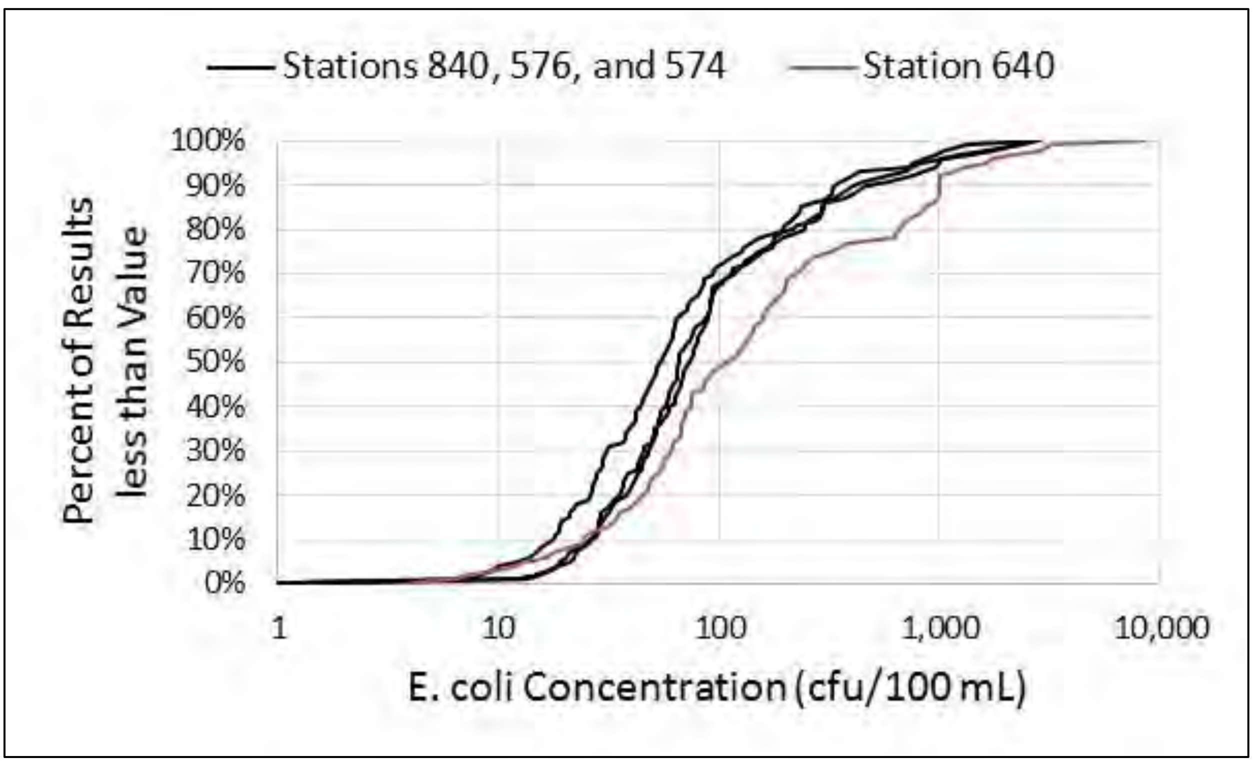


Figure 4-4: Differences in *E.coli* Concentrations between station 640 and other surrounding stations

These observations from the data represent the understanding of water quality patterns that guided James River water quality model calibration decisions, which are further described in the sections below.

4.2 Model Evaluation and Performance Criteria

Model evaluation and performance criteria are principles and standards for evaluating the success of a model calibration. In some cases, statistical evaluations of model output are useful in that they can be related to industry standards. In other cases, reliable statistical standards are unavailable and model calibration is guided primarily by visual evaluation of graphics comparing model and data. Considerations that guided the model calibration process are described for each model below.

4.2.1 Watershed Model

The evaluation of the hydrology calibration involved statistical and visual comparisons between the modeled flows at the outlet of the upstream portion of the Falling Creek watershed and observed flows at the Falling Creek USGS gage. Annual and cumulative modeled flow volume were evaluated. Comparisons were also made between model results and gaged flows for 18 individual storm events. For each event, model results were qualitatively and statistically evaluated based on the shape of the hydrograph, total event volume, and event peak flows.

The evaluation of the water quality calibration relied upon graphical summaries of model results. These summaries included boxplots, cumulative frequency distributions, and one-to-one plots of model results versus observed data. The primary calibration parameters were pollutant build-up and wash-off, baseflow concentration of *E.coli*, and in-stream *E.coli* decay rate. Due to the lack of available water quality data, the final calibration of the watershed model was completed as part of the water quality calibration for the James River EFDC model.

4.2.2 CSS Model

The performance evaluation of the original Wet Weather Combined Sewer (WWCS) model was conducted by Greeley and Hansen and included visual comparisons of flow hydrographs for individual wet weather events at the metering locations as well as 1:1 plots for comparisons of wet weather event flow volume and peak flows. The model evaluation is described in the Collection System Hydraulic model report of the Wastewater Collection System Master Plan by GH (Greeley and Hansen, 2012).

Brown and Caldwell evaluated the adjusted Clean Water Plan version of the CSS model (described in Section 3.2) against available flow observations as well as the underlying WWCS model by GH and the comparison described in detail in the IP Model Development documentation (Brown and Caldwell, 2016). This includes flow comparisons for individual wet weather events at meter locations (against observations) as well as volumetric comparisons at CSO locations on an event and annual basis against the WWCS model.

4.2.3 Receiving Water Quality Model

Evaluation of the hydrodynamic model performance relied on graphical summaries of model output. In the riverine reach, modeled depths and velocities were plotted against modeled discharge and compared against observed depths and velocities plotted against observed discharge. These relationships of depth and velocity versus discharge are strongly influenced by the hydraulic characteristics of the James River including bed slope, width, and channel roughness. In the estuarine reach, the model was evaluated using two other graphic types: time series and one-to-one plots. These tools were used to assess the phasing and amplitude of the modeled tides and the effect of river flows on water levels in the estuarine reach.

Evaluation of the water quality model performance also relied on graphical summaries of model output, including time series plots and cumulative frequency distributions (CFDs). Emphasis was placed on evaluating the model's consistency with elevated *E.coli* concentrations which would most significantly influence compliance with water quality standards.

4.3 Hydrology and Hydrodynamics Calibration Results

Hydrology and hydrodynamics describe the quantities and rates of water moving through a system. In the James River water quality modeling framework, this includes movement of storm runoff from the watershed into and through tributaries and storm water sewers, movement of water and wastewater into and through the combined sewer system and through the wastewater treatment plant and combined sewer overflows, and movement of water into and through the James River. Calibration of hydrology and hydrodynamics is important in that it strongly influences the concentrations and persistence of pollutants in an environmental system.

4.3.1 Watershed Model

The purpose of the hydrology calibration was to: 1) reasonably approximate the volume and timing of observed flows in Falling Creek and 2) develop hydrologic parameters that could be used for all subcatchments and stream channels in the watershed model extent. In the absence of robust site-specific data, it was assumed that all subcatchments and stream channels in the model would have similar hydrologic properties. This assumption was considered reasonable because median values are similar for subcatchment parameters, such as impervious area, percent slope, and soil properties between the gaged portion of the Falling Creek watershed and the other watersheds included in the model extent. The model was run for calendar years 1985 to 1994, and modeled cumulative flows and storm event hydrographs were compared to observed flows at the USGS gage. Subcatchment percent impervious area and stream channel roughness values were adjusted to bring the modeled results into alignment with observed values.

On a cumulative basis, the model results reasonably match observed flows for all years until spring of 1993 and spring of 1994 (Figure 4-5).

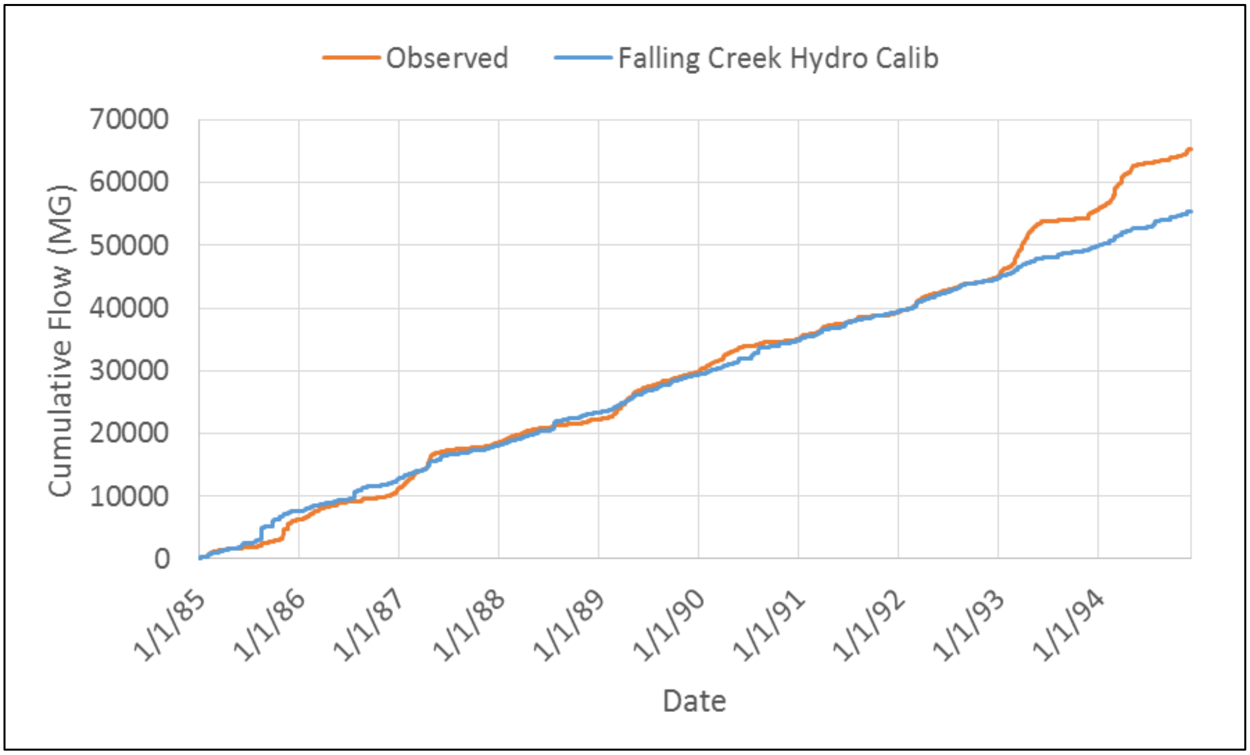


Figure 4-5: Observed and Modeled Cumulative Flow Volume at the Falling Creek Gage

For the period 1985 to 1994, the model underpredicted observed flows by approximately 15%. However, when the flows from 1993 and 1994 were excluded, the difference in cumulative volume between modeled and observed flows decreased to -0.5% (Table 4-3). The cause for the 1993 and 1994 increases in observed flows are unknown, but similar increases were observed in four other USGS gages in the region: Totopotomoy Creek near Studley, VA (USGS 01673550); James River near Richmond, VA (USGS 02037500); Appomattox River at Mattoax, VA (USGS 02040000); and Chickahominy River near Providence Forge, VA (USGS 02042500), indicating that this is not merely an instrumental problem at a single gage (Figure 4-6). Variations could be attributable to differences in rainfall in the Falling Creek watershed and at the Richmond Airport, which are approximately 11.7 miles apart as the crow flies.

Table 4-3: Observed and Modeled Annual Flow Volumes at the Falling Creek Gage

Year	Observed Total Annual Flow (MG)	Modeled Total Annual Flow (MG)	Percent Difference Between Modeled and Observed
1994	9,614	5,584	-41.9%
1993	10,740	5,181	-51.8%
1992	5,678	5,209	-8.3%
1991	4,214	4,609	9.4%
1990	5,253	5,521	5.1%
1989	7,566	6,110	-19.2%
1988	3,677	5,143	39.9%
1987	7,435	5,417	-27.1%
1986	4,875	5,066	3.9%

Table 4-3: Observed and Modeled Annual Flow Volumes at the Falling Creek Gage			
Year	**Observed Total Annual Flow (MG)**	**Modeled Total Annual Flow (MG)**	**Percent Difference Between Modeled and Observed**
1985	6,262	7,639	22.0%
OVERALL	**65,313**	**55,477**	**-15.1%**
OVERALL (excl. '93-'94)	**44,959**	**44,712**	**-0.5%**

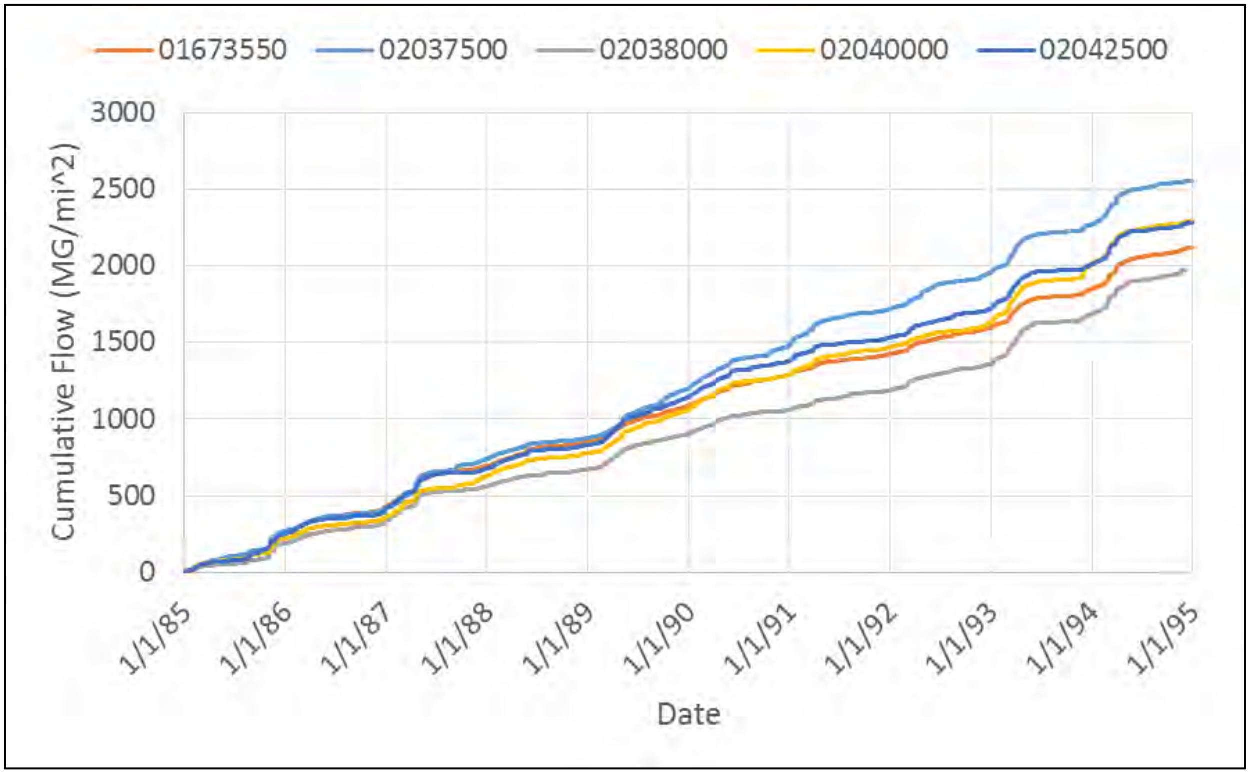


Figure 4-6: Area Normalized Cumulative Flow Volume for USGS Gages in the Richmond Region

On an event basis, model results tend to over predict event volumes and peak flows (Figure 4-7 and Figure 4-8), but the general shape of the hydrographs tend to match (Figure 4-9). The model currently only uses precipitation from one gage at Richmond International Airport (RIA). Variations on an event basis could be attributable to differences in rainfall in the Falling Creek watershed and at the Richmond Airport, which are approximately 11.7 miles apart as the crow flies.

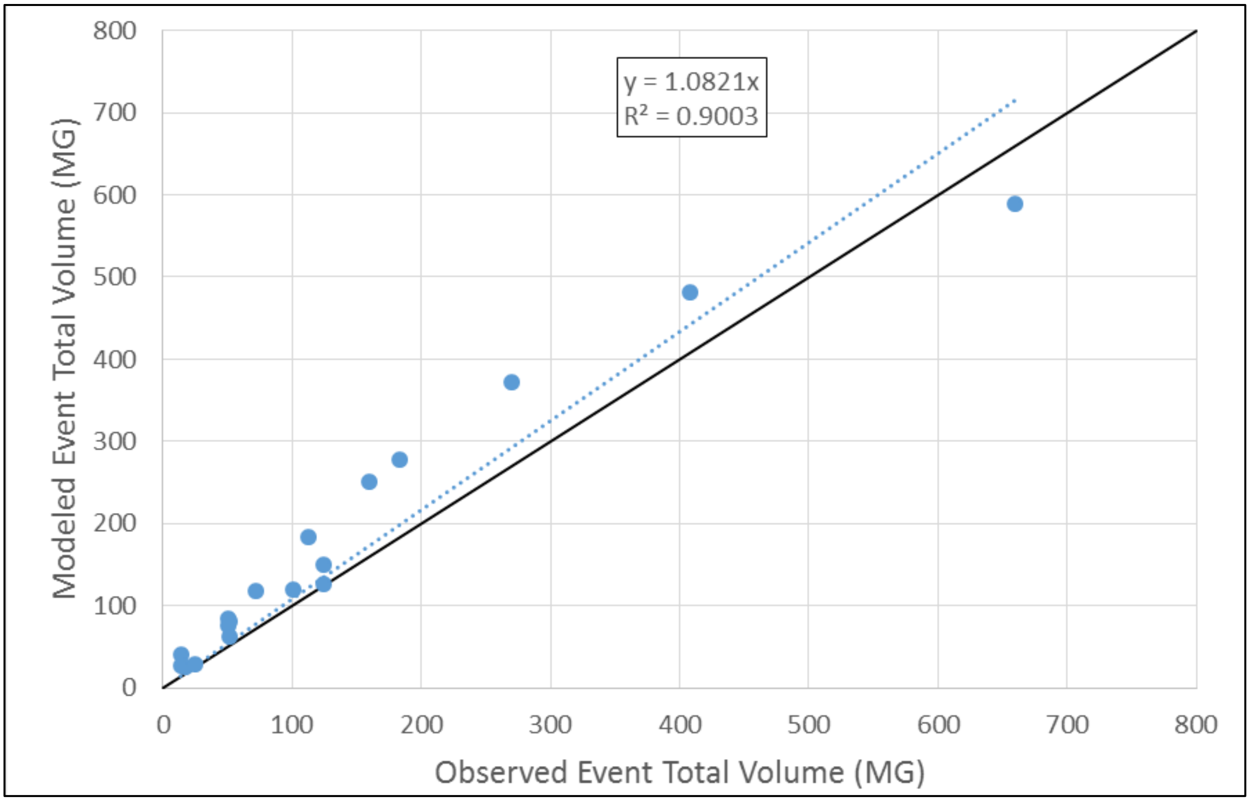


Figure 4-7: Modeled vs Observed Event Volume

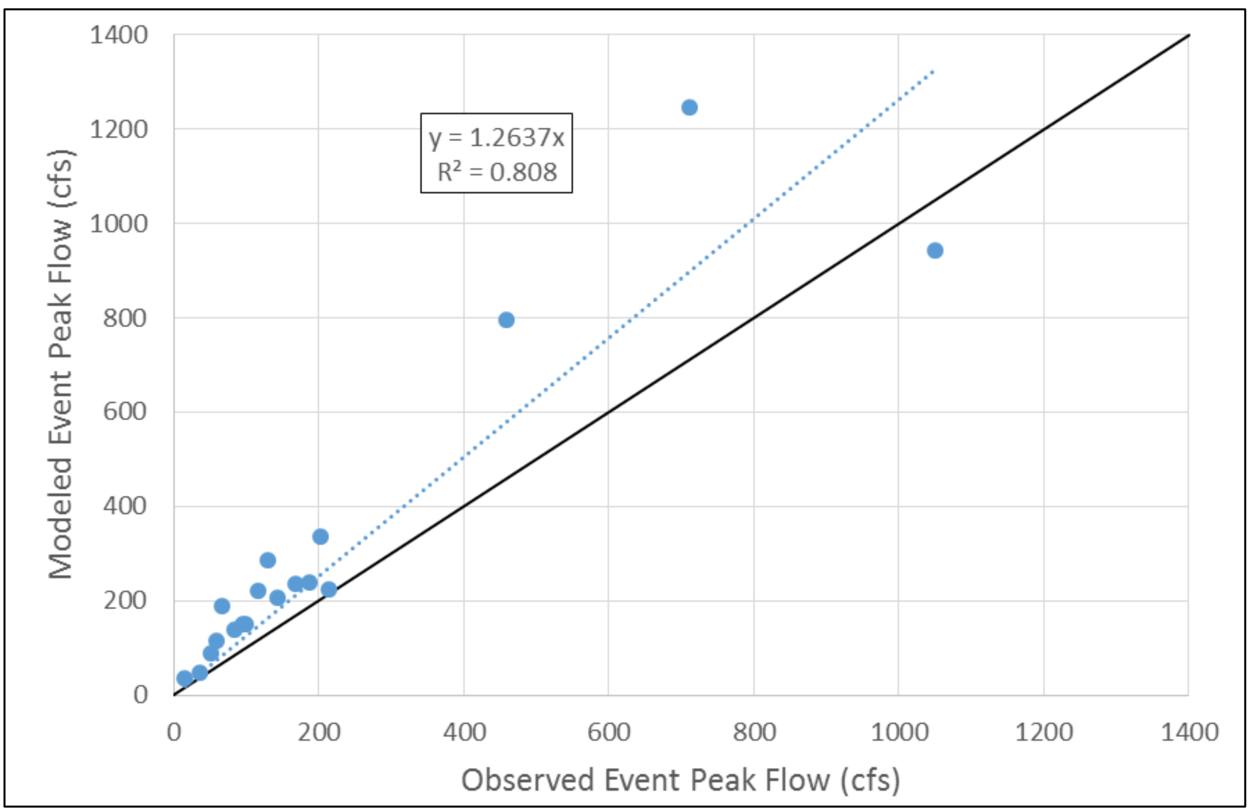


Figure 4-8: Modeled vs. Observed Event Peak Flow Rate

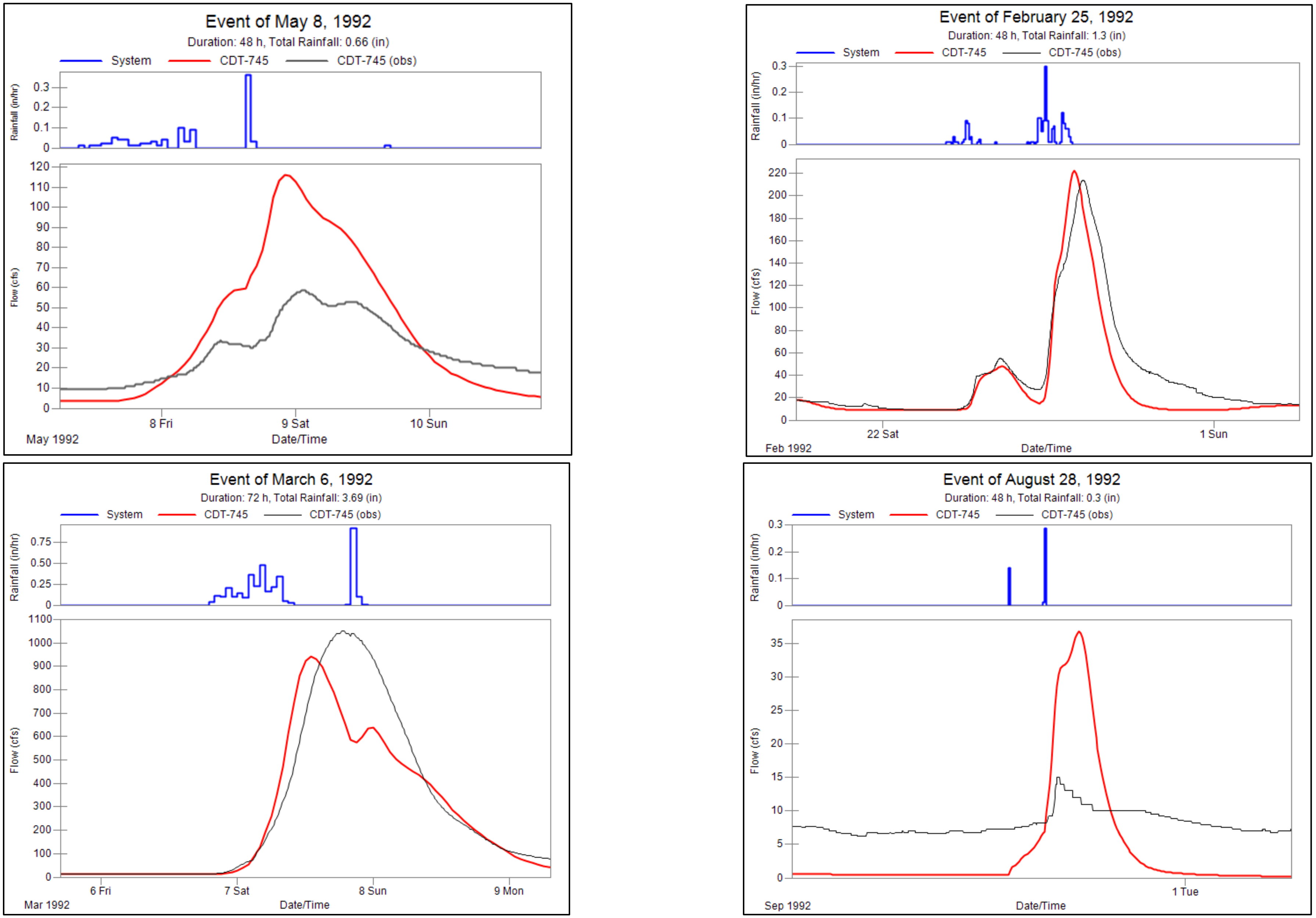


Figure 4-9: Modeled vs Observed hydrographs for four events at Falling Creek Gage

Three calibration parameters were used to adjust cumulative volumes, event volumes, and event peak flows: percent impervious area, Manning's N for in-channel roughness, and Manning's N for overbank roughness. Adjustments to modeled cumulative volume were made by adjusting the percent impervious area. Adjustments to event peak flows and the timing of peak flows were made by adjusting in-channel and overbank Manning's values. Manning's N for in-channel roughness was varied between 0.035 and 0.05 for a main channel that was assumed to be clean, winding and have some pools and shoals. Manning's N for overbank roughness was varied between 0.04 and 0.08 for overbanks that were assumed to have light brush and trees (Chow, 1959).

Impervious area is not typically a calibrated parameter, but initial model runs underestimated observed cumulative flows (dotted green line in Figure 4-10). To determine the cause of the underestimated flows, NLCD impervious cover data were compared to a planimetric impervious layer provided by the City of Richmond. The analysis revealed that the NLCD impervious layer underestimated the median percent impervious area, especially in less urban areas. To correct the underestimation of impervious area a linear regression was used to adjust the NLCD impervious area upwards for consistency with the planimetric data (dotted blue line in figure below). Finally, because the amount of directly connected impervious area is not known, the percent impervious area for each subcatchment was adjusted downward to account for impervious areas that are not directly connected to a waterway (solid blue line in figure below). Results from each run are summarized in Figure 4-10.

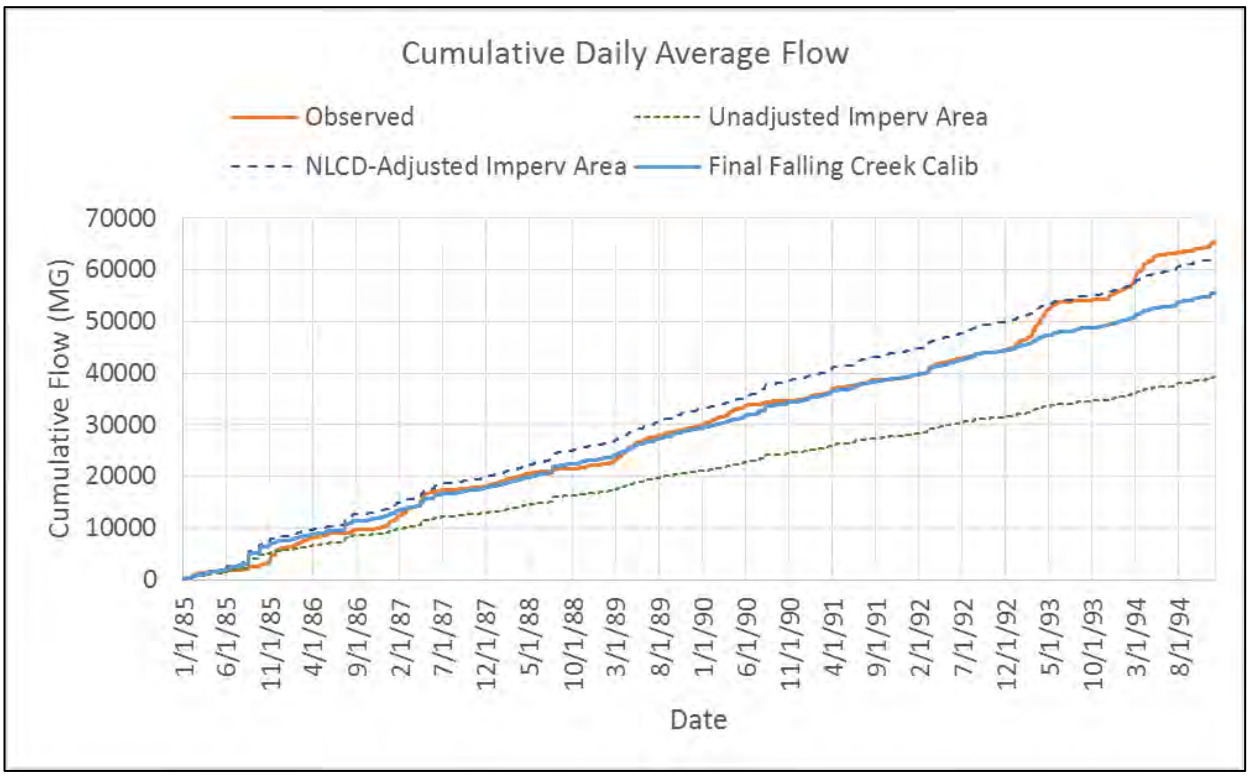


Figure 4-10: Model calibration results (impervious area)

4.3.2 CSS Model

The CSS calibration of the original Wet Weather Combined Sewer (WWCS) model focused both on achieving the appropriate volume and peak flows within the sewer system and on characterizing the discharge at the combined sewer outfalls, specifically at CSO 06 (Shockoe Retention Basin). While calibration within the sewer system was deemed acceptable and representative of conditions at that time, calibration at the Shockoe Retention Basin was more difficult to achieve due to the complex hydraulic situation in this area as well as to the manual overflow operations that occur at this location (Greeley and Hansen, 2015).

The original WWCS model was modified and adapted so that it could be used in hindcast mode for a long-term continuous period, and in order to operate the model for evaluating CSS alternatives. After the modifications, the performance of the resulting CSS IP model was checked against monitoring data as well as against the results from the underlying original WWCS model. A discussion of the results is included in the CSS model review memorandum (Brown and Caldwell, 2016). Overall, the CSS IP model predicts lower overall CSS volume discharges and events compared to the results documented in the 2002 LTCP re-evaluation report, as well as compared to the CSS Annual Reports. These differences can be attributed to two main reasons:

- Numerous changes to the CSS model were performed since the 2002 LTCP re-evaluation, and the CSS model was re-calibrated on a few different occasion. This results in the CSO discharge volumes and number of CSO events to be different from those reported in the 2002 LTCP re-evaluation. These differences are deemed justified based on the additional monitoring data that was used to conduct the re-calibration, and on the CSS model revisions, including operational and physical changes to the combined sewer system and waste water treatment plant system that were implemented since the 2002 Long Term Control Plan Re-Evaluation.
- The CSS IP model uses standard operating rules to model the CSO operations at the Shockoe Retention Basin, causing the CSO discharges modeled at this location to be different from those reported in the CSS Annual Report, where the CSO discharges are calculated by using the real-time operator logs and which are interweaved with the results from the CSS model.

4.3.3 Receiving Water Quality Model

The purpose of the hydrodynamic model calibration was to adjust model parameters within defensible ranges to achieve reasonable agreement between modeled and observed water levels and velocities. The model was run for calendar years 2011 through 2013, and the modeled relationships between river discharge and water level, as well as river discharge and velocity were compared to the observed relationships in the riverine reach. Modeled roughness heights, which represent both grain roughness associated with substrate and larger scale bed forms, were adjusted within bounds consistent with Manning's N roughness values cited in the FEMA Flood Insurance Study (FEMA, 2014). These adjustments were made to bring the modeled water levels and velocities in closer agreement with the observed data.

Figure 4-11 and Figure 4-12 illustrate the riverine model calibration and show sensitivity of the model results to varying roughness height inputs. The calibrated bed roughness heights varied from 5 to 50 millimeters corresponding to Mannings N values from 0.03 to 0.045. Roughness heights were halved in the sensitivity test named "Lower Roughness Test," and they were doubled in the sensitivity test named "Higher Roughness Test." Increases in bed roughness caused increases in modeled water surface elevations and decreases in current velocities. The calibrated roughness inputs provided a balance of accurately simulating both water surface elevations and current velocities.

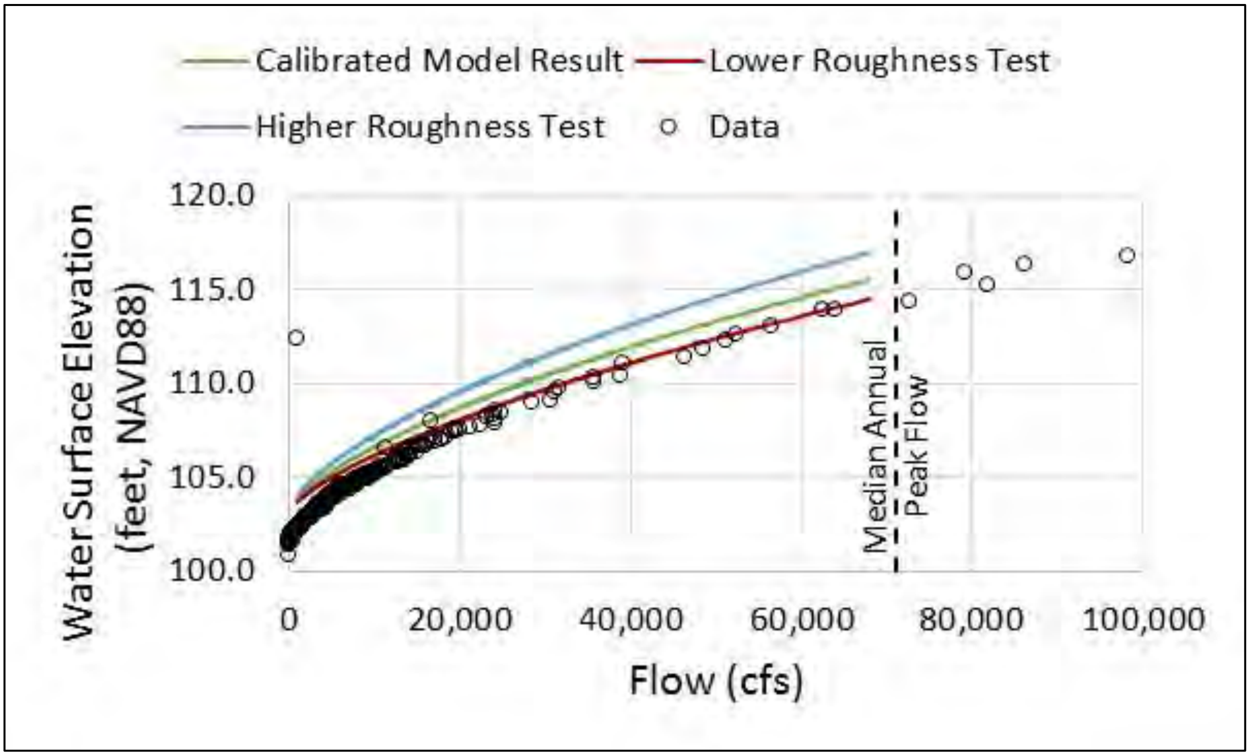


Figure 4-11: Comparison of Modeled and Observed Water Levels at upstream USGS gage

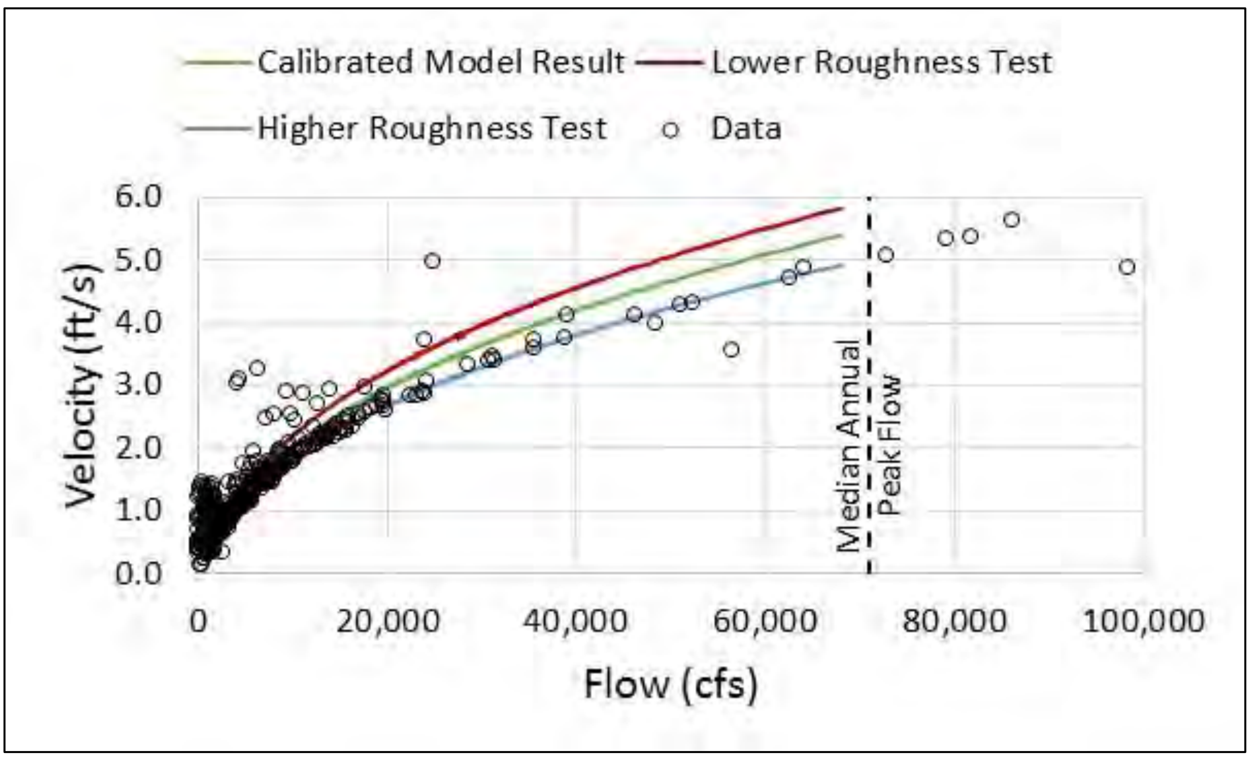


Figure 4-12: Comparison of Modeled and Observed Velocities at upstream USGS gage

Calibration to USGS water level data in the estuarine reach was achieved by adjusting the water level at the boundary to account for the effect of river flow on water levels. Water levels at the boundary were reduced relative to the gaged water levels to account for changes in water level between the gage and the model boundary. The data were adjusted according to the expression:

$$Z_{boundary} = Z_{Gage} - C * Q^n$$

Where:

- $Z_{boundary}$ is the estimated water level at the downstream boundary in feet
- Z_{gage} is the observed water surface elevation at the USGS gage (#02037705) in feet,
- C and n are constants which were determined via calibration to be 4.4e-7 and 1.5; and,
- Q is the James River flow rate in cubic feet per second

The data were also shifted by approximately three minutes backward in time to account for propagation of the tides from the model boundary to the gage location.

Figure 4-13 and Figure 4-14 illustrate the estuarine model calibration and Figure 4-15 shows how the model performed in the absence of this flow-based water level adjustment at the downstream boundary. Without this flow-based adjustment to water levels, modeled water levels are biased four feet high relative to the data during the highest flow conditions.

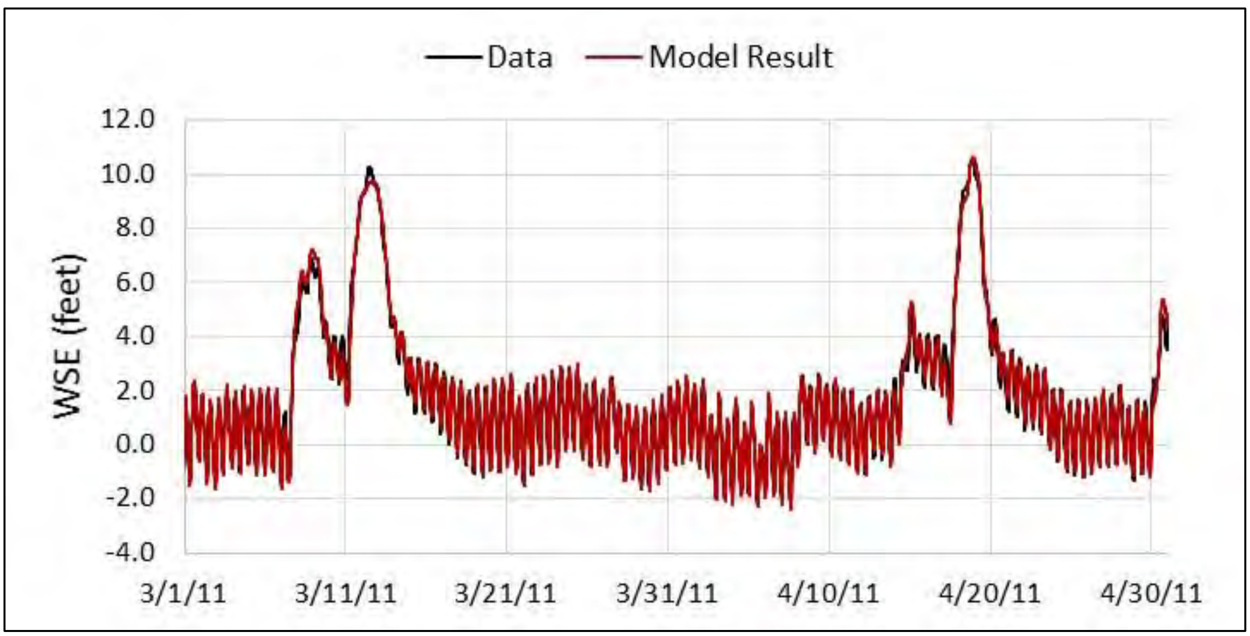


Figure 4-13: Time Series Comparison of Modeled and Observed Water Levels at downstream USGS gage

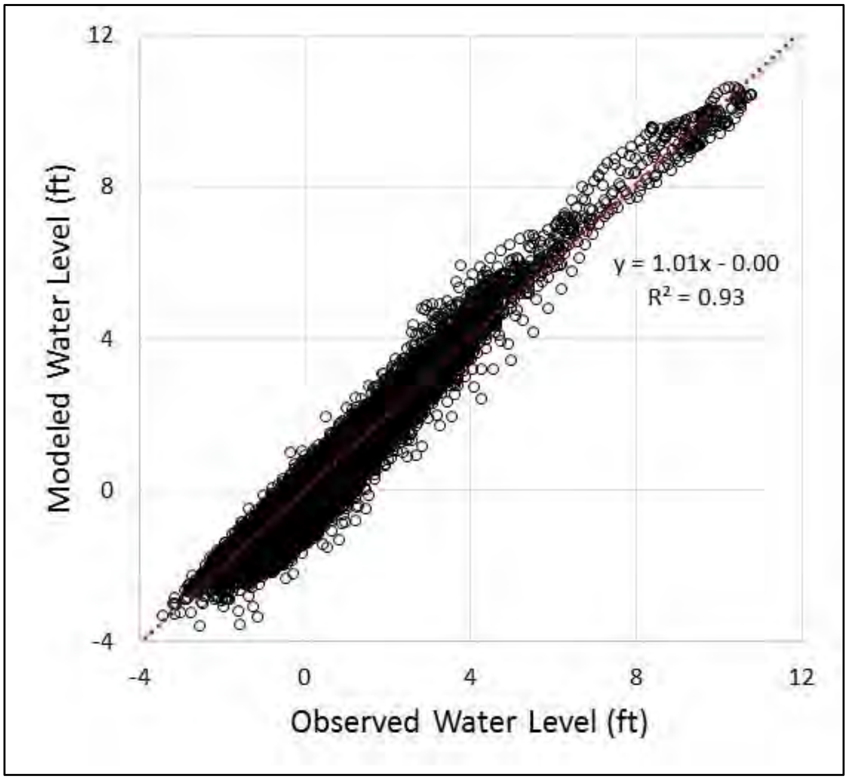


Figure 4-14: One-to-one Comparison of Modeled and Observed Water Levels at downstream USGS gage

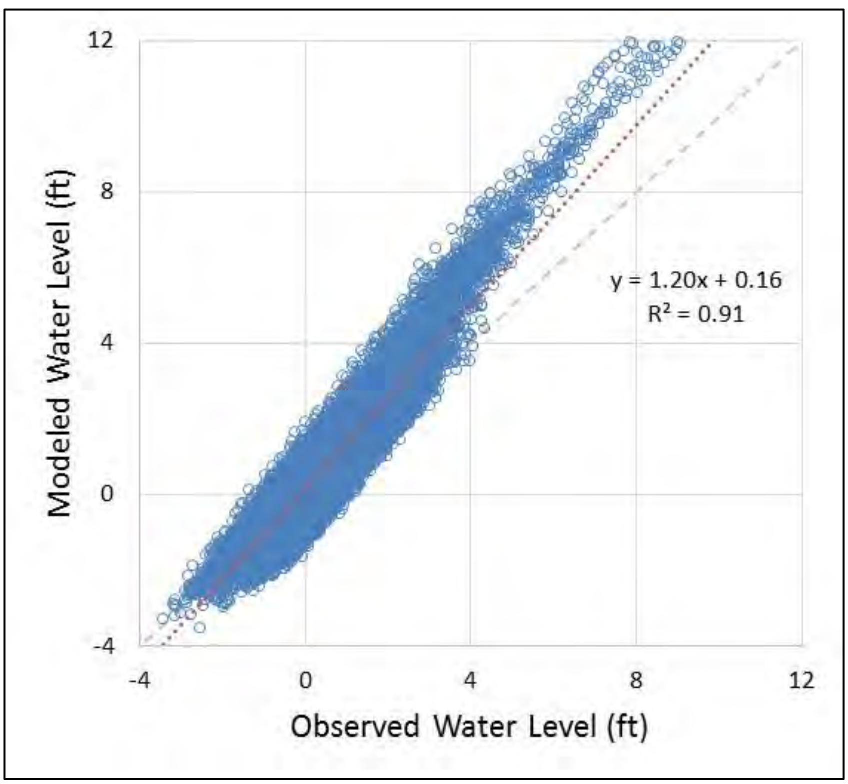


Figure 4-15: One-to-one Comparison of Modeled and Observed Water Levels at downstream USGS gage without calibration of water levels at the boundary

4.4 Water Quality Calibration Results

Calibration of water quality conditions involved adjusting inputs that influence the quantity, timing, and locations of *E.coli* delivered to the receiving waters and adjusting inputs that influence the survival of *E.coli* in the streams. *E.coli* sources in the water quality modeling framework include *E.coli* washoff from the watershed, persistent background sources of *E.coli* (e.g.: wildlife), *E.coli* in combined sewer overflows and treatment plant effluent, and *E.coli* originating from upstream locations in the James River watershed.

4.4.1 Watershed Model

The main objectives of the watershed water quality calibration were to estimate *E.coli* loading to the receiving water quality model and the approximate timing of these loads. To evaluate the first objective, the distribution of modeled *E.coli* concentrations was compared to observed data using boxplots. To evaluate the second objective, model results were compared to observed data using one-to-one plots, where the observed data is compared to the modeled data for a given model time step.

Data from the Falling Creek location were primarily used to calibrate the watershed model for two reasons: First, Falling Creek stations 399/400 have the greatest quantity of observed data. Second, since Falling Creek is the only tributary in the watershed model with a USGS flow gage, the modeled flows are likely to be the most accurately represented. Therefore, accurately modeling observed concentrations in Falling Creek would result in the best estimation of *E.coli* loads delivered to the receiving water quality model. Since there is a limited amount of data available in the tributaries, the initial calibration was considered complete and satisfactory once the modeled results from Falling Creek and the majority of the other five tributaries matched observed values within reason.

The model was run for the calendar years 2011 to 2013 and modeled *E.coli* concentrations were compared to observed results for six tributaries. Figure 4-16 and Figure 4-17 illustrate the watershed model water quality calibration. Model results at Falling Creek reasonably approximate the median observed concentration and the distribution of observed values. Modeled median values for four out of the other five tributaries also appear to be reasonable, with the modeled medians within one order of magnitude of the observed medians. Maximum modeled *E.coli* concentrations are generally greater than the observed data, which is assumed to be due to the lack of wet weather data collected in the tributaries. One-to-one plots were evaluated in light of the fact that in-stream *E.coli* concentrations can vary greatly in time and space (USEPA, 2010). To account for the natural variability that can occur when sampling *E.coli*, two additional sets of lines were added to the 1-to-1 plot: the first set of dashed lines represent a two-times (2x) confidence interval representing the variability in monitoring data results associated with field-collection efforts. The second set of dotted lines represents a ten-time (10x) confidence interval which represents the possible variability in monitoring data results associated with both the field collection efforts and the laboratory methods. The majority of points on the one-to-one plots fall within the 10x confidence interval for all stations.

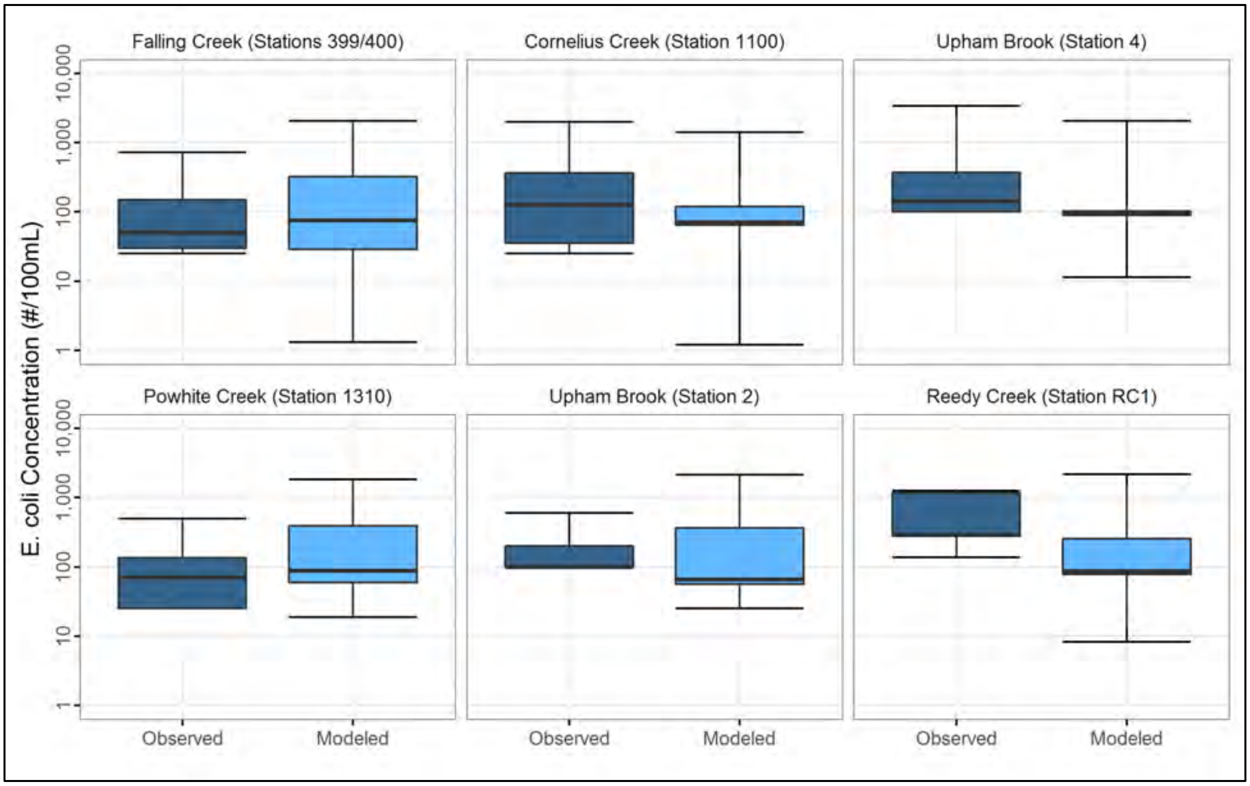


Figure 4-16: Boxplots of Modeled vs. Observed E.coli Concentrations in Select Richmond Tributaries

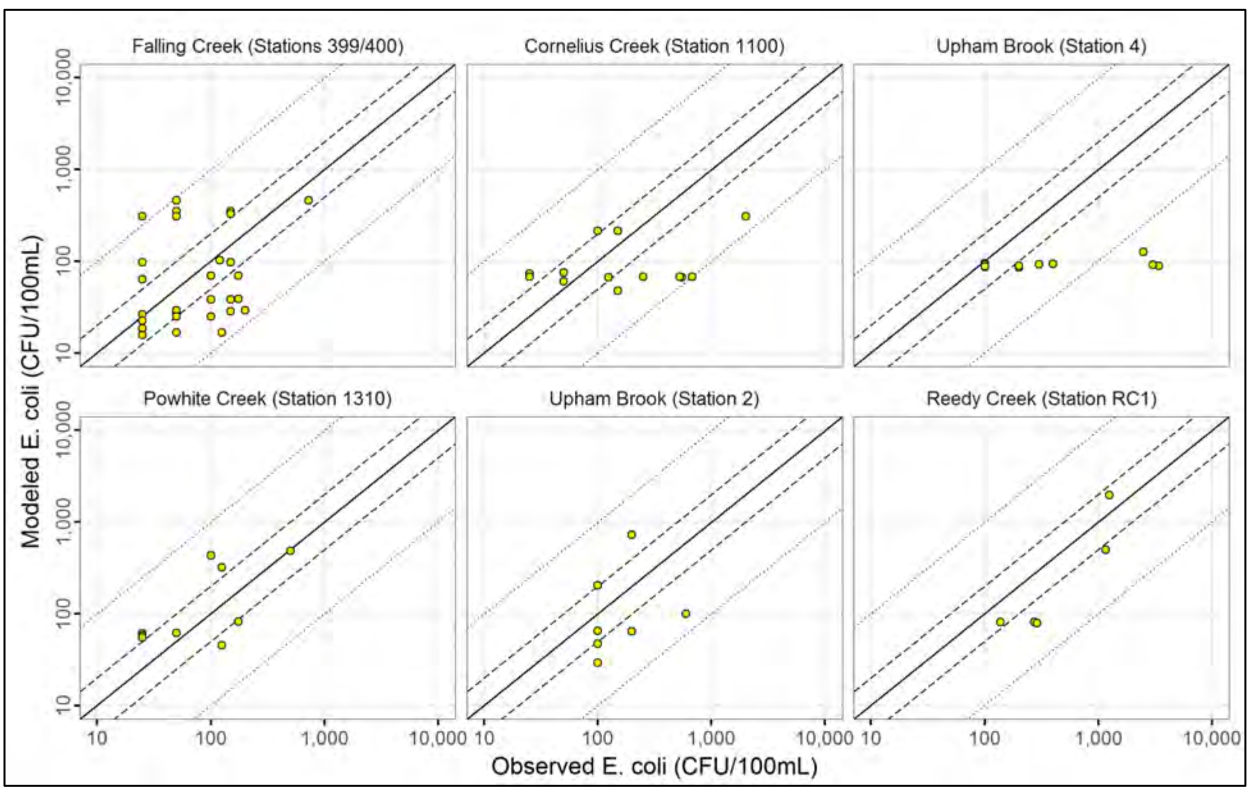


Figure 4-17: One-to-One Plots of Modeled vs Observed E.coli Concentrations in Select Richmond Tributaries

Calibration of the watershed model to better represent the *E.coli* concentrations was achieved by adjusting the values of four main parameters: pollutant build-up rate, pollutant wash-off rate, baseflow *E.coli* concentration, and in-stream decay rate. Pollutant build-up and wash-off had the greatest influence on wet weather in-stream concentrations, while baseflow *E.coli* concentration had the greatest influence on dry weather concentrations. Of the six stations evaluated, *E.coli* decay rate was found to have the greatest influence on Falling Creek, the largest tributary in the model extent. The impact of in-stream decay rate for the other five stations was nominal because travel times in these tributaries was generally shorter.

4.4.2 CSS Model

Explicit water quality calibration of the CSS model was not conducted. Rather, the CSO discharges were assigned bacteria concentrations based on monitoring results conducted for the development of the original LTCP. Additionally, the WWTP discharges were assigned bacteria concentrations based on the current bacteria water quality standards. Section 3.3 and 5.2 discusses the pollutant concentrations assigned to the various CSS outfalls and the WWTP discharge streams in more detail.

4.4.3 Receiving Water Quality Model

The primary objectives of the James River water quality model calibration were to: 1) evaluate the reasonableness of modeled *E.coli* loadings by source type and 2) evaluate the completeness of modeled *E.coli* sources. These objectives were achieved by evaluating consistency between modeled and observed *E.coli* concentrations and identifying and resolving any significant biases. The water quality model calibration is controlled in large part by estimates of *E.coli* concentrations from upstream of the study area and by estimates of *E.coli* loads from the watershed model and CSO model. Because of this, the water quality model calibration is a consistency check between the load estimates and sampling data in the James River.

The model was run for calendar years 2011 through 2013 and modeled *E.coli* concentrations were compared to observed concentrations at six stations. Figure 4-18 and Figure 4-19 illustrate the James River water quality model calibration. Median modeled *E.coli* concentrations are within 15% of median observed *E.coli* concentrations except at Station 641 where, as described in Section 4.1.3, the sampling data are anomalously high and not suitable for model calibration. Maximum modeled *E.coli* concentrations are all higher than observed *E.coli* concentrations. This is because model results are computed for every hour of the three year period, while samples were only taken occasionally, making it unlikely that the samples would capture the highest *E.coli* concentrations that actually occur in the river.

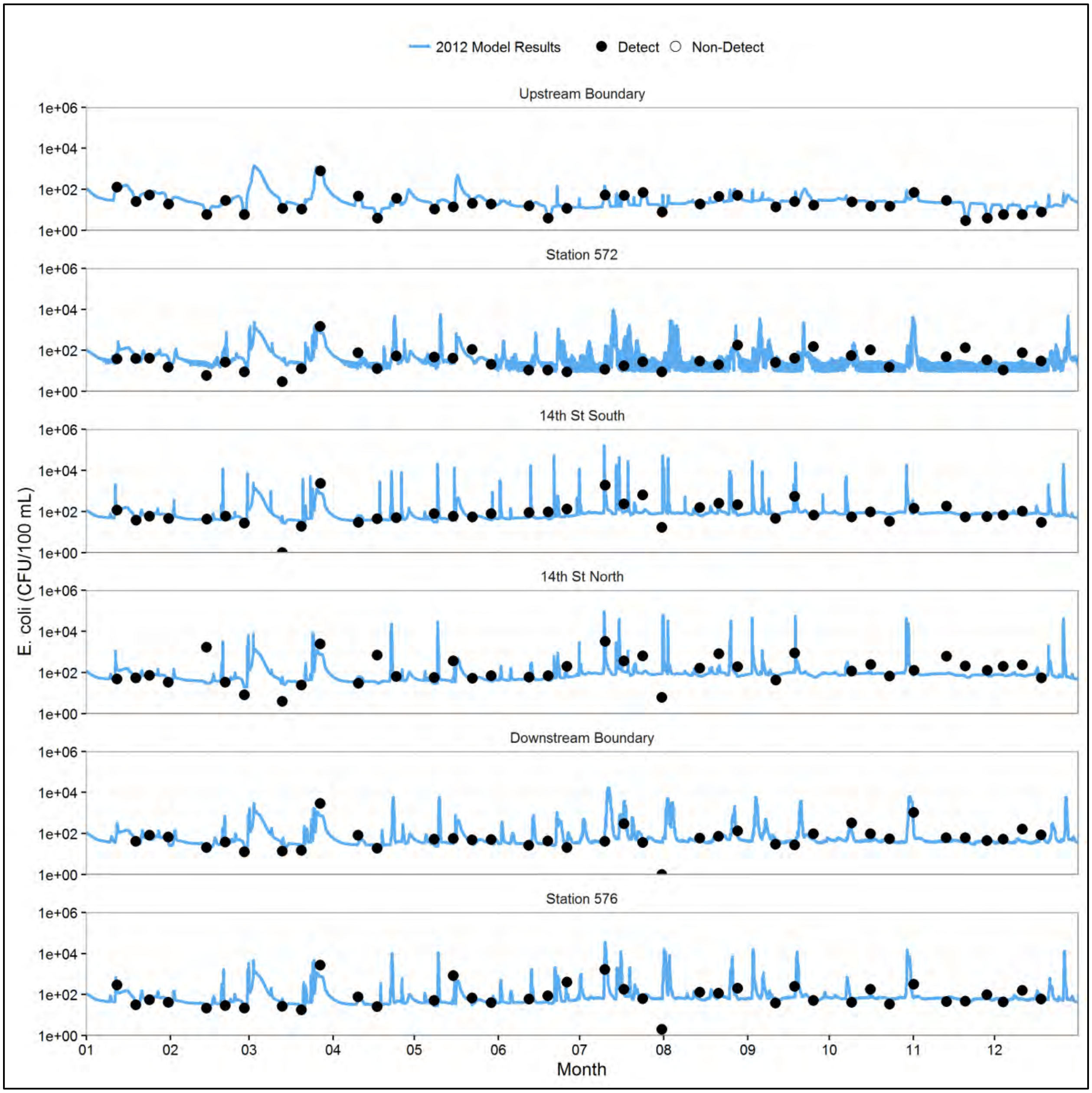


Figure 4-18: Time Series Comparison of Modeled and Observed *E.coli*

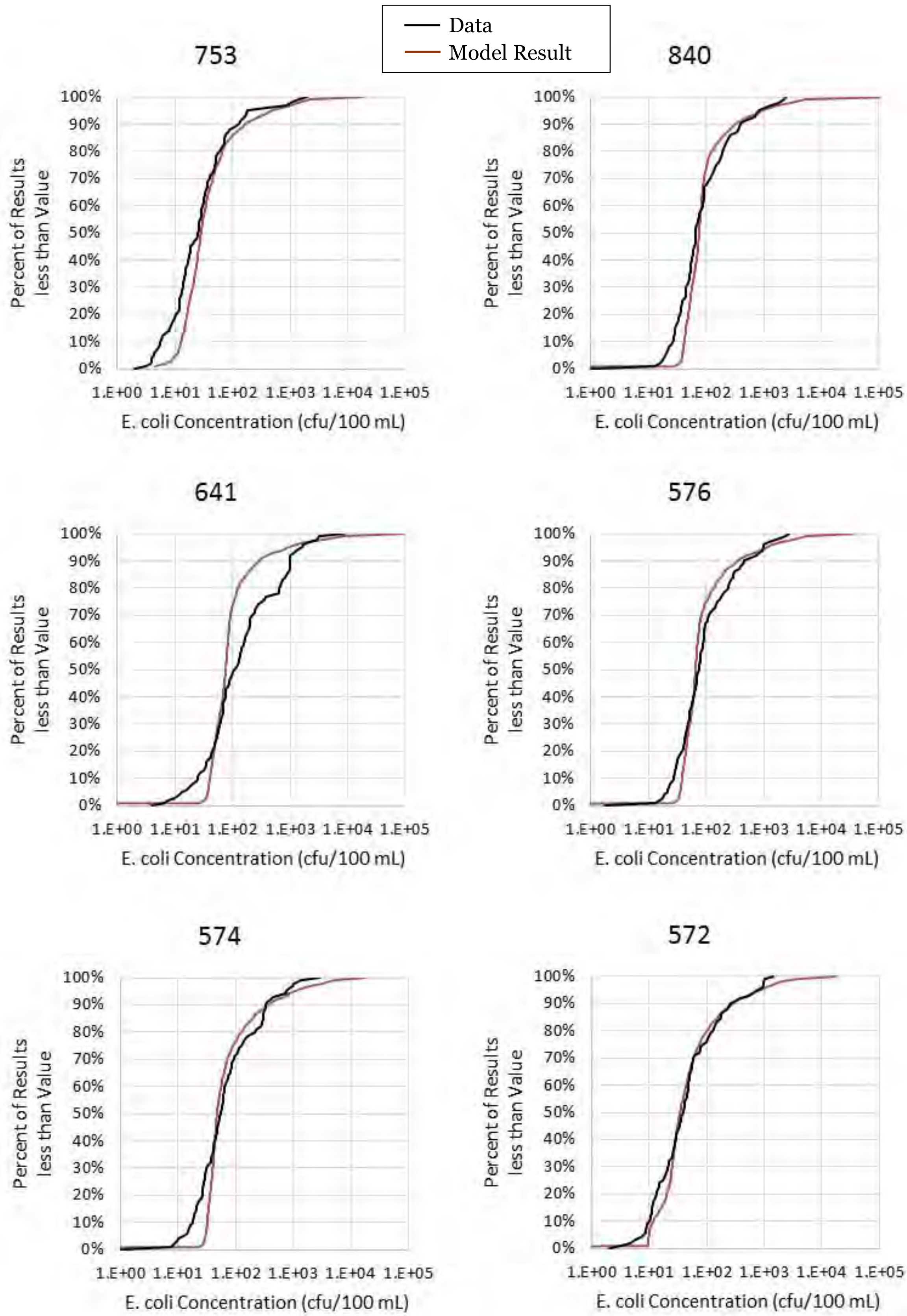


Figure 4-19: Cumulative Frequency Distribution Comparisons of Modeled and Observed *E.coli*

Calibration of the water quality model required the introduction of a significant unknown source between the Huguenot Bridge and the 14th Street Bridge (Figure 4-20). It is assumed that this source represents bacteria contributions from common background sources such as wildlife and failing septic systems. This source was introduced to the model at a constant rate of 3.2E+12 CFU/day just downstream of the Poney Pasture Park. This assumed loading rate is of the same order of magnitude as the loading rate estimated for failing septic systems and wildlife in the James River Richmond Bacteria TMDL (MapTech, 2010). Increases to instream *E.coli* concentrations due to the background source are generally between 30 and 40 CFU/100 mL. The decision to input this load near the park is not meant to indicate that the source(s) necessarily originates there. Additional sampling data would be required to identify the spatial distribution of this source(s) between the Huguenot Bridge and the 14th Street Bridge.

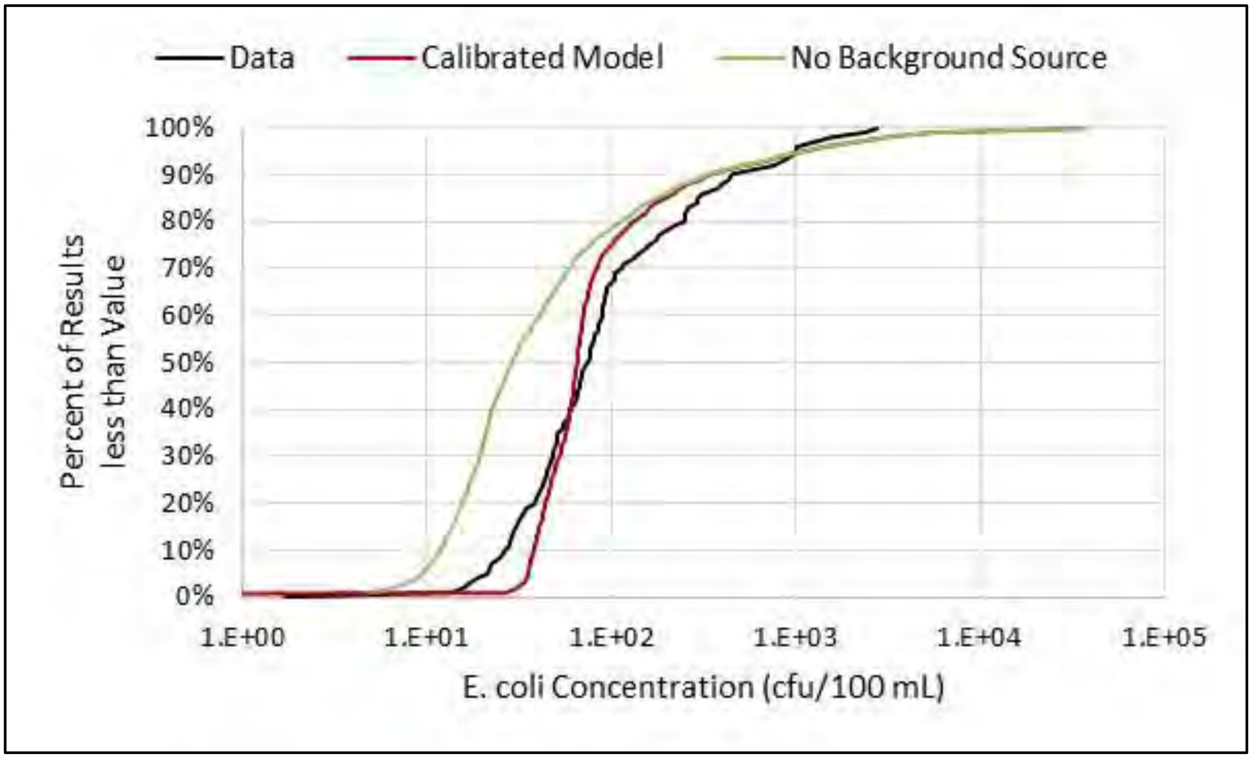


Figure 4-20: Sensitivity of Model Calibration to the Background Source

Figure 4-21 and Figure 4-22 illustrate sensitivity of the model results to adjustments of all major *E.coli* loading assumptions. In each plot, the source type of interest was reduced by 50% to evaluate its influence on modeled *E.coli* concentrations. Model results at the downstream city limit are shown. In these figures, the green dashed line represents the difference between the calibrated model result and the source reduction sensitivity test result. Reductions in persistent sources such as the James River upstream of Richmond and the background source always have some influence on *E.coli* concentrations. However, wet weather sources only reduce *E.coli* concentrations when precipitation has occurred. As a result, CSOs, for instance, only reduce concentrations thirty-five percent of the time (i.e. for the 65th to 100th percentile on the plots).

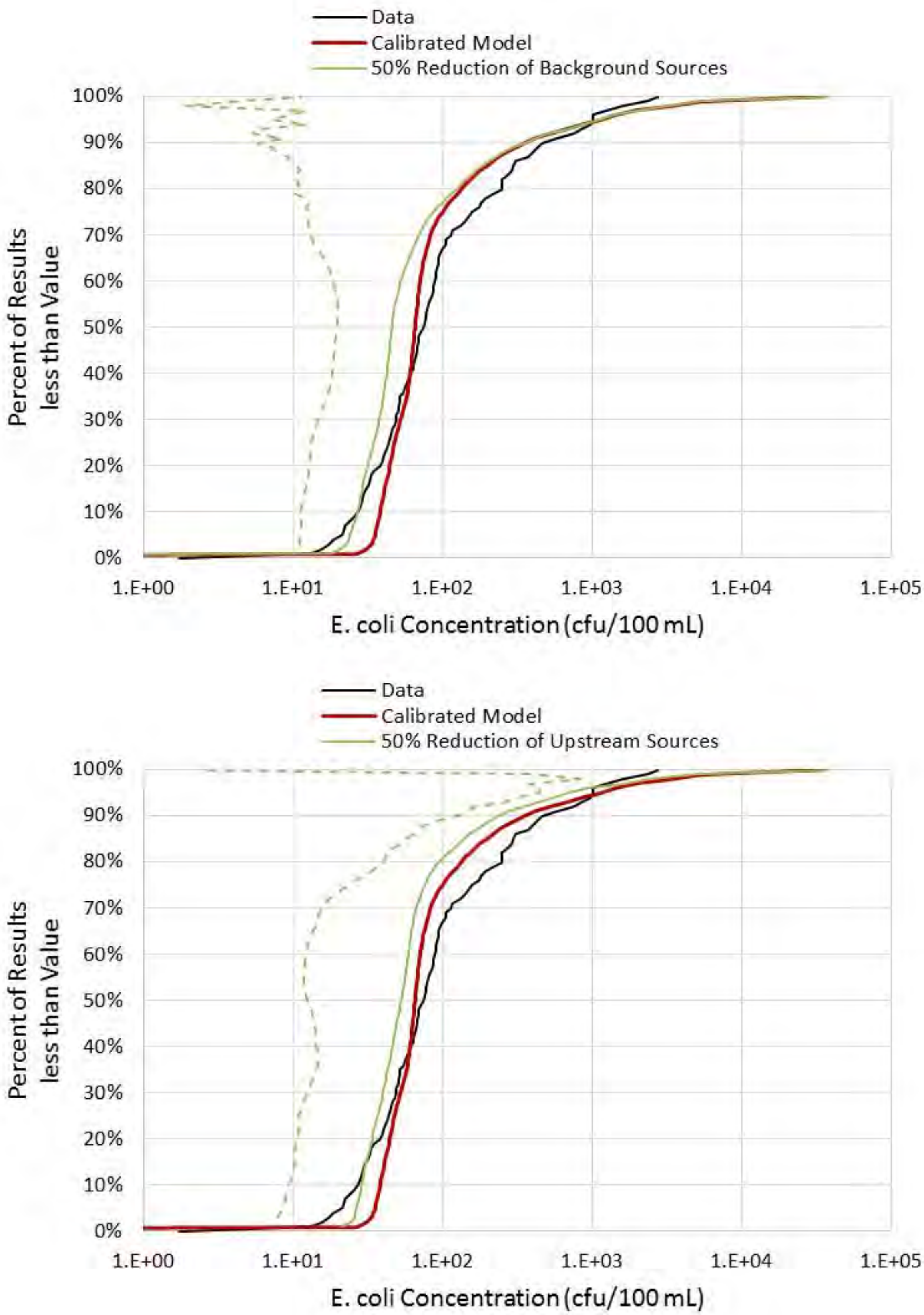
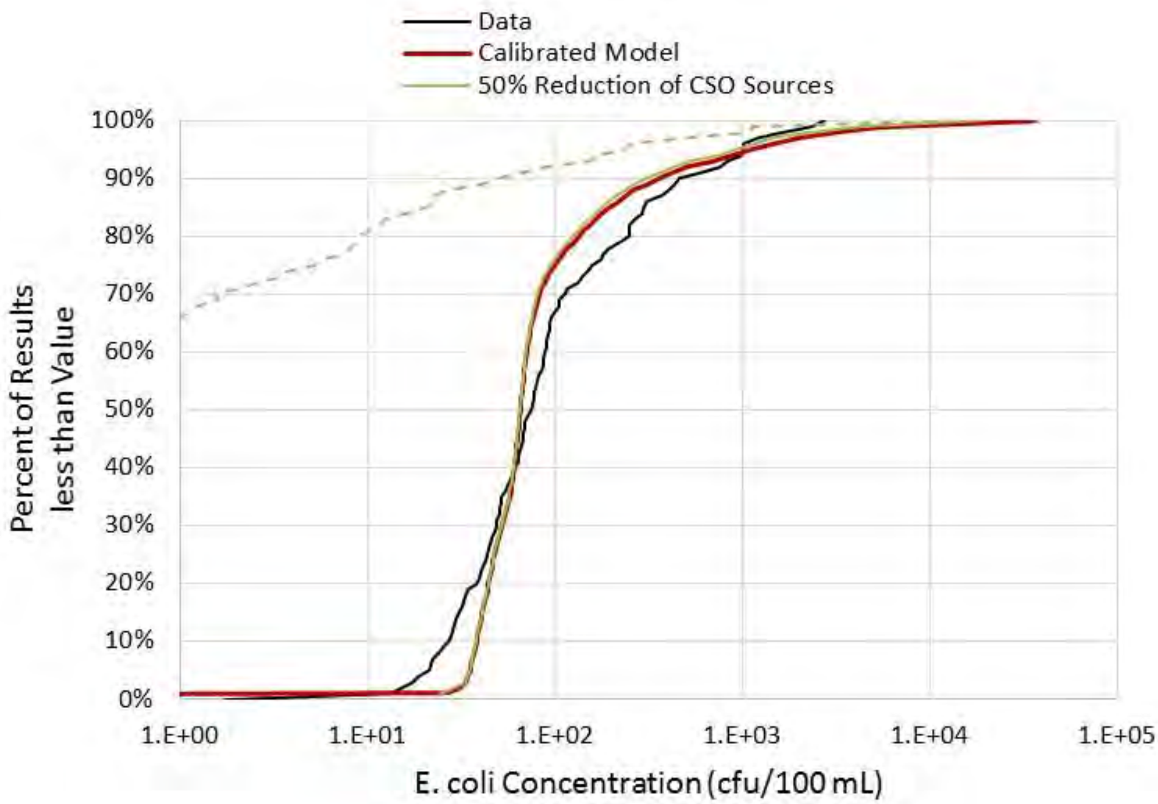


Figure 4-21: Sensitivity of Model Results to 50% Reduction of Persistent Sources



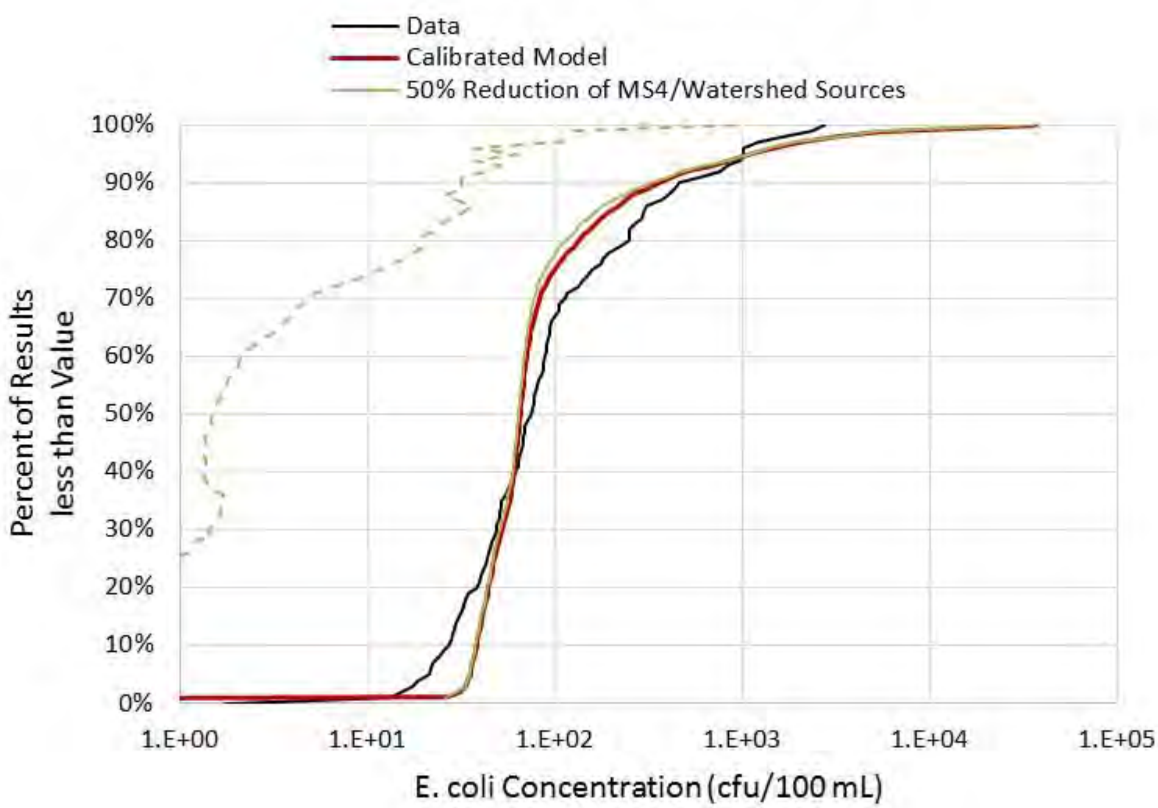


Figure 4-22: Sensitivity of Model Results to 50% Reduction of Wet Weather Sources

5 Model Application and Results

5.1 Overview

To date, the model has been applied to evaluate the following:

- Current conditions: Best representation of current conditions, and includes all the Phase I and Phase II CSO improvements from the LTCP.
- Baseline Conditions: represents the current condition, plus all the currently funded Phase III collection system improvement projects from the LTCP.
- Green Infrastructure in the MS4 Area Strategy: represents the baseline conditions, plus the implementation of 104 acres of green infrastructure on city-owned area in the MS4.
- Green Infrastructure in CSO Area Strategy: represents the baseline conditions, plus the implementation of 18 acres of green infrastructure on city-owned area in the CSS area.
- CSS Infrastructure Improvements Strategy: represents the baseline conditions, plus all the remaining unfunded Phase III collection system improvement projects from the LTCP.

The sequencing of the modeling applications is shown in the figure below.

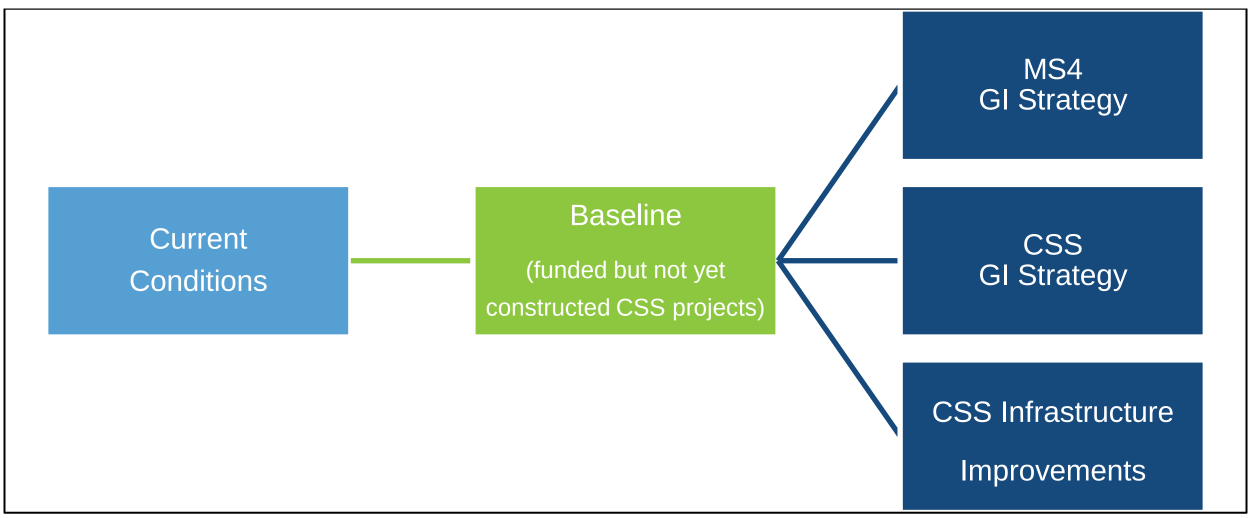


Figure 5-1: Sequencing of Model Applications

These conditions and strategies were evaluated using several metrics related to bacteria reduction, including:

- Bacteria load reduction from combined sewer and tributary discharges, expressed as Billion CFU
- Overall average percent improvement in monthly geomean water quality standard compliance at the downstream city limit
- Reduction in number of CSO events

- Reduction in CSO volume (Million gallons)

These four metrics are used in the Strategy Calculator, a spreadsheet tool that is used to evaluate and score the different management strategies across a wide range of goals and objectives (LimnoTech, 2017).

The model is further used to evaluate water quality benefits relative to the monthly geometric mean standard and the statistical threshold value (STV) standard, on a monthly basis. The geometric mean standard states that the monthly geometric mean *E.coli* concentration must fall below 126 cfu/100 mL to be in compliance. The VDEQ statistical threshold value standard states that no more than 10% of *E.coli* concentrations in a month may exceed 235 cfu/100 mL to be in compliance.

5.2 Methodology for Model Application and for Evaluating Model Results

The three-year period of 2011 through 2013 was selected as the application period because it represents a continuous time period that includes typical wet, dry, and average precipitation conditions, with corresponding responses in James River flow conditions. This is shown in Figure 5-2.

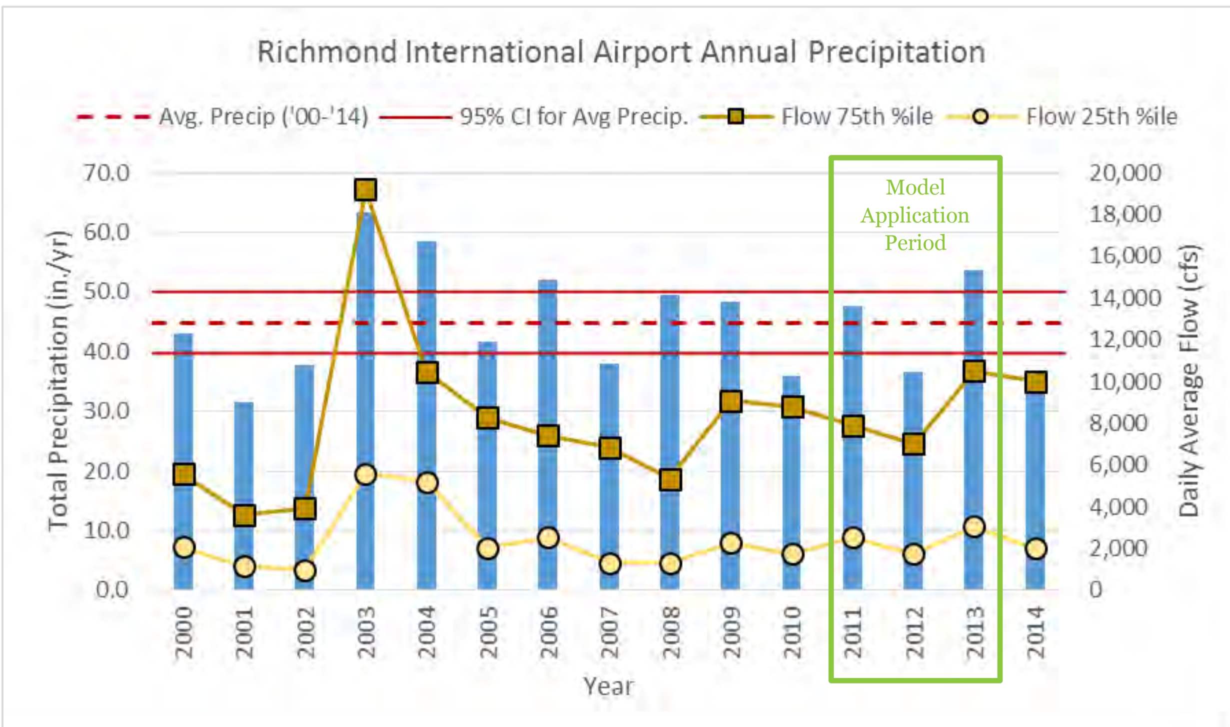


Figure 5-2: Precipitation and Daily Average Flow at Richmond International Airport

The following process was followed when applying the water quality model components to evaluate the various strategies:

1. Simulate any improvements to the combined sewer system or treatment plan with the CSS model;
2. Relay model results from potential CSS improvements in the Gillies or Almond Creek tributaries to the watershed model;
3. Simulate any MS4 strategies or CSS improvements in the Gillies or Almond Creek improvements with the watershed model;

4. Simulate the impact of improvements in the James River by relaying CSS model results (i.e. time series of overflow discharge and bacteria load) and watershed model results (i.e. time series of tributary flows and bacteria loads) to the James River Receiving Water Quality Model.
5. Summarize the results of the model runs using the metrics described in the previous section.

After running the water quality modeling framework through the process described above, water quality compliance was evaluated at the downstream boundary of the city, Richmond's National Pollutant Discharge Elimination System (NPDES) compliance point. *E.coli* concentrations at this point were compared to the monthly geometric mean of 126 CFU/100 mL and the STV of <10% of all samples exceeding 235 CFU/100mL. For each month that violated the water quality standard, a detailed component analysis was completed. The component analysis tracks the relative contribution of each *E.coli* source (upstream, CSOs, watershed/MS4, background, and WWTP) to the modeled concentration in the James River. This type of analysis is useful to evaluate which sources of bacteria have the greatest impact on water quality conditions in the James River for a given point in time or location in the river.

Additionally, model results were summarized to determine the overall bacteria load reduction, CSO volume reduction, reduction in number of CSO overflow events, and to evaluate the percent improvement towards monthly geomean water quality standard compliance at the downstream city limit. The "percent improvement towards monthly geometric mean compliance", also dubbed "percent improvement" for convenience, ranges from 0% to 100%, with 0% corresponding to the existing state of compliance and 100% corresponding to full compliance with the monthly geomean water quality standard. The "percent improvement" is computed as follows:

$$I_p = \frac{\sum_1^n V_{n,scenario} - \sum_1^n V_{n,current}}{\sum_1^n V_{n,current}}$$

Where:

- "I_p" is Percent Improvement,
- "V" is the compliance metric value for a given month, (e.g. the geometric mean value for December 2011),
- "n" is an index for the month, and
- the subscripts "scenario" and "current" correspond to a scenario of interest and the current condition, respectively.

Graphically, each summation term in this equation is the total bar height above the water quality standard as shown in Figure 5-3. If, under a particular scenario, the total bar height above the standard is small compared to the current conditions, then the "percent improvement" will be nearly 100% and the system will be near full compliance. If the total bar height under a particular scenario is similar to that of the current condition, then the "percent improvement" will be nearly 0%.

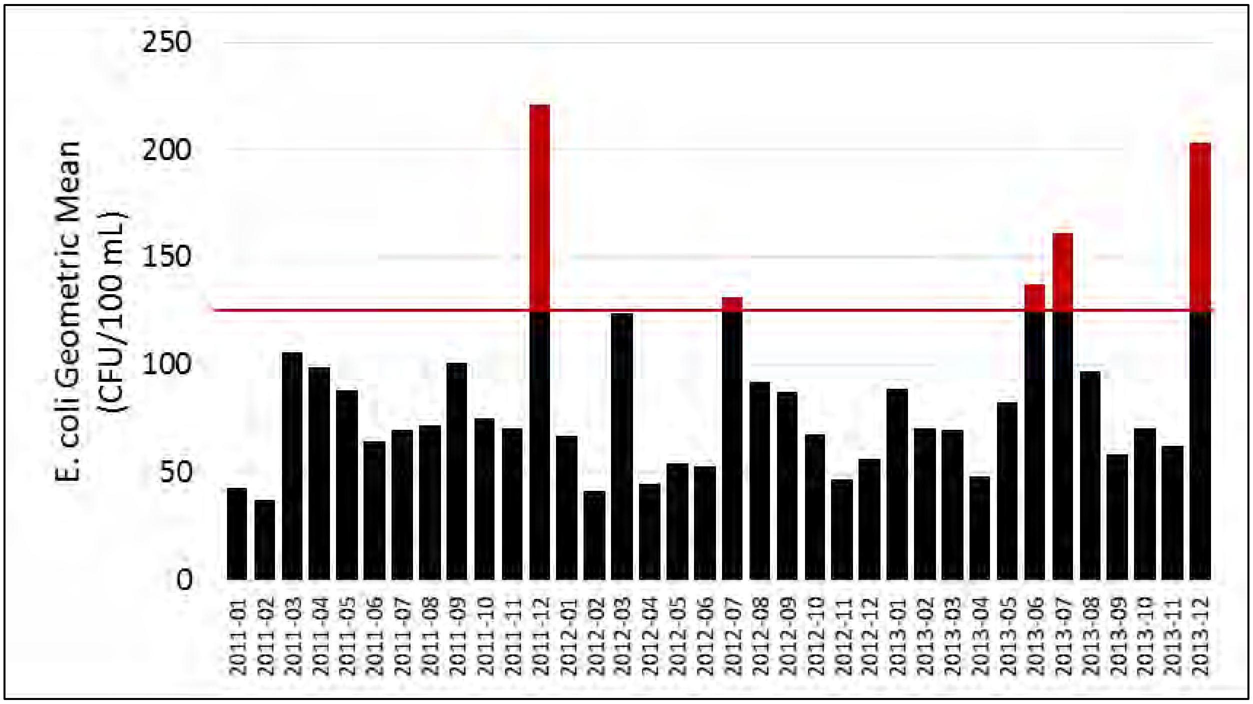


Figure 5-3: Graphical Depiction of the "Percent Improvement" Metric

5.3 Overview of Model Scenarios

Each strategy that was evaluated by the water quality model required unique changes to the model inputs, as further described in the sections below.

5.3.1 Current Conditions

Because the model calibration period and model application period are the same, no further changes were implemented to assess the current conditions.

5.3.2 Baseline Conditions

The baseline conditions represents the current conditions plus the addition of all the currently funded Phase III collection system improvement projects from the LTCP. These projects include the sewer separation of CSO 028A and CSO 028E, replacement of the CSO 04 regulator, and increasing the wet weather treatment capacity of the treatment plant to 140 MGD. These three projects were modeled in the CSS model, and results were passed down to the watershed model and the receiving water quality model. Because these projects are already funded and included in the City's planning documents, this condition was considered to be the baseline condition against which other additional strategies would be compared for the purpose of evaluating the metrics used in the Strategy Calculator.

Additional discussion of the projects included in the baseline conditions is presented in Section 5.3.5

5.3.3 Green Infrastructure in the MS4 Area Strategy

The "green infrastructure in the MS4 area" strategy proposed to implement green infrastructure to treat 104 acres of impervious area owned by the Department of Public Utilities (DPU) or Department of Parks & Recreation (DPR), in addition to all the currently funded phase III collection system improvement projects included in the baseline conditions. The acreage of green infrastructure was determined by identifying the total area of land that is owned by either DPU or DPR, using ArcGIS. Additional information such as topography and soil type was then superimposed over the DPU and DPR properties. Through this visual analysis, it was determined that roughly 50% of the DPU/DPR land would likely not be conducive to the implementation of green infrastructure without significant engineered modifications such as land leveling or soil amendments. Therefore the total available land for this strategy was reduced by half. The remaining area was summarized by subwatershed so that it could be simulated in the watershed model.

All area available for green infrastructure implementation within a subwatershed was modeled as one representative green infrastructure practice since the specific types of green infrastructure are unknown at this planning stage. The generic practices were modeled using SWMM storage nodes with an assumed effective depth of 1.5 feet and sized in area to capture a 1.2 inch storm (90th percentile storm on an average annual basis). The modeled generic green infrastructure practices account for evaporation and bottom infiltration into the native soil. It was assumed that all green infrastructure is being drained within 48 hours to provide storage volume for back-to-back rainfall events. This was simulated by using an appropriately sized orifice to simulate practice underdrains. Potential flows exceeding the green-infrastructure capacity in the model were handled by a weir simulating practice overflow or flow rejection. Water quality routines were applied to the water volumes stored in the practices.

5.3.4 Green Infrastructure in the CSS Area Strategy

The "green infrastructure in the CSS area" strategy proposed to implement green infrastructure to treat 18 acres of impervious area owned by the Department of Public Utilities (DPU) or Department of Parks & Recreation, in addition to all the currently funded phase III collection system improvement projects included in the baseline conditions. The acreage of green infrastructure included in this strategy was determined through the same process as described in the previous section. Additionally, green infrastructure in the CSS model was simulated in the same way as is done in the MS4 area, as described in the previous section.

5.3.5 CSS Infrastructure Improvements Strategy

The "*CSS Infrastructure Improvements*" strategy[2] includes ten projects that are included in the Phase III collection system upgrades described in the LTCP (Greeley and Hansen, 2002):

1. CSO 14 regulator upgrade
2. CSO 028A & 028E sewer separation
3. CSO 04 & CSO 05 regulator replacement
4. Lower Gillies sewer conveyance
5. WWTP wet weather treatment to 140 MGD
6. WWTP wet weather treatment to 300 MGD
7. CSO 21 replacement
8. CSO 21 additional 2 MG storage
9. Shockoe Retention Basin (SRB) expansion
10. SRB disinfection

[2] Alternative LTCP projects are currently being evaluated by Brown and Caldwell but results are not yet available to be included as of March 2017.

Of those ten projects, #1-#3 and #5 are included in the Baseline Conditions, since these projects are currently funded by the City of Richmond. Implementation of all ten projects represents the obligations under the LTCP, and is commonly referred to as the "*full LTCP*" scenario.

The unfunded projects were modeled in isolation to determine individual impact on CSO volume discharge, bacteria load reduction, and impact on the receiving water quality. These CSS "scenarios" are summarized in Table 5-1 and Table 5-2.

Table 5-1: Description of CSS Projects Evaluated by the Water Quality Model

CSS Scenario	CSS Project Name	CSS Project Description
Current	Current Conditions	Current sewer conditions, including all LTCP Phase I and Phase II projects.
14-3	Baseline Conditions	Includes the currently funded projects: -- CSO 04, 014, and 05 regulator upgrades -- CSO 028A & 028E disconnection -- WWTP wet weather treatment up to 140 MGD
14-2	Gillies Conveyance	Lower Gillies Wet Weather Conveyance Interceptor to convey more flow to the WWTP
15-4	300 MGD Wet Weather Treatment	WWTP wet weather treatment up to 300 MGD
15-5	CSO 21 Replacement	Replacement of the CSO 21 regulator and additional 2MG storage
18-4	SRB Expansion	Shockoe retention basin (SRB) expansion to 15MG
18-5	SRB Expansion and Disinfection	SRB Expansion to 15MG and chlorine disinfection of the SRB discharge at CSO 06
19-3A	Full LTCP	All 10 Phase III projects, Full Long-term Control Plan (LTCP) achieved.

Table 5-2: CSS Water Quality Model Matrix

CSS Project	CSS Scenario						
	Baseline (14-3)	**14-2**	**15-4**	**15-5**	**18-4**	**18-5**	**Full LTCP (19-3A)**
CSO 14 regulator upgrade	X	X	X	X	X	X	X
CSO 028A & 028E separation	X	X	X	X	X	X	X
CSO 04 & CSO 05 replacement	X	X	X	X	X	X	X
Lower Gillies Conveyance		X					X
WWTP wet weather treatment to 140 MGD	X	X		X	X	X	
WWTP wet weather treatment to 300 MGD			X				X
CSO 21 replacement and additional 2MG storage				X			X
SRB expansion					X	X	X
SRB disinfection						X	X

In addition to making changes to the CSS model elements and configuration to represent the individual CSS improvements, the E.coli concentrations associated with the WWTP were also modified depending on the CSS project. Under current conditions, the WWTP treats inflows up to 75 MGD, with no supplemental treatment during wet weather flows. Several CSS scenarios simulate wet weather treatment up to 140 MGD, and yet others simulate wet weather treatment up to 300 MGD. The WWTP treatment scheme for each scenario is summarized in Table 5-3.

Table 5-3: WWTP Treatment for Each CSS Scenario				
CSS Scenario	**Full Treatment (MGD)**	**Primary Treatment (MGD)**	**Preliminary Treatment (MGD)**	**Total Treatment (MGD)**
Current	75	--	--	75
14-3	75	65	--	140
14-2	75	65	--	140
15-4	85	55	160	300
15-5	75	65	--	140
18-4	85	55	--	140
18-5	85	55	160	140
19-3A	85	55	160	300

E.coli concentrations associated with each treatment pathway were estimated based on previous modeling, and a flow-weighted average *E.coli* concentration was calculated to estimate the total *E.coli* contribution from the WWTP. All influent to the WWTP was assumed to have an *E.coli* concentration of 235,000 CFU/100mL. It was assumed that influent receiving full treatment would result in an effluent concentration of 126 CFU/100 mL, consistent with the effluent concentration guidelines in the VAPDES permit (#VA0063177). Effluent concentrations from primary and preliminary treatment facilities were calculated according to the following formula:

$$Effluent\ E.coli\ concentration = \frac{influent\ concentration}{reduction\ factor}$$

The effluent reduction factors for primary and preliminary treatment were calculated using formulas that were developed as part of ongoing modeling efforts by Greeley and Hansen (Greeley and Hansen, personal communication, 11/15/2016).). The primary treatment reduction factor is governed by the following equation:

$$Log\ reduction\ factor = 0.76 * \ 10^{2.57904-1.2563*\log(Q)}$$

Where: Q is the inflow in MGD

The preliminary treatment reduction is governed by the following equation:

$$Log\ reduction\ factor = 0.76 * \ 10^{2.77053-1.2563*\log(Q)}$$

Where: Q is the inflow in MGD

For both treatment pathways, the reduction factor is large when flows are small due to increased contact time with the UV disinfection system. Therefore, a treatment floor of 126 cfu/100 mL was set because it was assumed that the treatment capacity of the primary and preliminary pathways could not exceed full treatment.

Post-processing was also required to simulate disinfection at SRB. All influent to SRB was assumed to have an *E.coli* concentration of 111,000 CFU/100 mL, consistent with *E.coli* EMC for CSO 06. The effluent reduction factor for SRB was calculated using a formula that was developed as part of ongoing modeling efforts by Greeley and Hansen (Greeley and Hansen, personal communication, 11/15/2016.)

$$Log\ reduction\ factor = 11.8102 - 3.1211 * \log(Q)$$

Where: Q is the flow rate in MGD

Similar to the WWTP alternative treatment pathways, the SRB reduction factor is large when flows are small due to increased contact time with the chlorine disinfection system. Therefore, a treatment floor of 126 cfu/100 mL was set because it was assumed that the SRB treatment capacity could not exceed full treatment at the WWTP.

5.4 Results

The James River water quality model was configured to compute *E.coli* concentrations at an hourly interval for the three year typical period. These results were compared against the monthly water quality standards and summarized at key locations of interest along the river. Additionally, results were also summarized to show the overall bacteria load reduction, CSO volume reduction, and reduction in number of CSO events.

5.4.1 Current Conditions

Figure 5-4 show the modeled monthly geomean concentrations and the percent exceedance of the STV standards at the downstream boundary of the city. For each month that violated the water quality standard, a detailed component analysis was completed. The component analysis tracks the relative contribution of each *E.coli* source (upstream, CSOs, watershed/MS4, background, and WWTP) to the modeled concentration in the James River. This type of analysis is useful to evaluate which sources of bacteria have the greatest impact on water quality conditions in the James River for a given point in time or location in the river.

Under current conditions, the geometric mean water quality standard is violated at the downstream city limit (the compliance evaluation point) for 4 months of the 36 month typical period. Significant contributors to non-compliance are upstream sources, the background sources, and CSOs. Non-compliance tends to occur when James River flows and upstream James River concentrations are high or when James River flows are low and significant precipitation events cause combined sewer discharges.

The statistical threshold value standard is more frequently violated, with 16 of 36 months exceeding the standard at the downstream City limit. Significant contributors to non-compliance of the STV standards are mainly CSOs and upstream sources, and to a lesser extent, the MS4/Watershed source. The CSOs are a more frequent and greater contributor to water quality violations using the STV standard than using the monthly geometric mean standard.

These results illustrate that:

- The James River is in violation of both the geometric mean and the statistical threshold value water quality standards for some months out of the three year simulation period.
- The primary cause of a water quality standard violation can sometimes be linked to Richmond combined sewer overflows, while at other times it is due to upstream sources. Background and MS4/Watershed sources play a smaller overall role in the bacteria water quality violations. The WWTP does not contribute significantly to bacteria water quality violations.

Figure 5-5 illustrates the E.coli monthly geometric mean in the James River, from a few miles upstream of the city limits to a few miles past the downstream city limits. During some months, for example in April 2012 (orange line), the James River is compliant upstream of the city and local *E.coli* sources are small enough that the James River is also compliant downstream of the city. During other months, like in June of 2013 (blue line), the James River is compliant upstream of the city but because of the contributions from background, watershed, and CSO sources, the James River exceeds the water quality standards at the downstream city limit. Finally during some months, like December 2011 (dark green line), the river is non-compliant with the water quality standards upstream of the city and remains non-compliant downstream of the city.

Table 5-4 shows the E.coli load, CSO volume, and number of CSO events under the existing conditions.

Table 5-4: Existing Condition: E.coli Load, CSO Volume, and Number CSO Events

Metric	Value
Average yearly E.coli load (billion cfu)	9,651,987
Average annual number of CSO events	53
Average yearly CSO volume discharged (million gallons)	1,670

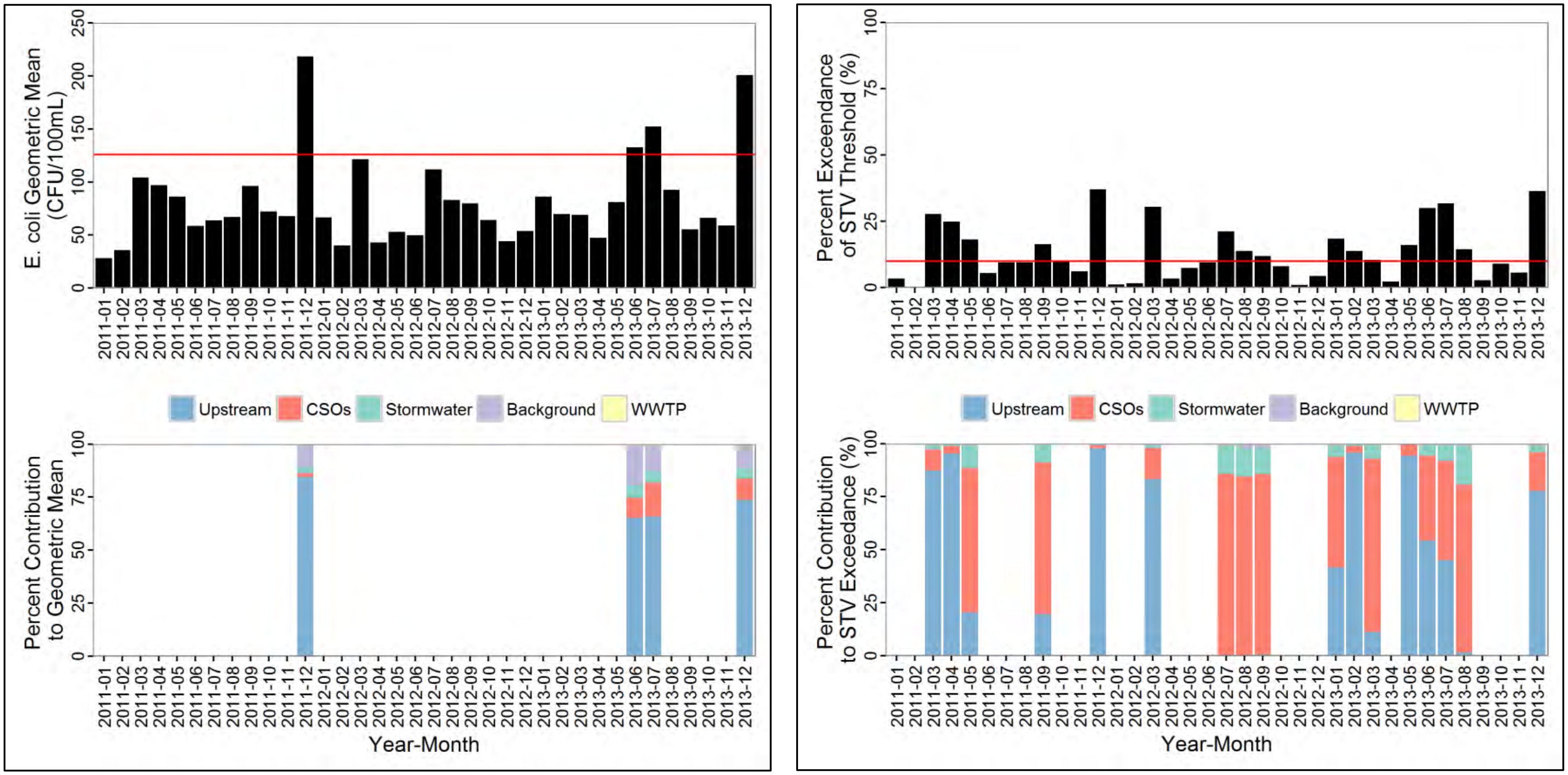


Figure 5-4: Existing Condition: Monthly Geometric Mean and STV Standard Model Results

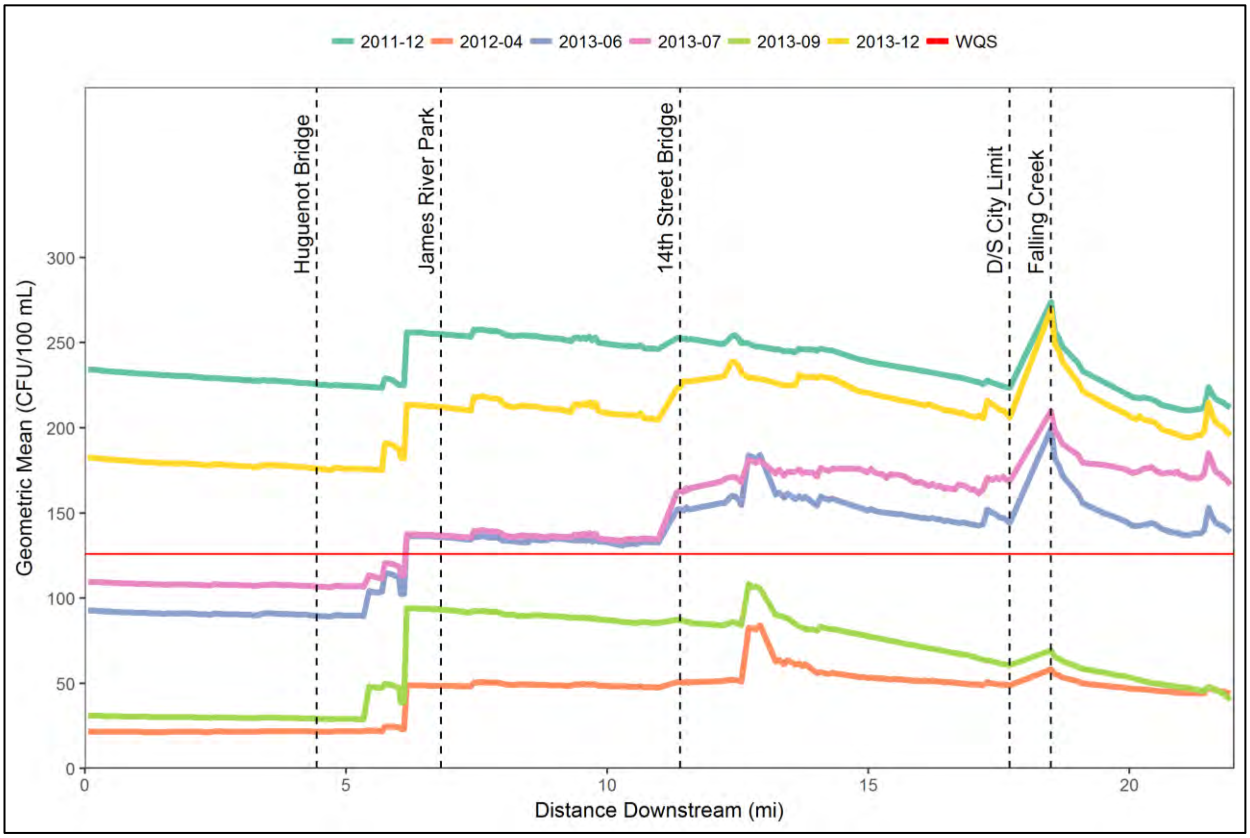


Figure 5-5: Lateral and temporal variability in E.coli concentration in the James River

5.4.2 Baseline Conditions

Figure 5-6 shows the modeled monthly geomean concentrations and the percent exceedance of the STV standards at the downstream boundary of the city for the baseline condition. For each month that violated the water quality standard, a detailed component analysis was completed. Similar to current conditions, under baseline conditions, the geometric mean water quality standard is violated at the downstream city limit (the compliance evaluation point) for 4 months of the 36 month typical period. Significant contributors to non-compliance are upstream sources, the "background" or "unknown" source, and CSOs. Non-compliance tends to occur when James River flows and upstream James River concentrations are high or when James River flows are low and significant precipitation events cause combined sewer discharges.

The statistical threshold value standard is more frequently violated, with 16 of 36 months exceeding the standard at the downstream City limit. Significant contributors to non-compliance of the STV standards are mainly CSOs and upstream sources, and to a lesser extent, the MS4/Watershed source. Though the baseline projects significantly reduce CSOs, these projects alone are not sufficient to bring the James River into compliance with water quality standards.

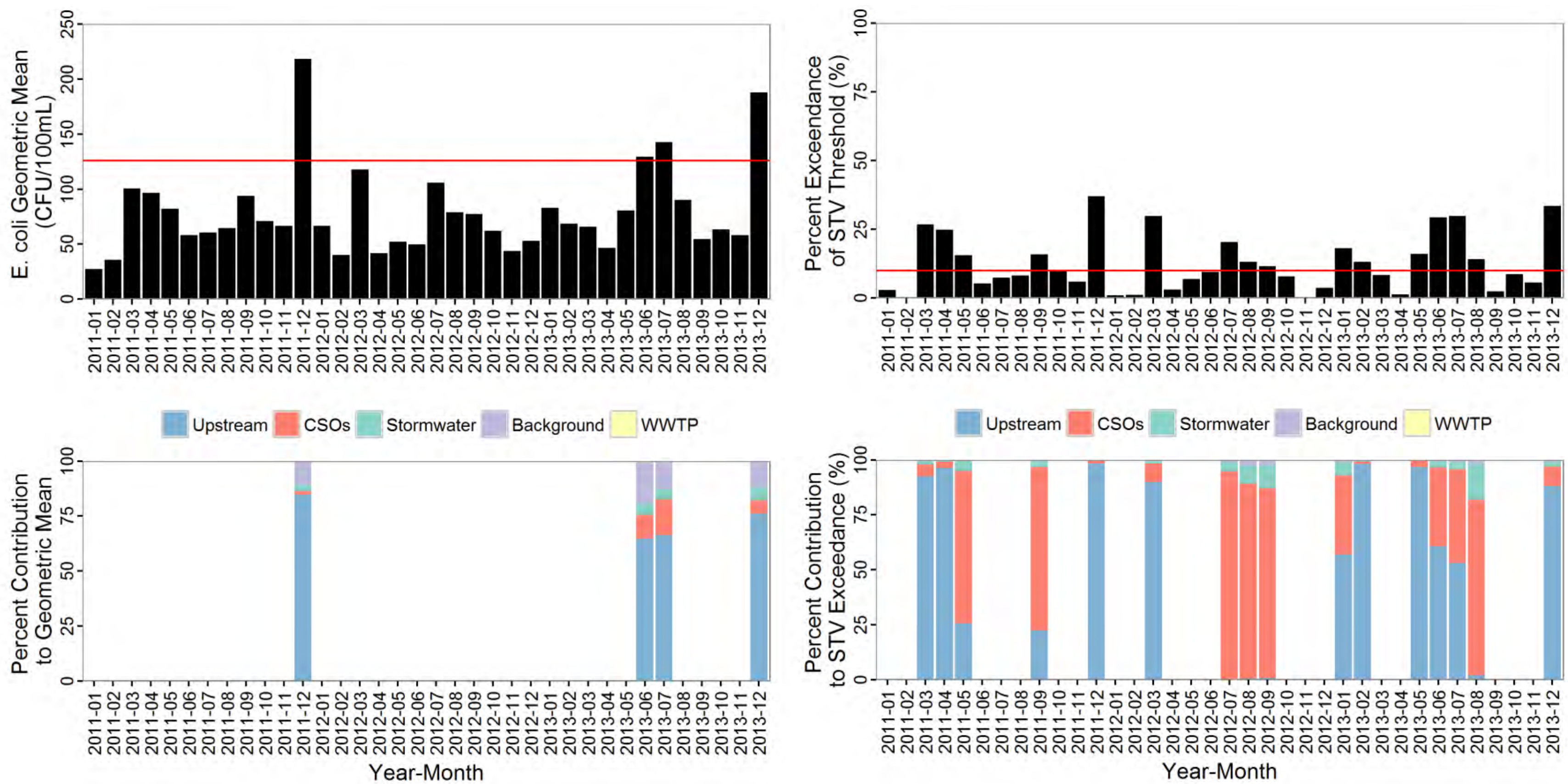


Figure 5-6: Baseline Condition: Monthly Geometric Mean and STV Standard Model Results

Table 5-5 shows the E.coli load, CSO volume, and number of CSO events under the existing conditions. The baseline conditions represent the improvements due to the implementation of several CSO improvement projects. Compared to the existing conditions, these projects collectively reduce the E.coli loads by approximately 18%, reduce the number of overflows by 2 events, and reduce the yearly CSO volume discharged by approximately 29%.

Table 5-5: Baseline Condition: E.coli Load, CSO Volume, and Number CSO Events	
Metric	**Value**
Average yearly E.coli load (billion cfu)	7,958,183
Average annual number of CSO events	51
Average yearly CSO volume discharged (million gallons)	1,190
Percent improvement compared to current conditions (%)	12.8

5.4.3 Green Infrastructure in the MS4 Area Strategy

The "*green infrastructure in the MS4 area*" strategy proposed to implement green infrastructure to treat 104 acres of impervious area owned by the Department of Public Utilities (DPU) or Department of Parks & Recreation, in addition to all the currently funded phase III collection system improvement projects included in the baseline conditions. Table 5-6 shows the E.coli load, CSO volume, and number of CSO events under the "Green Infrastructure in the MS4 Area" strategy. This strategy reduces the E.coli load entering the James River only slightly compared to the baseline conditions (<0.6% reduction). This strategy only targets Richmond's MS4 area, so the number of CSO events and the yearly CSO volume are not affected compared to the baseline scenario.

Table 5-6: Green Infrastructure in MS4 Strategy: E.coli Load, CSO Volume, and Number CSO Events	
Metric	**Value**
Average yearly E.coli load (billion cfu)	7,954,132
Average annual number of CSO events	51
Average yearly CSO volume discharged (million gallons)	1,190
Percent improvement compared to current conditions (%)	13.0

5.4.4 Green Infrastructure in the CSS Area Strategy

The *"green infrastructure in the CSS area*" strategy proposed to implement green infrastructure to treat 18 acres of impervious area owned by the Department of Public Utilities (DPU) or Department of Parks & Recreation, in addition to all the currently funded phase III collection system improvement projects included in the baseline conditions. Table 5-7 shows the E.coli load, CSO volume, and number of CSO events under the "Green Infrastructure in the CSS Area" strategy. This strategy reduces the E.coli load entering the James River only slightly compared to the baseline conditions (<0.6% reduction). This strategy specifically targets the CSS area. The area of GI implementation (18 acres) is not significant enough to reduce the number of CSO events, but it does reduce the annual CSO volume discharged slightly compared to the baseline scenario.

Table 5-7: Green Infrastructure in CSS Strategy: E.coli Load, CSO Volume, and Number CSO Events	
Metric	**Value**
Average yearly E.coli load (billion cfu)	7,905,833
Average annual number of CSO events	51
Average yearly CSO volume discharged (million gallons)	1,180
Percent improvement compared to current conditions (%)	12.9

5.4.5 CSS Infrastructure Improvement Strategy

Table 5-6 shows the E.coli load, CSO volume, and number of CSO events under the "CSS Infrastructure Improvement" strategy. This strategy includes numerous projects intended to reduce the number of CSO events and CSO volume discharged.

Table 5-8: CSS Infrastructure Improvement Strategy: E.coli Load, CSO Volume, and Number CSO Events			
Metric	**Value**	**Reduction Compared to Baseline Conditions**	**Reduction Compared to Existing Conditions**
Average yearly E.coli load (billion cfu)	4,407,072	45%	54%
Average annual number of CSO events	50	2%	5%
Average yearly CSO volume discharged (million gallons)	228	81%	86%
Percent improvement compared to current conditions (%)	21.3%	-	-

Figure 5-7 illustrates water quality compliance at the downstream City limit for the CSS Infrastructure Improvement strategy. Under this strategy, the geometric mean water quality standard is violated at the downstream city limit (the compliance evaluation point) for 3 months of the 36 month typical period. Non-compliance occurs because the upstream sources contribute significant flow and high bacteria loads.

The statistical threshold value standard is more frequently violated, with 16 of 36 months exceeding the standard at the downstream City limit. Significant contributors to non-compliance of the STV standards are mainly CSOs and upstream sources, and to a much lesser extent, the MS4/Watershed source. The CSOs continue to contribute to non-compliance under the STV standards, especially during the summer months. The CSOs are a more frequent and greater contributor to water quality violations using the STV standard than using the monthly geometric mean standard.

These results illustrate that:

- Controlling City of Richmond bacteria sources alone would not achieve compliance with water quality standards.
- Reducing combined sewer overflows via the CSS Infrastructure Improvement strategies would significantly reduce the average yearly CSO volume discharged (81% reduction compared to the baseline conditions). It would also improve compliance with water quality standards, especially during times when upstream sources are not significantly contributing to water quality violations.

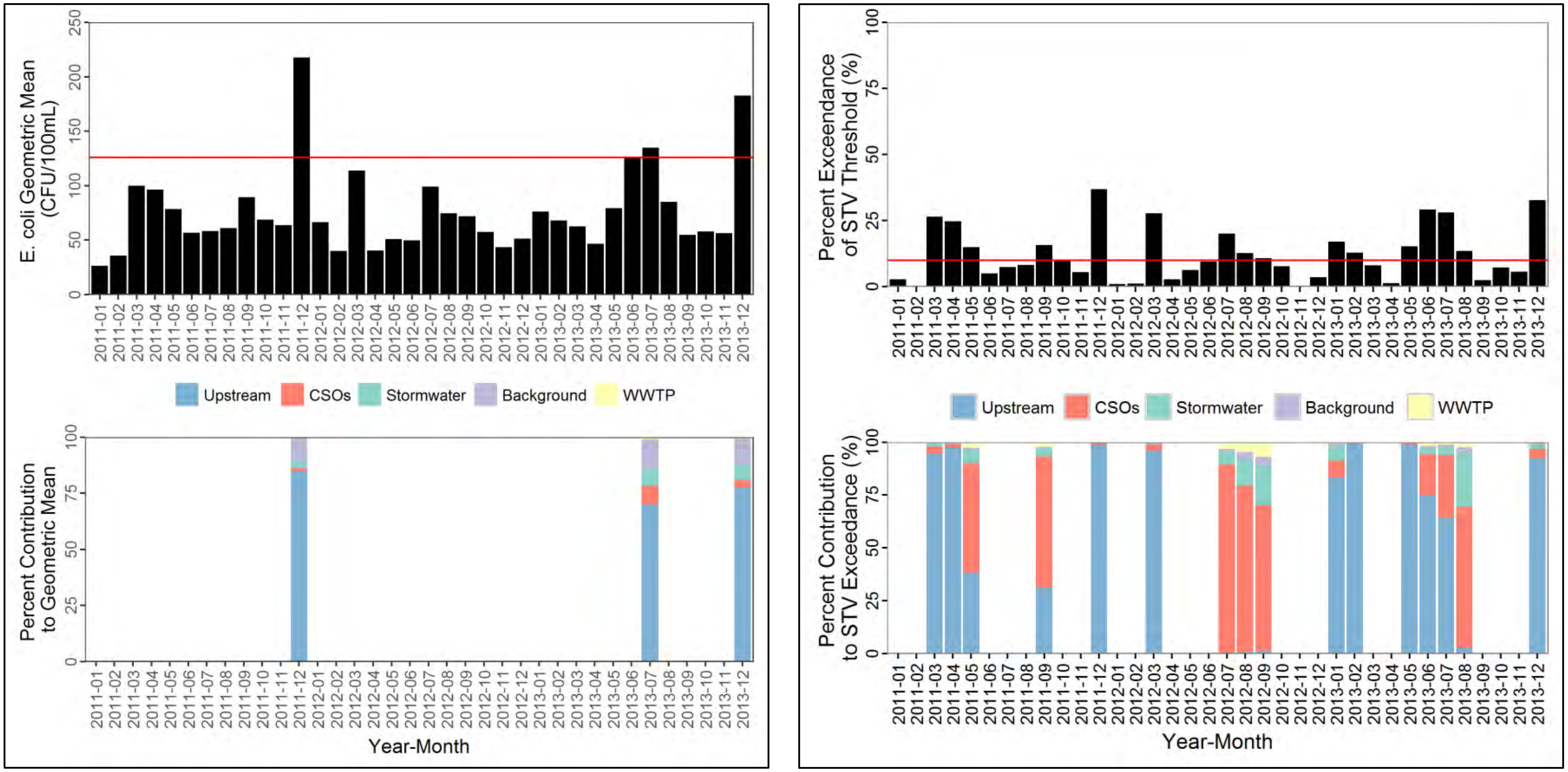


Figure 5-7: CSS Improvement Infrastructure Strategy: Monthly Geometric Mean and STV Standard Model Results

5.4.5.a CSS Infrastructure Improvement Strategy with Upstream Load Reductions

The James River Bacteria TMDL (MapTech, 2010) details the *E.coli* load reductions that would be necessary to achieve water quality compliance upstream of the City. These reductions, which were based on an independent analysis of water quality, were generally greater than 50%. Based on this information, the Water Quality model was applied for the CSS Infrastructure Strategy, whereby upstream load reductions were incrementally reduced until the downstream water quality criteria would be achieved under the monthly geomean standard. If all other sources remain the same, and with the CSS Infrastructure improvements in place, upstream sources would need to be reduced by 50% in order to meet the monthly geomean standard. These results are shown in

Figure 5-8.

5.4.5.b Evaluating Individual CSS Infrastructure Improvement Projects

The CSS Infrastructure Improvement Strategy consists of several different projects as outlined in the LTCP, and shown in Table 5-1 and Table 5-2. Each project was evaluated in isolation to determine individual project impact on bacteria load reduction and on the percent improvement towards meeting the monthly E.coli geometric mean water quality standard. Figure 5-9 summarizes the *E.coli* load reductions and Table 5-9 shows the "percent improvement" for each project scenario. Even though the individual scenarios can achieve significant E.coli load reductions (22%-67% reductions), the "percent improvement" shows smaller gains that vary between 13% and 21%. This is because E.coli loads from the CSS system make up only a fraction of the total *E.coli* load in the James River.

5.4.5.c Evaluating Alternative CSS Improvement Projects

It is anticipated that the modeling framework will be applied during the summer and fall of 2017 to evaluate alternative CSS reduction projects that may provide similar benefits to the LTCP projects, but at a reduced cost. These alternatives will be evaluated against the existing LTCP projects, and results will be presented as they become available.

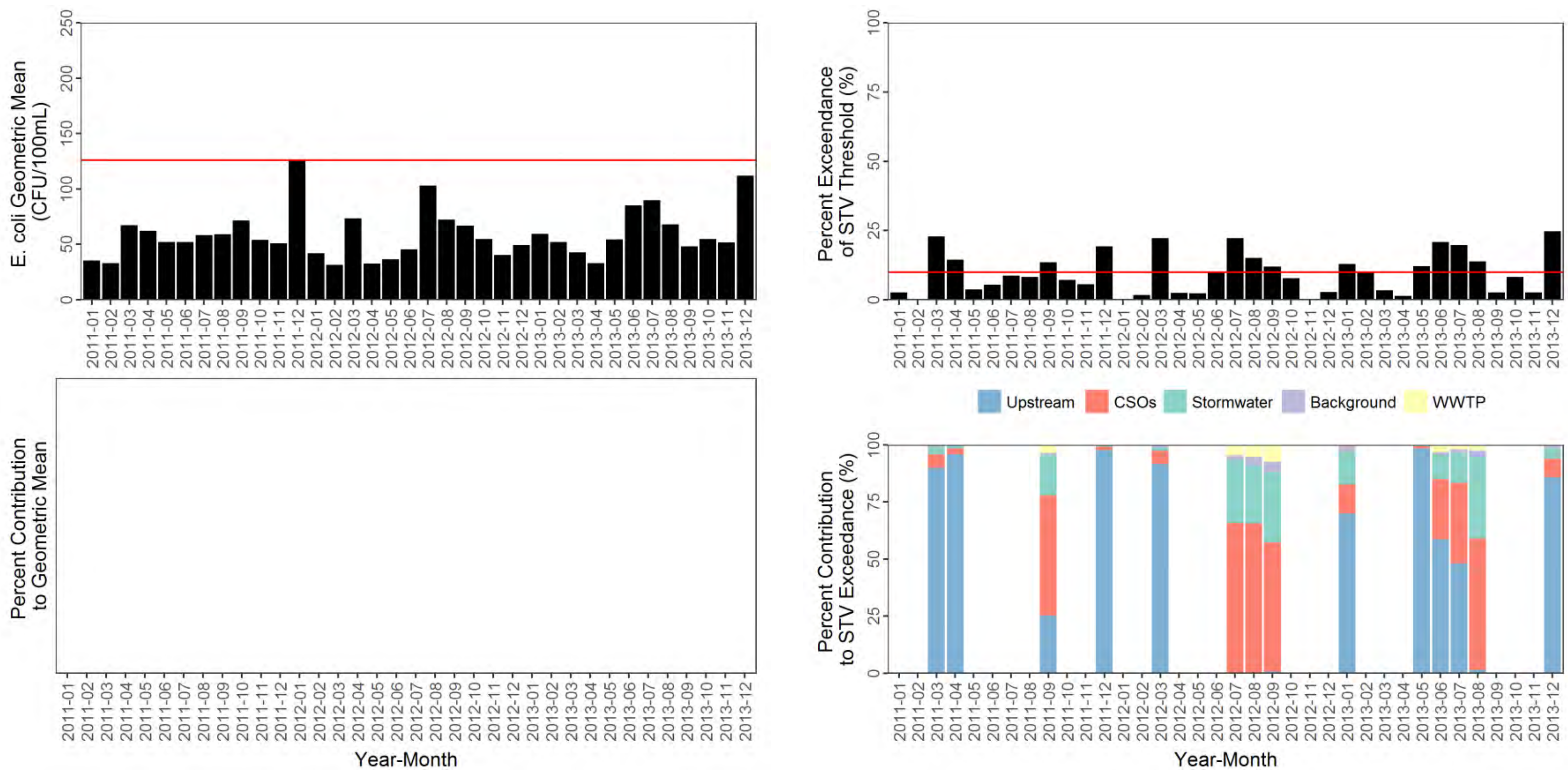


Figure 5-8: Modeled Water Quality Concentration with CSS Improvement Infrastructure Strategy and a 50 Percent Reduction in Upstream Loads

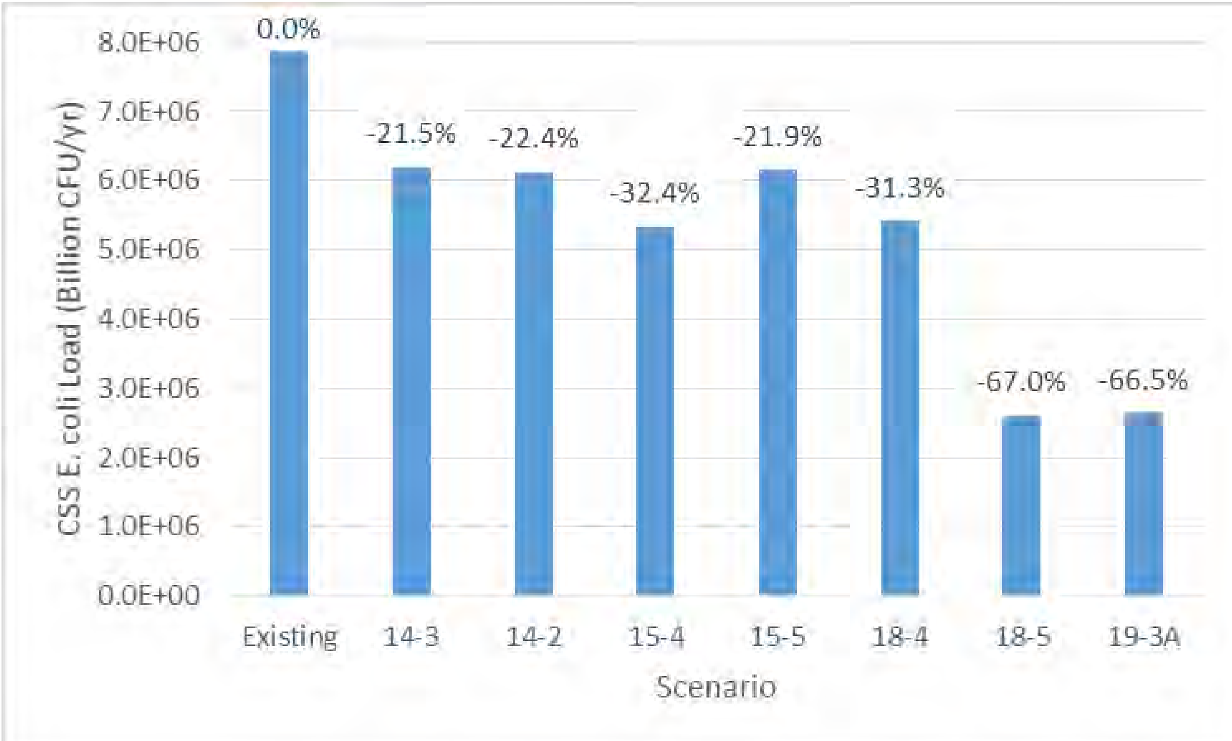


Figure 5-9: E.coli Load Reduction for Each CSS Infrastructure Improvement Project

Table 5-9: Percent Improvement Over Current Conditions for each CSS Infrastructure Improvement Project

CSS Scenario	Project	3-year Aggregate CSO Event Reduction (#)	3-year Aggregate CSO Volume Reduction (MG)	3-year Aggregate Exceedance of Geomean Standard (CFU/100ml)	Percent Improvement Over Current Conditions
Current	Current Conditions	--	--	200	--
14-3	Baseline Conditions	5	1,439	174	12.8%
14-2	Gillies Conveyance	5	1,468	174	13.2%
15-4	300 MGD Wet Weather Treatment	5	2,488	167	16.6%
15-5	CSO 21 Replacement	6	1,634	175	12.5%
18-4	SRB Expansion	1	1,950	168	16.1%
18-5	SRB Expansion and Disinfection	5	3,993	158	21.0%
19-3A	CSS Infrastructure Improvement Strategy (Full LTCP)	8	4,325	157	21.3%

5.4.6 Summary of Results for the Strategy Calculator

The strategies were evaluated using several metrics related to bacteria reduction, including:

- Bacteria load reduction from combined sewer and tributary discharges, expressed as Billion CFU
- Percent improvement in monthly geomean water quality standard compliance at the downstream city limit
- Reduction in number of CSO events
- Reduction in CSO volume (Million gallons)

These four metrics are used in the Strategy Calculator, a spreadsheet tool that is used to evaluate and score the different management strategies across a wide range of goals and objectives (LimnoTech, 2017). The results for the Strategy Calculator are summarized in Table 5-10.

Table 5-10: Strategy metric results used in the Strategy Calculator

Metric	GI in MS4	GI in CSS	CSS Infrastructure
Average yearly E.coli load reduction compared to the baseline (billion cfu)	4,051	52,350	3,551,112
Average reduction in annual number of CSO events compared to the baseline conditions	0	0	1
Average reduction in annual CSO volume discharged compared to the baseline conditions (million gallons)	0	9	962
Percent improvement compared to baseline conditions (%)	0.1	0.1	10

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7 Glossary

CSO: Combined sewer overflow

CSS: Combined sewer system

CWA: Clean Water Act

DCIA: Directly connected impervious area

DEM: Digital elevation model

EFDC: Environmental Fluid Dynamic Code

EMC: Event mean concentration

HSG: Hydrologic soil group

LiDAR: Light detection and ranging

MRLC: Multi-Resolution Land Characteristics

MS4: Municipal separate storm sewer system

NCDC: National Climatic Data Center

NLCD: National Land Cover Database

NRCS: National Resources Conservation Service

NOAA: National Oceanic and Atmospheric Administration

NRCS: National Resources Conservation Service

RIA: Richmond International Airport

SSO: Sanitary sewer overflow

SSURGO: Soil Survey Geographic database

SWMM: Storm Water Management Model

USGS: United States Geological Survey

Appendix 2. Strategy Fact Sheets

STRATEGY: RIPARIAN AREAS

Replace or restore 10 acres of riparian buffers according to state guidance. This may include:

- Implementing in the MS4 and / or the CSS areas of the City
- Replacing grassed buffers and impervious surfaces with a forested buffer
- Evaluating opportunities for inclusion of access points to waterbody for recreational activities

Riparian areas within urban environments often face numerous pressures from encroachment to increased pollutant impacts. The Riparian Area strategy includes the identification of areas within a 100 foot riparian buffer that have been compromised by insufficient vegetation to perform its function. This can stem from factors such as the removal of trees, lack of an understory, or presence of impervious surfaces.

A GIS analysis of the City's streams and the land cover surrounding these streams identified locations where these stream buffer deficiencies exist. The intent of the Riparian Area strategy is to replace or restore these deficient buffers. Several assumptions were made in association with this strategy including:

- Removal of two acres of impervious surfaces
- Restoration of eight acres of grassed areas to forest buffer
- Planting 125 trees per acre

Additionally, because one objective is to facilitate recreational access to the streams, this strategy will also incorporate four access points within these 10 acres of restored riparian area (1 access point per 1,000 feet of buffers replaced/restored).

This strategy also makes the assumption that there will be an investigation of the possibility to increase the width of riparian buffers within the City to 200 feet. If determined feasible, riparian buffers will be expanded upon where possible.

While this strategy is not traditionally considered "green infrastructure," it was characterized as such for the scoring of the strategies due to elements of the strategy, such as removal of impervious surfaces and tree planting.

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Riparian Area strategy was included in **TIER 1** of priorities for implementation.

METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC		METRIC		METRIC
√	TN reduction	√	Riparian buffers restored/increased	√	Area treated by GI
√	TP reduction	√	Habitat protected or restored		Streams restored
√	TSS reduction	√	Habitat connected by green corridor	√	Stormwater volume reduction
√	Bacteria reduction	√	Impervious surface reduced or treated	√	Stream access points added
	Reduction in no. of CSO events	√	Trees planted	√	Streams buffers added
	Reduction in CSO volume		Potable water consumption reduced		Conservation easements added
√	PCB, metals, and toxics reduction		Rain or storm water used for irrigation		Trash reduction
	Amount of water conserved		Percent increase in WQS compliance at James River compliance point		

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	19
Average yearly TP load reduction (lbs/yr)	4
Average yearly TSS load reduction (lbs/yr)	1,081
Average yearly E.coli load reduction (billion cfu/yr)	83

Cost Effectiveness	
Cost per pound TN removed	$58,902
Cost per pound TP removed	$292,553
Cost per pound TSS removed	$1,017
Cost per billion cfu E.coli removed	$13,190

STRATEGY: GREEN INFRASTRUCTURE IN THE MS4

Install or retrofit green infrastructure (GI) draining 104 acres of city-owned impervious surfaces (50% of all city-owned impervious area) through efforts such as:

- Installing GI on DPU property, specifically targeting city-owned vacant properties for stormwater management
- Installing a mix of GI, including bioengineered tree boxes (like Filtera-type practices)
- Installing GI on Parks department property (e.g.: playgrounds, parks, cemetery roadways, vacant properties, etc.)
- Retrofitting four DPU stormwater BMPs (e.g., dry ponds to more efficient BMPs); draining at least 6 acres of impervious surface

This green infrastructure (GI) strategy is intended to represent a general mix of practices typically included in GI implementation efforts. As part of the development of this high-level strategy, the IWRM Planning Team made a variety of assumptions and decisions with regard to the GI types included, area treated, and load reductions efficiencies, and other benefits provided by the GI practices. These assumptions and decisions were necessary so that this strategy could be modeled at a high level in order to calculate expected load and stormwater volume reductions, and provide metric scores to assess how well the strategy meets the goals and objectives of the IWRM.

The Mix of GI and Associated Acres Assumed for GI in the MS4

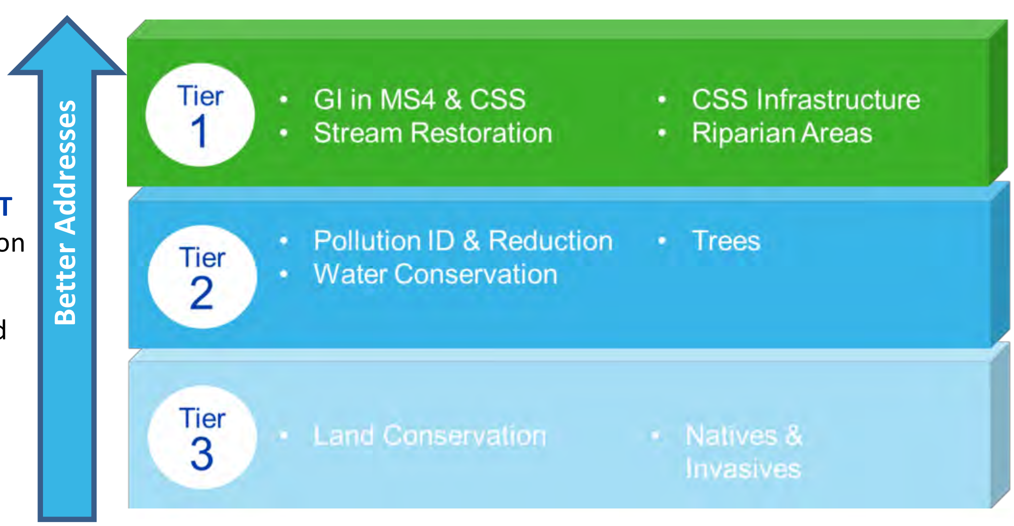
Green Infrastructure Practice	Area Treated (acres)
Engineered tree boxes	17
Stormwater pond retrofit (dry pond to wet pond)	6
Green roofs	1
Rainbarrels	16
Permeable pavement - A/B soils, underdrain	10
Permeable pavement - C/D soils, underdrain	10
Bioretention/raingardens - A/B soils, underdrain	21
Bioretention/raingardens - C/D soils, underdrain	23
Total Area Treated by Green Infrastructure in the MS4 area	**104**

The mix of GI types included and shown below is based on some of the more common GI types that are routinely implemented in the region. The practices assumed for this strategy are not meant to be exclusive or all-encompassing; other practices such as constructed wetlands, impervious surface disconnection, or nutrient management, could also be included under this strategy. The "final" list of GI practices will be determined though the Framework Planning process, as the City and stakeholders move closer to evaluating projects for implementation (see Chapter 7 of the City's Integrated Water Resources Management Plan for additional discussion on Framework Planning).

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, GI in the MS4 was included in **TIER 1** of priorities for implementation.



METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC
√	TN reduction
√	TP reduction
√	TSS reduction
√	Bacteria reduction
	Reduction in no. of CSO events
	Reduction in CSO volume
√	PCB, metals, and toxics reduction
	Amount of water conserved

	METRIC
	Riparian buffers restored/increased
√	Habitat protected or restored
	Habitat connected by green corridor
√	Impervious surface reduced or treated
√	Trees planted
	Potable water consumption reduced
√	Rain or storm water used for irrigation
√	Percent increase in WQS compliance at James River compliance point

	METRIC
√	Area treated by GI
	Streams restored
√	Stormwater volume reduction
	Stream access points added
	Streams buffers added
	Conservation easements added
	Trash reduction

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs)	414
Average yearly TP load reduction (lbs)	90
Average yearly TSS load reduction (lbs)	42,397
Average yearly E.coli load reduction (billion cfu)	3,531

Cost Effectiveness	
Cost per pound TN removed	$30,181
Cost per pound TP removed	$138,687
Cost per pound TSS removed	$295
Cost per billion cfu E.coli removed	$3,540

STRATEGY: GREEN INFRASTRUCTURE IN THE COMBINED SEWER SYSTEM (CSS)

Install or retrofit green infrastructure (GI) draining 18 acres of city-owned impervious surfaces through efforts such as:

- Installing GI on DPU property, specifically targeting city-owned vacant properties for stormwater management
- Installing a mix of GI, including bioengineered tree boxes (like Filtera-type practices)
- Installing GI on Parks department property (e.g.: playgrounds, parks, cemetery roadways, vacant properties, etc.)

This green infrastructure (GI) strategy is intended to represent a general mix of practices typically included in GI implementation efforts. As part of the development of this high-level strategy, the IWRM Planning Team made a variety of assumptions and decisions with regard to the GI types included, area treated, and load reductions efficiencies, and other benefits provided by the GI practices. These assumptions and decisions were necessary so that this strategy could be modeled at a high level in order to calculate expected load and stormwater volume reductions, and provide metric scores to assess how well the strategy meets the goals and objectives of the IWRM.

The Mix of GI and Associated Acres Assumed for GI in the CSS

Green Infrastructure Practice	Area Treated (acres)
Engineered tree boxes	2.9
Green roofs	0.2
Rainbarrels	2.7
Permeable pavement - A/B soils, underdrain	1.8
Permeable pavement - C/D soils, underdrain	1.8
Bioretention/raingardens - A/B soils, underdrain	4.1
Bioretention/raingardens - C/D soils, underdrain	4.5
Total Area Treated by Green Infrastructure in the MS4 area	**18**

The mix of GI types included and shown here is based on some of the more common GI types that are routinely implemented in the region. The practices assumed for this strategy are not meant to be exclusive or all-encompassing; other practices such as constructed wetlands, impervious surface disconnection, or nutrient management, could also be included under this strategy. The "final" list of GI practices will be determined though the Framework Planning process, as the City and stakeholders move closer to evaluating projects for implementation (see Chapter 7 of the City's Integrated Water Resources Management Plan for additional discussion on Framework Planning).

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, GI in the CSS was included in **TIER 1** of priorities for implementation.

METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC
√	TN reduction
√	TP reduction
√	TSS reduction
√	Bacteria reduction
	Reduction in no. of CSO events
√	Reduction in CSO volume
√	PCB, metals, and toxics reduction
	Amount of water conserved

	METRIC
	Riparian buffers restored/increased
√	Habitat protected or restored
	Habitat connected by green corridor
√	Impervious surface reduced or treated
√	Trees planted
	Potable water consumption reduced
√	Rain or storm water used for irrigation
√	Percent increase in WQS compliance at James River compliance point

	METRIC
√	Area treated by GI
	Streams restored
√	Stormwater volume reduction
	Stream access points added
	Streams buffers added
	Conservation easements added
√	Trash reduction

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs)	74
Average yearly TP load reduction (lbs)	16
Average yearly TSS load reduction (lbs)	7,393
Average yearly E.coli load reduction (billion cfu)	40,642

Cost Effectiveness	
Cost per pound TN removed	$45,270
Cost per pound TP removed	$209,375
Cost per pound TSS removed	$453
Cost per billion cfu E.coli removed	$82

STRATEGY: STREAM RESTORATION

This strategy includes the rehabilitation of 2,500 linear feet of stream, including activities such as removal of concrete channels and repair of incised banks. These streams can be located within the MS4 or the CSS areas of the City. This strategy also includes the evaluation of opportunities for inclusion of access points to a waterbody for recreational activities.

The 2,500 linear feet selected for this Stream Restoration Strategy was based upon a similar expanse included within the City's Chesapeake Bay TMDL Action Plan. Several assumptions were made in the development of this strategy including the following:

- The EPA CBP-approved pollutant reduction for this practice considers the ecoregion within which the stream restoration takes place. Because Richmond is split approximately in half between the Coastal Plain and the Piedmont ecoregions, it was assumed that 50% of the stream rehabilitation efforts would occur in each.
- Stream restoration projects will include a riparian buffer of 100 feet, but, where possible, the buffer will be increased to 200 feet.
- The average width of the streams restored was assumed to be 50 feet.
- This 100-foot buffer along the 2,500 linear feet of stream restoration results in almost 6 acres of riparian buffer restored or increased.
    - This is separate from what is included in the Riparian Area Strategy.
- Trees would be planted at a density of 125 trees per acre with over 700 trees planted.
    - This is separate from what is included in the Tree Strategy.
- Because improving waterfront access for recreation is an objective for the IWRM Plan, an access point for residents was assumed to be included for every 1,000 feet of stream restored. Two access points are therefore assumed for this 2,500 linear feet of stream restoration.

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Stream Rehabilitation strategy was included in **TIER 1** of priorities for implementation.

METRICS

The table below shows the metrics that are addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC
√	TN reduction
√	TP reduction
√	TSS reduction
	Bacteria reduction
	Reduction in number of CSO events
	Reduction in CSO volume
	PCB, metals, and toxics reduction
	Amount of water conserved

	METRIC
√	Riparian buffers restored/increased
√	Habitat protected or restored
√	Habitat connected by green corridor
	Impervious surface reduced or treated
√	Trees planted
	Potable water consumption reduced
	Rain or storm water used for irrigation
	Percent increase in WQS compliance at James River compliance point

	METRIC
√	Area treated by GI
√	Streams restored
	Stormwater volume reduction
√	Stream access points added
	Stream buffers added
	Conservation easements added
	Trash reduction

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	188
Average yearly TP load reduction (lbs/yr)	170
Average yearly TSS load reduction (lbs/yr)	75,013
Average yearly E.coli load reduction (billion cfu/yr)	--

Cost Effectiveness	
Cost per pound TN removed	$15,467
Cost per pound TP removed	$17,059
Cost per pound TSS removed	$39
Cost per billion cfu E.coli removed	--

STRATEGY: TREE PLANTING

Increase natural land cover by focusing on tree planting, including:

- Increasing tree canopy on City property by 5%
- Protecting existing tree canopy by following maintenance addressed in the Tree Planting Master Plan

The tree planting strategy is intended to protect as well as increase the amount of tree canopy that covers Richmond. As part of the development of this high-level strategy, the IWRM Planning Team made a variety of assumptions and decisions with regard to the number and density of trees planted, area treated, load reduction efficiencies, and other benefits provided by tree planting. These assumptions and decisions were necessary so that this strategy could be modeled at a high level in order to calculate expected load and stormwater volume reductions, and provide metric scores to assess how well the strategy meets the goals and objectives of the IWRM. For example, it was assumed that 2,000 trees per year would be planted at a density of 125 trees/acre and that a single tree could reduce up to 466 gallons of storm water per year.

In addition to reducing target pollutant loads and stormwater volume, increasing the tree canopy also provides additional benefits to the public and to wildlife. As part of the tree planting strategy, trees planted in 50% of targeted areas are intended to increase or protect existing habitat, and 25% of the areas targeted for tree planting will be part of green corridors.

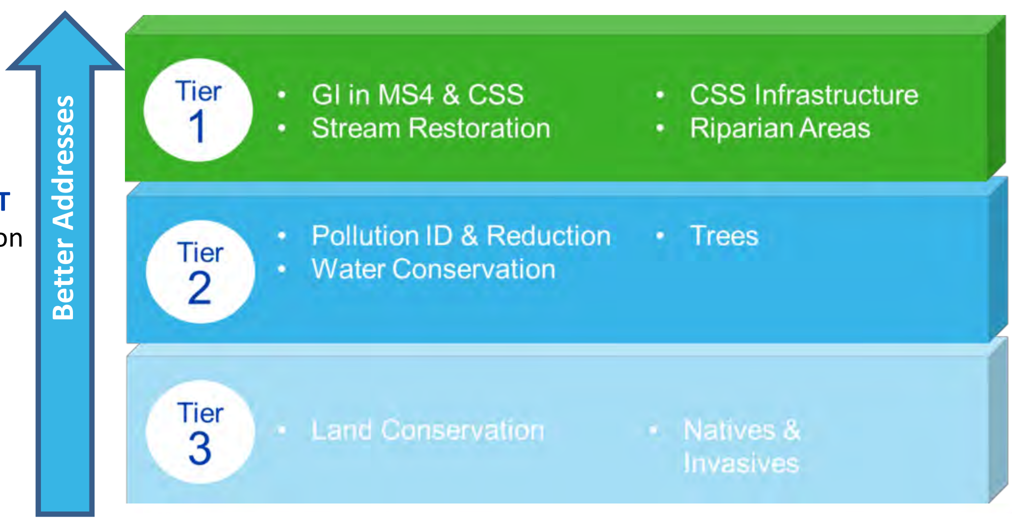
Acres Assumed for Tree Planting in the MS4

Tree Planting Practice	Area (acres)
Total area targeted for tree planting	80
Effective tree canopy area	33
Tree canopy area over impervious area	7
Tree canopy area over pervious areas	26
Habitat protected/restored	17
Habitat protected by green corridor	8

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Tree Planting strategy was included in **TIER 2** of priorities for implementation.



METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC
√	TN reduction
√	TP reduction
√	TSS reduction
	Bacteria reduction
	Reduction in no. of CSO events
	Reduction in CSO volume
√	PCB, metals, and toxics reduction
	Amount of water conserved

	METRIC
	Riparian buffers restored/increased
√	Habitat protected or restored
√	Habitat connected by green corridor
√	Impervious surface reduced or treated
√	Trees planted
	Potable water consumption reduced
	Rain or storm water used for irrigation
	Percent increase in WQS compliance at James River compliance point

	METRIC
√	Area treated by GI
	Streams restored
√	Stormwater volume reduction
	Stream access points added
	Streams buffers added
	Conservation easements added
	Trash reduction

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	30
Average yearly TP load reduction (lbs/yr)	4
Average yearly TSS load reduction (lbs/yr)	447
Average yearly E.coli load reduction (billion cfu/yr)	--

Cost Effectiveness	
Cost per pound TN removed	$72,158
Cost per pound TP removed	$520,833
Cost per pound TSS removed	$4,925
Cost per billion cfu E.coli removed	--

STRATEGY: NATIVE PLANT RESTORATION/INVASIVE PLANT REMOVAL

Increase the number and variety of native plants in the City of Richmond by:

- Using 80% native plants in new landscaping at public facilities by 2023
- Removing 5% of invasive plant species on DPU and park properties and replace with native species

The native plant restoration/invasive plant removal strategy focuses on populating new landscaping projects with plant species native to Richmond, actively removing invasive plant species and replacing them with native, and promoting public awareness of invasive plants. As part of the development of this high-level strategy, the IWRM Planning Team made a variety of assumptions and decisions with regard to the area treated, load reductions efficiencies, and other benefits provided by the native plant restoration/invasive plant removal. These assumptions and decisions were necessary so that this strategy could be modeled at a high level in order to calculate expected load and stormwater volume reductions, and provide metric scores to assess how well the strategy meets the goals and objectives of the IWRM.

There are two main components of the native restoration/invasive removal. The first component focuses on native plant restoration and invasive plant removal on City property. The native plant restoration/invasive plant removal strategy will also take several other factors into account such as biodiversity and the suitability of a species for a given location. Plantings of native species will focus on a wide variety of plants that are commonly found in the Coastal Plain/Piedmont region. In areas of the city that are not expected to receive supplemental watering, only drought-tolerant, native species will be considered. The second component of this strategy will be to develop a "do not plant" list of invasive species to raise awareness of problem species and to help guide local gardeners.

Strategy Elements	
20	Acres of native planting and/or invasive removal
2,000	Trees planted

While this Strategy does not offer significant reductions in target pollutants, they do provide a number of other benefits for the public, the city, and local wildlife, including: increased recreational space, plant biodiversity that will support a wider range of wildlife, and decreased watering costs associated with maintaining appropriately placed native plant species.

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Native Plant Restoration/Invasive Plant Removal strategy was included in **TIER 3** of priorities for implementation.

METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

METRIC
TN reduction
TP reduction
TSS reduction
Bacteria reduction
Reduction in no. of CSO events
Reduction in CSO volume
PCB, metals, and toxics reduction
Amount of water conserved

	METRIC
	Riparian buffers restored/increased
√	Habitat protected or restored
√	Habitat connected by green corridor
	Impervious surface reduced or treated
√	Trees planted
	Potable water consumption reduced
	Rain or storm water used for irrigation
	Percent increase in WQS compliance at James River compliance point

METRIC
Area treated by GI
Streams restored
Stormwater volume reduction
Stream access points added
Streams buffers added
Conservation easements added
Trash reduction

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness for various strategies is evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) only. Because this strategy doesn't result in reduction of these pollutants, cost effectiveness could not be calculated.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	--
Average yearly TP load reduction (lbs/yr)	--
Average yearly TSS load reduction (lbs/yr)	--
Average yearly E.coli load reduction (billion cfu/yr)	--

Cost Effectiveness	
Cost per pound TN removed	--
Cost per pound TP removed	--
Cost per pound TSS removed	--
Cost per billion cfu E.coli removed	--

STRATEGY: WATER CONSERVATION

Reduce water consumption by 10% (from 2009-2014 baseline) through efforts such as:

- Installing water efficient fixtures as a policy by 2023 in all new public facility construction
- Implementing incentive programs that provide retrofits for low income households
- Encouraging water conservation on City properties
- Installing conservation landscaping on city-owned properties

This water conservation strategy is intended to represent a general mix of practices typically included in water conservation implementation efforts. As part of the development of this high-level strategy, the IWRM Planning Team made a variety of assumptions and decisions with regard to the conservation measures included, gallons of water conserved, load reductions efficiencies, and other benefits provided by the conservation practices. These assumptions and decisions were necessary so that this strategy could be modeled at a high level in order to calculate expected load and stormwater volume reductions, and provide metric scores to assess how well the strategy meets the goals and objectives of the IWRM.

The Mix of Conservation Practices and Associated Gallons Conserved Assumed for Water Conservation

Water Conservation Practice	Water Conserved (million gallons)
1,000 New rain barrels	0.52
Conservation incentives	250
Improvements in the water distribution system	250
Total Water Conserved by Water Conservation Practices (over five years)	**500.52**

The mix of conservation activities included and shown here is based on incorporation of common water conservation practices, such as rain barrels and encouraging water conservation by City staff. An incentive program is also planned that will include retrofits of low flush toilets and other fixtures. The "final" list of water conservation practices will be determined though the Framework Planning process, as the City and stakeholders move closer to evaluating projects for implementation (see Chapter 7 of the City's Integrated Water Resources Management Plan for additional discussion on Framework Planning).

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Water Conservation strategy was included in **TIER 2** of priorities for implementation.

METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the Water Conservation strategy

	METRIC
√	TN reduction
√	TP reduction
√	TSS reduction
	Bacteria reduction
	Reduction in no. of CSO events
	Reduction in CSO volume
	PCB, metals, and toxics reduction
√	Amount of water conserved

	METRIC
	Riparian buffers restored/increased
	Habitat protected or restored
	Habitat connected by green corridor
√	Impervious surface reduced or treated
	Trees planted
√	Potable water consumption reduced
√	Rain or storm water used for irrigation
	Percent increase in WQS compliance at James River compliance point

	METRIC
√	Area treated by GI
	Streams restored
√	Stormwater volume reduction
	Stream access points added
	Streams buffers added
	Conservation easements added
	Trash reduction

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	11
Average yearly TP load reduction (lbs/yr)	1
Average yearly TSS load reduction (lbs/yr)	422
Average yearly E.coli load reduction (billion cfu/yr)	--

Cost Effectiveness	
Cost per pound TN removed	$24,092
Cost per pound TP removed	$195,744
Cost per pound TSS removed	$639
Cost per billion cfu E.coli removed	--

STRATEGY: LAND CONSERVATION

Place an additional 10 acres of city-owned land under conservation easement. When selecting acreage to include in the easement consideration will be given to the following factors:

- Prioritizing the conservation of land that creates connected green corridors
- Evaluating opportunities for inclusion of access points to waterbodies for recreational activities

The land conservation strategy focuses on placing an additional 10 acres of City-owned land under conservation easement. As part of the development of this high-level strategy, the IWRM Planning Team made a variety of assumptions and decisions with regard to implementation. It was assumed that 50% of the land included in the conservation easement would create connected green corridors. Green corridors are areas of open space that connect fragmented green spaces together allowing for the improved movement of people and wildlife.

Land Conservation Benefits
Conservation/restoration of habitat
Improved connectivity between habitats
Increased public open space
Increased mobility for wildlife
Increased access to recreational opportunities

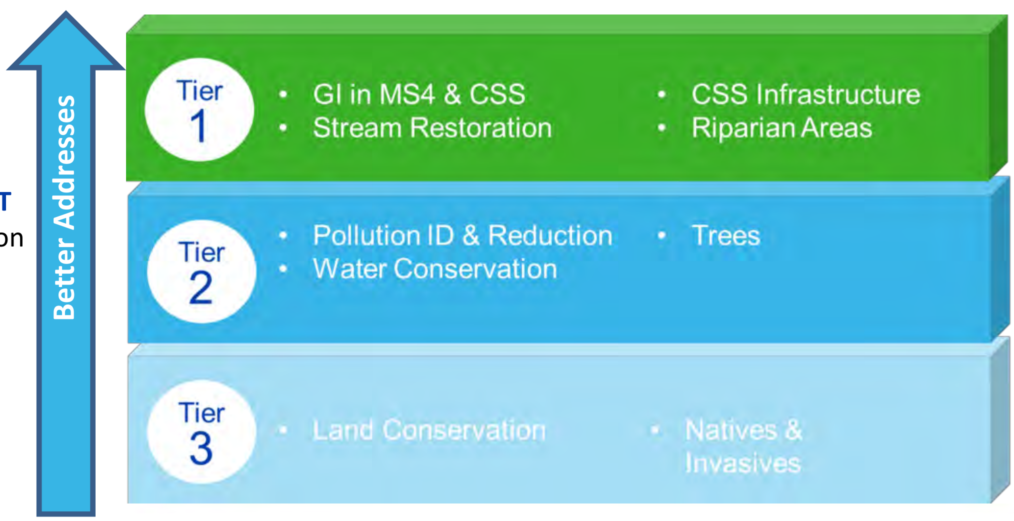
While the land conservation strategy does not offer significant reductions in target pollutants, they do provide a number of other benefits for both local wildlife and the public, including: habitat protection, habitat restoration, increased recreational space, and an increased number of access points to waterbodies within the City.

Because there are no regulatory requirements driving land conservation in the City, this strategy also helps the City address the IWRM Plan objective to exceed regulatory requirements, when possible.

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Land Conservation strategy was included in **TIER 3** of priorities for implementation.



METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC		METRIC		METRIC
	TN reduction		Riparian buffers restored/increased		Area treated by GI
	TP reduction	√	Habitat protected or restored		Streams restored
	TSS reduction	√	Habitat connected by green corridor		Stormwater volume reduction
	Bacteria reduction		Impervious surface reduced or treated	√	Stream access points added
	Reduction in no. of CSO events		Trees planted		Streams buffers added
	Reduction in CSO volume		Potable water consumption reduced	√	Conservation easements added
	PCB, metals, and toxics reduction		Rain or storm water used for irrigation		Trash reduction
	Amount of water conserved		Percent increase in WQS compliance at James River compliance point		

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness for various strategies is evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) only. Because this strategy doesn't result in reduction of these pollutants, cost effectiveness could not be calculated.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	--
Average yearly TP load reduction (lbs/yr)	--
Average yearly TSS load reduction (lbs/yr)	--
Average yearly E.coli load reduction (billion cfu/yr)	--

Cost Effectiveness	
Cost per pound TN removed	--
Cost per pound TP removed	--
Cost per pound TSS removed	--
Cost per billion cfu E.coli removed	--

STRATEGY: POLLUTANT IDENTIFICATION AND REDUCTION

Reduce the contribution of pollutants to the municipal separate stormwater sewer system (MS4) area by:

- Conducting at least one special study per year in hot spot areas to identify illicit discharges/connections
- Collecting data associated with non-structural BMPs to facilitate quantification of pollutant reduction

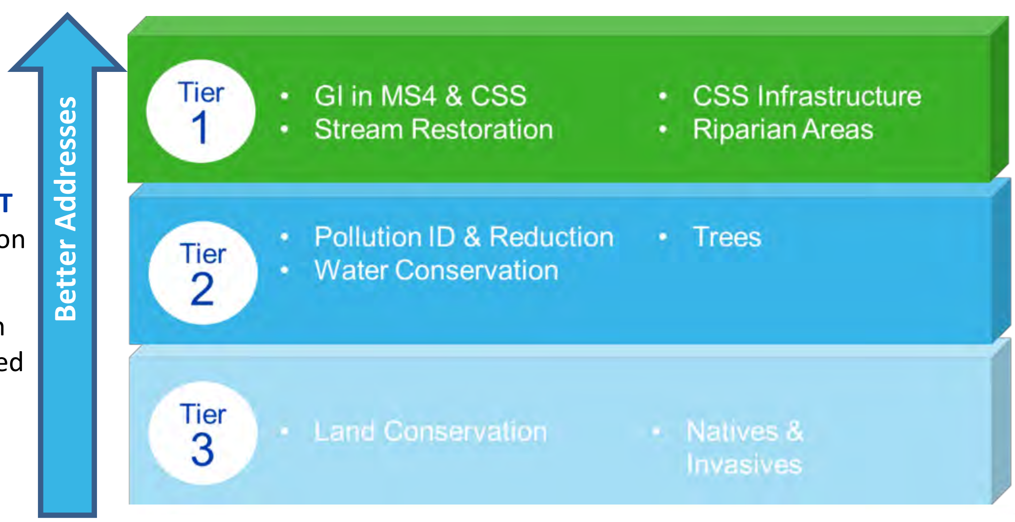
The first part of this strategy involves identifying and eliminating illicit discharges within the MS4 area. Illicit discharges are sources of pollutants collected to storm drains that contribute contaminants to the system during periods of dry weather. This strategy will find and eliminate illicit discharges by conducting at least one special study each year in an area that has been deemed a "hot spot" for pollutant loading. By targeting "hot spots" the city can effectively and efficiently target relatively large sources of pollutants by eliminating the source of the discharge or by implementing a best management practice (BMP) to reduce the pollutant loading. Over five years, at least 3 of these studies will be used to meet pollutant reductions required by the Chesapeake Bay TMDL.

The second part of this strategy involves data collection for non-structural best management practices (BMPs). Currently, the assumptions associated with implementing non-structural BMPs such as catch basin clean outs and street sweeping are based on region-specific literature reviews. Because there is not an approved or commonly used methodology in place to account for pollutant reductions associated with pet waste removoal, this practice was not accounted for quantitatively in the strategy calculator. By collecting site-specific data on pollution reduction practices, the City will be able to refine the pollutant removal rates associated with these projects and to better quantify their impact on the James River. As additional data and research substantiate the quantification of additional pollutant removal practices, these will also be taken into consideration.

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Pollutant Identification and Reduction strategy was included in **TIER 2** of priorities for implementation.



METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC	METRIC		METRIC
√	TN reduction	Riparian buffers restored/increased		Area treated by GI
√	TP reduction	Habitat protected or restored		Streams restored
√	TSS reduction	Habitat connected by green corridor		Stormwater volume reduction
	Bacteria reduction	Impervious surface reduced or treated		Stream access points added
	Reduction in no. of CSO events	Trees planted		Streams buffers added
	Reduction in CSO volume	Potable water consumption reduced		Conservation easements added
√	PCB, metals, and toxics reduction	Rain or storm water used for irrigation	√	Trash reduction
	Amount of water conserved	Percent increase in WQS compliance at James River compliance point		

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	448
Average yearly TP load reduction (lbs/yr)	162
Average yearly TSS load reduction (lbs/yr)	57,893
Average yearly E.coli load reduction (billion cfu/yr)	--

Cost Effectiveness	
Cost per pound TN removed	$36,597
Cost per pound TP removed	$100,882
Cost per pound TSS removed	$284
Cost per billion cfu E.coli removed	--

STRATEGY: IMPLEMENT CSS INFRASTRUCTURE PROJECTS

Implement projects outlined in Richmond's combined sewer overflow long-term control plan (CSO LTCP), including:

- Installing wet weather interceptor in Lower Gillies Creek to convey more flow to the WWTP
- Increasing wet weather treatment to 300 MGD at the WWTP
- Expanding Shockoe Retention Basin by 15 MG to capture more combined sewer overflow
- Adding disinfection at the Shockoe outfall to reduce bacteria in combined sewer overflow
- Expanding secondary treatment at the WWTP to 85 MGD

Implementation of Richmond's combined sewer overflow long-term control plan (CSO LTCP) is required under a consent order from the State Water Control Board. The consent order was issued in 2005 and includes an implementation schedule and a description of LTCP projects that will be implemented. Projects that are part of this strategy are aimed at decreasing the volume of CSOs by rerouting flows from the combined sewer outfalls to the Richmond waste water treatment plan (WWTP) and Shockoe retention basin (SRB), where those flows can then receive some level of treatment before being released into the James River. Increasing the treatment capacity of the WWTP and SRB, will result in smaller pollutant loads entering the James River, thereby improving water quality.

Strategy Elements
Expanding wet weather treatment at the waste water treatment plant
Improving wet weather conveyance in Lower Gillies Creek to the waste water treatment plant
Expanding the Shockoe Retention Basin and disinfecting combined sewer overflows at SRB
Expanding secondary treatment at the waste water treatment plant

STRATEGY TIERS

Priorities for implementation are based on how well the strategy addresses selected **METRICS, POLLUTANT REDUCTION**, and **COST EFFECTIVENESS**. Each is discussed on the following page.

Overall, the Implement CSS Infrastructure Strategy was included in **TIER 1** of priorities for implementation.

METRICS

The table below shows the metrics that were addressed by this strategy. Additional details regarding information and assumptions related to this strategy and the numeric metric results can be found in the IWRM Planning Spreadsheet Calculator Tool, located at RVAH2O.org.

Metrics evaluated for the GI in the MS4 strategy

	METRIC
√	TN reduction
√	TP reduction
√	TSS reduction
√	Bacteria reduction
√	Reduction in no. of CSO events
√	Reduction in CSO volume
√	PCB, metals, and toxics reduction
	Amount of water conserved

	METRIC
	Riparian buffers restored/increased
	Habitat protected or restored
	Habitat connected by green corridor
	Impervious surface reduced or treated
	Trees planted
	Potable water consumption reduced
	Rain or storm water used for irrigation
√	Percent increase in WQS compliance at James River compliance point

	METRIC
	Area treated by GI
	Streams restored
	Stormwater volume reduction
	Stream access points added
	Streams buffers added
	Conservation easements added
√	Trash reduction

√ = metric was addressed by the strategy

POLLUTANT REDUCTION & COST EFFECTIVENESS

Cost effectiveness was evaluated for the permit-driven metrics (TN, TP, TSS, bacteria) and expressed as cost per unit pollutant removed.

Pollutant Removal	
Average yearly TN load reduction (lbs/yr)	7,066
Average yearly TP load reduction (lbs/yr)	903
Average yearly TSS load reduction (lbs/yr)	116,843
Average yearly E.coli load reduction (billion cfu/yr)	3,551,112

Cost Effectiveness	
Cost per pound TN removed	$55,507
Cost per pound TP removed	$434,293
Cost per pound TSS removed	$3,357
Cost per billion cfu E.coli removed	$110

SUPPORTING ACTIONS TO MAIN STRATEGIES

While strategies have been defined as "activities, actions, or items that will help meet goals and objectives" of the Integrated Water Resources Management (IWRM) Plan, a number of additional actions have been identified to support or facilitate the implementation of these strategies. These supporting actions to the main strategies include efforts that may broaden the main strategy, additional specificity on how a strategy could be implemented, or identify additional resources and data needs to fully implement the main strategy. These supporting actions are not necessarily quantifiable in and of themselves and may be components of multiple main strategies. They may also involve efforts on non-City property and rely on resources that are outside the DPU's authority.

The development of strategies that meet the goals and objectives of the IWRM Plan resulted in a number of supporting actions related to:

- Partnerships
- Maintenance
- Monitoring, assessment & planning
- Incentives & credits
- Regulations, ordinances & codes
- Outreach

A summary of each of the supporting actions is discussed below and specific examples of these actions are included in the following tables.

The following table identifies which of these supporting actions are included in each strategy. For instance, the Riparian Area, Green Infrastructure (GI) in the municipal separate storm sewer system (MS4), and Tree Strategies address each of the six supporting actions. Alternatively the Pollution Identification (ID), Combined Sewer System (CSS) Infrastructure, and Land Conservation Strategies address only two supporting actions.

	Riparian Area	GI in MS4	GI in CSS	Stream Restor.	Natives/ Invasives	Trees	Land Cons.	Water Cons.	Pollution ID	CSS Infrast.
Partnerships	√	√	√	√	√	√	√	√		
Maintenance	√	√	√	√	√	√				
Monitoring	√	√	√	√	√	√			√	√
Incentives	√	√			√	√		√		
Regulations	√	√	√			√		√		
Outreach	√	√	√	√	√	√	√	√	√	√

Partnerships

The purpose of establishing partnerships is to facilitate a greater level of future implementation. This could be as the result of partnerships within the City, such as with Department of Planning or the Parks, Recreation, and Community Facilities. Partnerships may also include non-City agencies, such as watershed groups or neighborhood associations that can help facilitate implementation of strategies on private property. Non-DPU City departments, watershed groups, or neighborhood associations could work collectively with DPU to cost share implementation of strategies through shared staff and resources or through collaboration of actions. Additional specificity related to partnerships (along with other supporting actions) are expected to be refined over time as additional discussions and agreements are made with potential partners.

Maintenance
Many of the selected strategies require maintenance to ensure the strategy is performing as it should and will continue to meet its intended objectives. Part of this supporting action includes ensuring that sufficient funding is available and is part of each applicable strategy.

Monitoring, Assessment & Planning
The intent of this supporting action is to gather data and information and use these results to help inform and guide future implementation. This can include monitoring of specific practices, such as pre- and post-construction monitoring of a stream restoration project. It could also include the inventory and mapping of areas associated with the various strategies, such as riparian buffers or invasive species. Monitoring also includes the continuation of the James River and tributary sampling that is being used to evaluate the status and trends that are seen in the City's water quality and aquatic biological communities. As DPU is just one of the organizations that is conducting monitoring, another supporting action could include the initiation of a workgroup to improve coordination of data collection efforts.

Incentives & Credits
These supporting actions are intended to further evaluate, develop, and implement mechanisms to incentivize new initiatives or higher levels of future implementation. Specific actions can relate to expansion of the stormwater credit program to include reference to additional strategies, such as restoration of riparian buffers or removal of invasive and planting of native species on private land.

Regulations, Ordinances & Codes
This includes analyzing and modifying, if necessary, the framework within which implementation will occur. For instance, the Riparian Area Strategy is based on implementation within a 100 foot stream buffer. This supporting action could include evaluating expansion of this buffer to a 200 foot buffer. Additionally, City zoning and planning-related ordinances could be reevaluated to include language related to impervious area or to protect existing trees on developed property.

Outreach
Each of the 10 main strategies includes opportunities for education and outreach. This can include identifying ways to potentially expand upon future implementation by conveying information on resources available or ways for partners and the public support implementation of a strategy. As the implementation portion of the IWRM Plan is developed in more detail, specific activities will be identified and opportunities to implement these activities will be discussed with partner organizations.

COSTS
Costs were evaluated for each of the Supporting Actions. This information is summarized in the table below and detailed further in Appendix 5 (Strategy Cost Estimation) of the IWRM Plan.

Supporting Action	Estimated Cost
Partnerships	$655,000
Maintenance	Cost was included in association with the individual strategies
Monitoring	$1,208,000
Incentives/ Credits	$500,000
Regulations	Assumed to be part of City staff's normal job duties
Outreach	$500,000

	Riparian Areas	Green Infrastructure (in MS4)	Green Infrastructure (in CSS)	Stream Restoration	Native/ Invasives	Trees	Land Conservation	Water Conservation	Pollution Identification	CSS Infrastructure
Supporting Actions										
Partnerships	**20** acres of riparian buffers on private properties: * Through purchase of land * Partnerships with residents: Promote program for buffers on private properties (include tiers of level of involvement - (1) maintenance agreement with city, (2) conservation agreement/ easement.)] * Partner with Master Naturalists to enlist their support to assist with riparian restoration	* **5** acres on DPW property (rights of way, roadways, green alleys) Implement **10** acres of GI on private property: * Adopt a rain garden program - coordinate with residents, non-profits, commercial entities * Partner with City's community garden program to identify **3** acres of area for additional GI implementation * Partner with Public Works to ensure City greenways include GI (**5** acres of GI)	* **5** acres on DPW property (rights of way, roadways, green alleys) Implement **10** acres of GI on private property. : * Adopt a rain garden program - coordinate with residents, non-profits, commercial entities * Partner with City's community garden program to identify **1** acres of area for additional GI implementation * Partner with Public Works to ensure City greenways include GI (**2** acres of GI)	Promote requests for stream restoration by private landowners. Streamline the process by which these requests are addressed.	* Develop a program to encourage the use of native plants in private landscaping - sign up **20** private landscapers. * Initiate an adopt-a-lot program (**10** lots with invasive species removed, replanted, and maintained) * Partner with organizations, such as the James River Park System Invasive Plant Task Force, to better determine areas with significant invasive species issues and resources to deal with the problem.	* Partner with the public and other stakeholders, such as the Richmond Tree Stewards, to plant and maintain trees on public properties.	Partner with the public and other stakeholders to identify land to put in conservation easements. Include an additional **100** acres of non-City property in conservation easements.	* Partner with Richmond Redevelopment and Housing Authority to identify homes/properties that are eligible for upgrades to water efficient fixtures. * Partner with upstream localities and Virginia Department of Health to update/maintain Source Water Protection Plan		
	Hire DPU staff or assign 1 FTE to coordinate volunteers from corporate entities, watershed/environmental groups, and public with partnership opportunities associated with the IP effort. Staff to enlist/maintain **6** of partnerships per year									
	Hold **3** stakeholder meetings per year to continue communication with partners/stakeholders and add purpose to the IP effort.									
	Evaluate partnership network in 5 years (at the end of the permit cycle) to assess gaps and identify new public/private partners.									
Maintenance	Include funding to support maintenance of newly replanted / restored riparian buffers (to ensure success of plantings, prevention of establishment of invasive species, etc.)	Include funding to support maintenance of green infrastructure practices based on findings of the inspection program to ensure continued pollutant reduction credit.		Include funding to support maintenance of restored streams.	Include funding to support maintenance of newly planted native plants as well as to maintain newly established plantings where invasives have been removed from the landscape	Provide funding to support maintenance of trees on city property to ensure their survival and health.				
Monitoring, Assessments & Planning	Inventory and map riparian areas to better understand loss or growth of riparian buffers	Evaluate potential for conducting pre and post construction monitoring of key stormwater BMPs.		Conduct pre and post restoration monitoring per Chesapeake Bay Program requirements	Monitor growth/expansion of invasive species.	Inventory and map locations of trees and tree boxes to better understand loss or growth of tree coverage.			Implement IDDE-related monitoring to support this effort - supported by a desktop analysis of high risk dischargers	Continue monitoring effort associated with the CSO and WWTP discharge programs.
	Continue monitoring of 8 locations across the city for macroinvertebrate, habitat, and instream water quality. Continue monitoring at two locations for flow. Evaluate opportunities to expand the flow monitoring network across the City.									
	Evaluate the development of a monitoring data portal to facilitate sharing of data collected within the City with stakeholders and the public.									

<table>
<tr><th></th><th>Riparian Areas</th><th>Green Infrastructure (in MS4)</th><th>Green Infrastructure (in CSS)</th><th>Stream Restoration</th><th>Native/ Invasives</th><th>Trees</th><th>Land Conservation</th><th>Water Conservation</th><th>Pollution Identification</th><th>CSS Infrastructure</th></tr>
<tr><td rowspan="2"></td><td colspan="10">Initiate monitoring workgroup in year one made up of technical stakeholders and other key groups/individuals to evaluate current monitoring efforts and identify potential efficiencies and additional monitoring needs moving forward.</td></tr>
<tr><td colspan="10">Conduct assessments of 4 stream segments across the four watershed groupings to support the development of watershed restoration plans to address pollutant sources and watershed stressors.</td></tr>
<tr><td>Incentives/ Credits</td><td>Reevaluate the stormwater credit program to determine potential to include practices such as replacing or restoring riparian buffers.</td><td>* Reevaluate the stormwater credit program (through updates to the credit manual) to include additional practices including tree planting, green roofs, etc. Reevaluation of the credit program will also include increases of funding available for these credits to incentivize implementation on private property.
* Provide credits for residential and non-residential properties to reduce stormwater fees based on implementation of "green practices".</td><td></td><td></td><td>Evaluate incentives/credits for purchasing / planting native species (such as Montgomery County, MD).</td><td>* Reevaluate the stormwater credit program to determine potential to include practices such as planting trees on private property.

* Provide 500 trees for planting on private property or equivalent incentives to purchase native trees.</td><td></td><td>* Offer grants to replace 20 % of inefficient fixtures in moderate to low-income units.

* Evaluate expansion of incentive program to cover washing machines and dishwashers</td><td></td><td></td></tr>
<tr><td>Regs/ Ordinance/ Code</td><td>Evaluate expanding the regulatory buffer from 100ft to 200ft</td><td colspan="2">Evaluate inclusion of language in City zoning and planning-related ordinances to limit impervious area on developed property.</td><td></td><td></td><td>Evaluate inclusion of language in City zoning and planning-related ordinances to protect existing trees and add new trees on developed property.</td><td></td><td>Adopt permitting standards for water efficient appliances/ fixtures in city code</td><td></td><td></td></tr>
<tr><td rowspan="2">Outreach</td><td></td><td>Conduct outreach to advertise the resources, requirements, and services available through city related to green infrastructure for private property owners</td><td></td><td colspan="2"></td><td>Conduct outreach to advertise the resources, requirements, and services available through city related to tree planting and maintenance.</td><td></td><td>* Promote ability to use grey water for toilet flushing. Promote as way to achieve higher LEED standards.
* Encourage and incentivize water capture and reuse for landscaping
* Promote water conservation for commercial, industrial, and residential customers through efforts such as "Fix a Leak Week" and the City's Every Drop Counts initiative.</td><td>Conduct targeted outreach to high-risk industries, particularly in areas of the city identified as hot spots.</td><td></td></tr>
<tr><td colspan="10">Conduct outreach to educate the general public about the goals and objectives of RVAH2O, and the resources and services available through the city.</td></tr>
</table>

Appendix 3. RVA Clean Water Plan Goals, Objectives & Metrics

RVAH2O WATERSHED METRICS

GOAL	OBJECTIVES	METRICS
Manage wastewater and stormwater to improve the water quality and water quantity of ground water and surface water.	Develop one stormwater management plan to cover the City's four watershed groupings based on the City's watershed characterization report.	Plan produced (yes=1, no=0)
	Reduce nitrogen, phosphorus and sediment in discharges to achieve VPDES permit requirements (Chesapeake Bay TMDL).	• N reduction (lbs.) • P reduction (lbs.) • TSS reduction (lbs.)
	Reduce bacteria levels to achieve VPDES permit requirements (local TMDL and water quality standards).	• Percent increase in monthly geomean WQS compliance • Average yearly E. coli load reduction (billion cfu) • Average yearly reduction in CSO events (number) • Average yearly reduction in CSO volume discharged (million gallons)
	Reduce toxics (e.g., mercury, PAHs, PCBs), trash and other pollutants and address TMDLs for these pollutants.	• PCB, metals and toxics reduction (yes=1, no=0) • Trash reduction (lbs.)
	Develop green infrastructure, including riparian buffers and removal of impervious surfaces on development, existing development and redevelopment.	• Area treated by GI (acres) • Impervious surface reduced or treated (acres)
Protect and restore aquatic and terrestrial habitats to support balanced indigenous communities.	Restore streams to improve, restore and enhance native ecological communities.	• Streams restored (miles of streams) • Reduce stormwater volume discharging to streams (gallons) • Riparian buffers restored and/or increased (acres)
	Identify, protect and restore critical habitats.	Critical habitat protected or restored (acres)
	Enhance aquatic and terrestrial habitat connectivity.	Habitat connected by green corridor (acres)
	Investigate and, where feasible, promote actions that might surpass regulatory requirements.	Exceeds regulatory requirements (yes=1, no=0)
Engage and educate the public to share responsibility and take action on achieving healthy watersheds.	Engage and efficiently educate the public about standards, processes and actions associated with watershed health and public health.	Residents reached by effort (# of people)
	Assist in the education of citizens about overall water quality issues and benefits of improved water quality.	Residents reached by effort (# of people)
	Support and encourage local action to improve water quality.	• NGOs/community groups provided support by City (# of groups) • Money available for incentives (dollars)
	Provide quicker public notifications of spills or pollution from regulators or other "river watchers."	Time to notify (days)
Implement land conservation and restoration and incorporate these into planning practices to improve water quality.	Protect, restore and increase riparian buffers.	Riparian buffers restored and/or increased (acres)
	Reduce impervious surfaces.	Impervious surface reduced or treated (acres)
	Increase natural land cover with a focus on preserving, maintaining and increasing tree canopy.	Trees planted (acres)
	Incorporate green infrastructure in new development and redevelopment.	Area treated by GI (acres)
	Conserve lands where possible and consistent with Richmond's Comprehensive Plan.	Conservation easements added (acres)
Create partnerships across the watersheds internal and external to the City of Richmond to maximize benefits and minimize impacts to all stakeholders.	Develop and implement a source water prevention plan/strategy.	Plan produced (yes=1, no=0)
	Establish public-private partnerships to secure funding, implement strategies and projects, and achieve plan goals.	Partnerships implemented (# of)
	Maintain and expand the RVAH20 group.	Meetings held (# of)
Maximize water availability through efficient management of potable water, stormwater and wastewater.	Reduce use of potable water for industry and irrigation.	• Potable water consumption reduced (gallons) • Rainwater and stormwater used for irrigation (gallons)
	Achieve water conservation by improving the existing water conveyance system.	Amount of water conserved (gallons)
	Achieve water conservation by incentivizing upgrades to end-user water fixtures where appropriate.	Money available for incentives (dollars)
Provide safe, accessible, ecologically sustainable water-related recreational opportunities for all.	Improve water quality to promote safe recreation consistent with the City's Riverfront Plan.	• Percent increase in monthly geomean WQS compliance • Average yearly E. coli load reduction (billion cfu) • Average yearly reduction in CSO events (number) • Average yearly reduction in CSO volume discharged (million gallons)
	Promote ecologically sustainable management of riverfront and riparian areas.	Streams with buffers (length of streams with 100-foot buffer added)
	Improve river and waterfront access for recreation.	Access points (yes=1, no=0)
Work collaboratively to gather consistent high-quality data to characterize the status and trends of water resources and to gauge the effectiveness of restoration efforts.	Conduct water quality and biological monitoring.	Stations monitored (# of stations)
	Provide timely water quality information.	Time necessary for monitoring results (days)
	Collaborate with citizens and local/state agencies for coordinated monitoring.	Citizen groups/agencies coordinated with (# of)
	Utilize results to target restoration efforts and convey progress.	Project with monitoring component (yes=1, no=0)

RVA H2O EVERY DROP COUNTS

City of Richmond Department of Public Utilities

Appendix 4. Calculator Spreadsheet Tool

See attached Excel document.

Appendix 5. Strategy Cost Estimation

See attached Excel document.

Richmond - Crater

Hazard Mitigation Plan 2017

Charles City County
City of Petersburg
City of Richmond
Chesterfield County
City of Colonial Heights
Dinwiddie County
Town of McKenney
Goochland County
Greensville County
City of Emporia
Town of Jarratt
Hanover County
Town of Ashland
Henrico County
New Kent County
Powhatan County
Prince George County
City of Hopewell
Surry County
Town of Claremont
Town of Dendron
Town of Surry
Sussex County
Town of Stony Creek
Town of Wakefield
Town of Waverly





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1 Executive Summary

During 2003, the Commonwealth of Virginia encouraged its 21 planning districts to lead the development of local hazard mitigation plans. These plans, required by the Disaster Mitigation Act of 2000 (DMA2K) for hazard mitigation assistance (HMA) grant program eligibility, help local governments determine risks and vulnerabilities and identify projects to reduce these risks. The Richmond-Crater Multi-Regional Hazard Mitigation Plan is an update to plans approved in 2006 by the jurisdictions of the Richmond Regional Planning District Commission (PDC) and Crater PDC and the combined Richmond Regional and Crater PDC 2011 Multi-Regional Hazard Mitigation Plan.

The Richmond Regional and Crater PDCs convened a joint Hazard Mitigation Technical Advisory Committee (HMTAC) appointed by each respective locality chief administrative official to lead plan development for 26 member jurisdictions. The HMTAC met three times during the planning process and worked closely with Dewberry Consulting, LLC to develop the multi-regional plan update. Public input was sought throughout the process in accordance with DMA2K requirements.

1.1 Hazard Identification and Risk Assessment

A solid fact base is a key component of any plan. The Hazard Identification and Risk Assessment (HIRA) serves as the fact base for the regional hazard mitigation plan. The HIRA consists of three parts. Its purpose is to:

1. Identify which hazards could affect the Richmond-Crater region
2. Profile hazard events and determine what areas and community assets are the most vulnerable to damage from these hazards and
3. Estimate losses and prioritize the potential risks to the community.

For this plan update, certain hazards were not addressed due to the infrequency of occurrence and/or limited impact, several were combined and several added. Table 1-1 summarizes the results of the hazard identification, which are explained fully in Section 5.0, Hazard Identification and Risk Assessment.

Table 1-1. Planning Consideration Levels by Hazard Type for 2017 Update

Hazard Type	2011 Planning Consideration Level	Commonwealth of Virginia 2013 HIRA Hazard Ranking	2017 HMTAC Preliminary Ranking	2017 HIRA Ranking Analysis**
Flooding	Significant	High	Moderate	Moderate
Wind*	Moderate	Medium-High	High	Limited
Tornado*	Moderate	Medium-High	High	Significant
Hurricane*	Moderate	Not ranked	High	Significant
Winter weather	Moderate	Medium-High	High	Moderate
Thunderstorms* (including Hail and Lightning)	Moderate	Negligible	High	Moderate
Droughts (with Extreme Heat)*	Moderate	Droughts = Medium Extreme Heat = Negligible	Limited	Limited
Mass evacuation.	Moderate	Not ranked – Discussed in other Commonwealth of Virginia emergency operations plans	Limited	Limited
Wildfires	Limited	Medium	Limited	Limited
Earthquakes	Limited	Medium-Low	Limited	Limited
Landslides/shoreline erosion*	Limited	Landslide = Medium-Low Erosion = Negligible	Limited	Limited
Karst	Limited	Low	Limited	Limited

* Some event types were combined (Droughts/Heat and Landslide/Erosion) or separated (Wind/Tornado and Hurricanes/Thunderstorms) from other plans and votes to accommodate the 2017 HMTAC's current concerns for their regions.

** Ranking analysis explained in section Analysis and Data Sources.

The HIRA described each of the hazards in varying levels of detail consistent with each planning consideration level. In general, the HMTAC found that winter storm, tornado, wind, hurricane and thunderstorm hazards were the most significant. Quantitative analysis using various datasets found tornado and hurricane to be the most significant with flooding, winter weather and thunderstorms to have moderate predicted impacts.

Floods occur primarily along the three major watersheds in the region: the York, James, and Chowan Rivers. Flooding seems to occur most frequently in May, August, and September but more recently localized flooding occurred during severe storms in June and July, 2016. A new method to assess flooding risk was used – FEMA's Total Exposure in Floodplains version 2.0 or TEIF 2.0 which analyzes flood risk using building footprints apportioned within regulated flood hazard areas. The TEIF 2.0 methodology uses building footprints from local jurisdictions to apportion total replacement values of buildings at the census block-level (1000 square feet units). The TEIF methodology divides building replacement values by proportionate methods (area of each respective building footprint). For example if a census block is known to have $1M of value associated with all buildings and there are a total of ten (10) buildings in the census block - each building having the same exact size – a proportional distribution would dictate that each building has a value of $100,000. After Hazus values are dispersed to the building footprints, the buildings within the Special Flood Hazard Area were identified and the portions (or percent area) of buildings within the floodplain was calculated. Ultimately, the dispersed replacement values were tallied for the dollar value associated with each respective building that is entirely or partially in the floodplain. These values are then generalized into 1000 ft^2 blocks to comply with regulations and not target individual structures or building owners.

In Table 5-11 in Section 5, each jurisdiction was evaluated and ranked in the study area using the TEIF 2.0 revised analysis (except for City of Colonial Heights, which did not have building footprints at the time of analysis). The City of Richmond has the highest flood risk estimated at nearly $217M in damages.

Severe wind events, such as hurricanes and tornadoes, have historically affected the area. Generally, hurricanes tend to bring flooding rather than high winds but in Central Virginia the opposite is often true with high wind impacting areas with tree cover causing roof damage and power outages due to downed power lines. Flooding from tropical and sub-tropical storm events and severe thunderstorms tends to be localized and in many cases due to a high proportion of paved or impervious pavement in densely populated watersheds which cannot absorb high volumes of runoff during intense storms. Tornadoes recorded in the region have typically been F0 (40–72 mph; light damage) or F1 (73–112 mph; moderate damage) in intensity. A rare winter tornado event on February 24, 2016 resulted in three fatalities in the Town of Wakefield.

Winter storms can have major impacts on the region. Three winter storm events resulting in declared disasters have occurred in the Richmond-Crater region since 2011. Winter storms typically cause loss of utilities, business disruption, and road closures but not large structural impacts.

1.2 Capability Assessment

The capability assessment evaluates the current capacity of the communities of the Richmond-Crater region to mitigate the effects of the natural hazards identified in the HIRA. By providing a summary of each jurisdiction's existing capabilities, the capability assessment serves as the foundation for designing an effective hazard mitigation strategy.

Table 1-2. Mitigation Capability Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
Richmond Regional PDC	Planning High	Moderate	Moderate	N/A	Moderate
Crater PDC	Planning High	Moderate	Moderate	N/A	Moderate
Charles City County*	Moderate	Moderate	Moderate	Moderate	Moderate
Chesterfield County	High	High	High	High	High
City of Colonial Heights	Moderate	Moderate	Moderate	Moderate	Moderate
Dinwiddie County	Moderate	Moderate	Moderate	Moderate	Moderate
*Town of McKenney**	Limited	Limited	N/A	Limited	Limited
City of Emporia	Moderate	Moderate	Moderate	Moderate	Moderate
Goochland County	Moderate	Moderate	Moderate	Moderate	Moderate
Greensville County	Moderate	Moderate	Not Provided	Moderate	Moderate
*Town of Jarratt**	Limited	Limited	N/A	Limited	Limited
Hanover County*	Moderate	Moderate	N/A	Moderate	Moderate
*Town of Ashland**	Moderate	High	N/A	Limited	Moderate
Henrico County	High	High	High	High	High
City of Hopewell	Moderate	Moderate	Moderate	Limited	Moderate
New Kent County	Moderate	High	Moderate	Moderate	Moderate
City of Petersburg	Limited	Limited	Moderate	Limited	Limited
Powhatan County	Moderate	High	Moderate	Moderate	Moderate
Prince George County	Moderate	Moderate	Moderate	Moderate	Moderate
City of Richmond	Moderate	Moderate	Moderate	Limited	Moderate
Surry County*	High	High	N/A	High	High
*Town of Claremont**	Limited	Limited	N/A	Limited	Limited
*Town of Dendron**	Limited	Limited	N/A	Limited	Limited
*Town of Surry**	Limited	Limited	N/A	Limited	Limited

Table 1-2. Mitigation Capability Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
Sussex County*	Moderate	Limited	N/A	Limited	Limited
*Town of Stony Creek**	Limited	Limited	N/A	Limited	Limited
*Town of Wakefield**	Moderate	Moderate	N/A	Moderate	Moderate
*Town of Waverly**	Limited	Limited	N/A	Limited	Limited

High: No increase in capability needed (e.g., extensive regulations on development in place).
Moderate: Increased capability desired but not needed (e.g., funding exists for mitigation but availability fluctuates).
Limited: Increased capability needed (e.g., additional staff are needed to successfully implement mitigation projects).
Source: Capability Assessment Survey Results.
*Based on 2011 Self-Assessment; 2016 Survey not returned.

1.3 Mitigation Strategy

The HMTAC, at its October, 2016 meeting, aligned the updated regional mitigation goals to be consistent with the six Central Virginia Emergency Management Alliance priorities. A new goal, Goal 1 was added to provide mitigation emphasis:

Goal 1: Reduce risk exposure and vulnerabilities to hazards ranked “medium” and “high” by focusing on regional and local mitigation actions on priority hazards.

Goal 2: Prepare and protect the whole community within the Central Virginia Emergency Management Alliance (CVEMA) region through all-hazards planning staff, outreach publications and activities, and through training, and exercising volunteers and the general public.

Goal 3: Strengthen and sustain response coordination and collaboration through planning, equipment, training, and exercises to increase interoperability between all stakeholders in the CVEMA region and other regions/entities that impact interoperability within the region, to include, but not limited to voice, video, and data.

Goal 4: Provide support for public health and human service needs of the whole community through robust and coordinated sheltering capability, to include planning, resources, equipment, training, and exercises to include support of client needs tracking, family reunification services, information sharing, and public health response support.

Goal 5: In the aftermath of a catastrophic incident, provide restoration of basic services, long term housing, and revitalization of a sustainable economy that includes the health, social, cultural, historic, and environmental fabric of the community, through planning, staffing, equipment, training, and exercises.

Goal 6: Enhance and maintain public safety and incident management response capabilities to all hazard emergencies including acts of terrorism, through planning, staffing, equipment, training, and exercises.

Goal 7: Protect the critical infrastructure of the CVEMA region, and enhance the capability to disrupt criminal or terrorist threats through effective information and intelligence gathering and sharing, outreach, planning, equipment, training, and exercises.

In addition, committee members and their jurisdiction staff identified and prioritized mitigation actions for the regional planning district commissions and each jurisdiction. Counties, cities and the Town of Ashland met with PDC representatives to update mitigation actions; towns (except Ashland) were engaged by email or phone conversations by PDC planners and/or county emergency managers. Each jurisdiction's priorities were developed from data collected on past damages, existing exposure to risk, community goals, and weaknesses identified in Section 6.0: Capability Assessment along with local knowledge of local needs.

1.4 Plan Maintenance Procedures

The plan outlines a procedure for implementation, maintenance, and plan updates. The Richmond Regional and Crater PDCs will be responsible for monitoring this plan. The PDCs will request an annual progress update on implementation of local mitigation action plans from the HMTAC or the Central Virginia Emergency Management Alliance in November to be provided by January 31 and will likewise report on the same for their respective PDC. These annual progress reports will begin in 2018 and will include corrective action plans if needed, based on evaluation criteria set by the HMTAC. The annual progress reports will be consolidated by Richmond Regional and Crater PDCs and shared with the Virginia Department of Emergency Management (VDEM) and Federal Emergency Management Agency Region 3.

In accordance with Federal Emergency Management Agency (FEMA) regulations, a written update will be submitted to the Commonwealth and FEMA Region III every five years from the original date of the plan, unless circumstances (e.g., Presidential disaster declaration, changing regulations) require a formal update earlier. The public will be continually informed of changes to the plan as they occur.

1.5 Conclusion

This Richmond-Crater Multi-Regional Hazard Mitigation Plan embodies the continued commitment and dedication of the local governments and community members of the Richmond-Crater region to enhance the safety of residents and businesses by taking actions before a disaster strikes. While nothing can be done to prevent natural hazard events from occurring, the region is poised to minimize the disruption and devastation that so often accompanies these disasters.

2 Introduction

2.1 Mitigation

Mitigation is commonly defined as sustained actions taken to reduce or eliminate long-term risk to people and property from hazards and their effects. A mitigation plan states the aspirations and specific courses of action that a community intends to follow to reduce vulnerability and exposure to future hazard events. These plans are formulated through a systematic process centered on the participation of citizens, businesses, public officials, and other community stakeholders.

A local mitigation plan is the physical representation of a jurisdiction's commitment to reduce risks from natural hazards. Local officials can refer to the plan in their day-to-day activities and in decisions regarding regulations and ordinances, granting permits, and funding of capital improvements and other community initiatives. Additionally, these local plans will serve as the basis for states to prioritize future grant funding as it becomes available.

The Richmond-Crater Multi-Regional Hazard Mitigation Plan will continue to be a useful tool for all community stakeholders by increasing public awareness about local hazards and risks, and providing information about options and resources available to reduce those risks. Educating the public about potential hazards will help each jurisdiction protect itself against the effects of future hazards, and will enable informed decision-making regarding where to live, purchase property, or locate business.

The area covered by this plan includes:

- Town of Ashland
- Charles City County
- Chesterfield County
- City of Colonial Heights
- Town of Claremont
- Town of Dendron
- Dinwiddie County
- City of Emporia
- Goochland County
- Greensville County
- Hanover County
- Henrico County
- City of Hopewell
- Town of Jarratt
- Town of McKenney
- New Kent County
- City of Petersburg
- Powhatan County
- Prince George County
- City of Richmond
- Town of Stony Creek
- Town of Surry
- Surry County
- Sussex County
- Town of Wakefield
- Town of Waverly

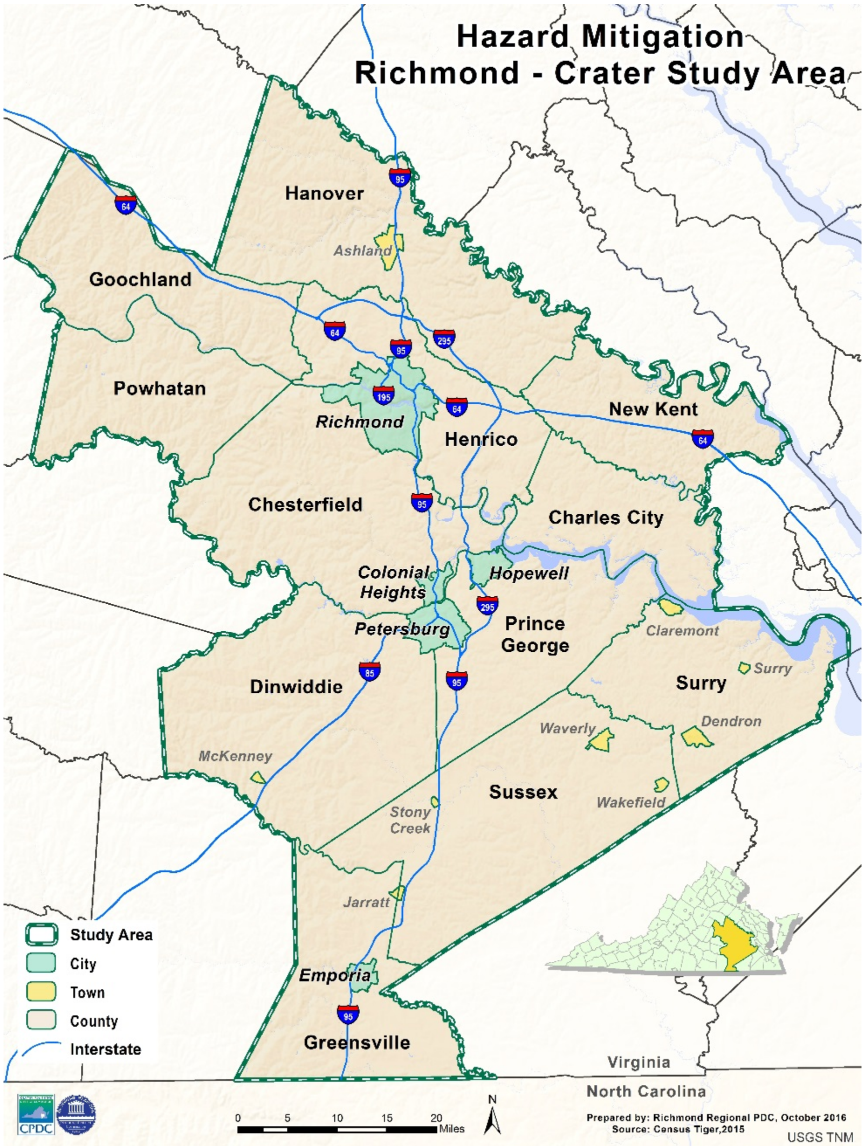

Figure 2-1. Richmond Regional – Crater Multi-Regional Hazard Mitigation Plan Update Communities

2.2 The Local Mitigation Planning Impetus

On October 30, 2000, President Clinton signed into law the Disaster Mitigation Act of 2000 (DMA2K), which required state and local mitigation plans that would help to reduce loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters.

DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act and added a new section to the law, Section 322, Mitigation Planning. Section 322 requires local governments to prepare and adopt jurisdiction-wide hazard mitigation plans for disasters declared after November 1, 2004, as a condition of receiving Hazard Mitigation Grant Program (HMGP) project grants and other non-disaster related mitigation grant assistance programs. Local governments must review and, if necessary, update their mitigation plans every five years from the original date of the plans in order to continue Hazard Mitigation Assistance (HMA) program eligibility.

The requirements for local mitigation plans are found in Section 44 Code of Federal Regulations Part 201.6. FEMA's *Local Multi-Hazard Mitigation* Planning Guidance issued on October 1, 2011 provides updated FEMA interpretation and explanation of local plan mitigation regulations and FEMA's expectations for mitigation plan updates. In addition, VDEM and FEMA now use the 2013 *Local Mitigation Plan Review Tool* to ensure that a plan meets FEMA's regulatory requirements as well as additional requirements identified by the Commonwealth.

2.3 Organization of the Plan

Section 3.0 – Planning Process defines the processes followed throughout the update of this plan including a description of the Richmond-Crater region's stakeholder involvement.

Section 4.0 – Community Profile provides a physical and demographic profile of the area, looking at characteristics such as geography, hydrography, development, people, and land uses.

Section 5.0 – Hazard Identification and Risk Assessment evaluates the natural hazards likely to affect the Richmond-Crater region, and quantifies whom, what, where, and how the region might be affected by natural hazards. Critical facility information has been redacted and is located in Appendix I, available upon request from the Richmond Regional and Crater Planning District Commissions.

Section 6.0 – Capability Assessment analyzes each of the local jurisdictions' policies, programs, plans, resources, and capabilities to reduce exposure to hazards in the community.

Section 7.0 – Mitigation Strategy addresses the Richmond-Crater region's issues and concerns for hazards by establishing a framework for mitigation activities and policies. The strategy includes updated goals and a range of updated mitigation actions to achieve these goals.

Section 8.0 – Plan Maintenance Procedures specifies how the plan will be monitored, evaluated, and updated, including a process for continuing stakeholder involvement after the plan is completed.

Section 9.0 – References includes a list of the reports and data used to develop this plan.

Appendices are included at the end of the plan, and contain supplemental reference materials and more detailed calculations and methodologies used in the planning process. The complete meeting and outreach support materials, history of federal disaster declarations in the region, additional HIRA data, and 2011 mitigation action status updates may all be found in the Appendices along with a detailed summary of updated information in the 2017 plan. Appendix D details the 2017 to 2022 Mitigation Actions for each jurisdiction and the PDCs.

3 Planning Process

The Richmond Regional and Crater PDCs each led the development of their first regional hazard mitigation plans for the jurisdictions within their respective regions during 2005.

For the required 2011 updates, the PDCs and their participating jurisdictions decided it was in the best interest of the regions to conduct a joint planning process, resulting in the Richmond-Crater Multi-Regional Hazard Mitigation Plan. This combined effort was chosen to leverage the advantage of shared resources, and build on the success of similar multi-jurisdiction partnering agreements. This approach has been continued for the 2017 Richmond-Crater Multi-Regional Hazard Mitigation Plan with technical assistance and support provided by Dewberry Consulting, LLC.

The HMTAC worked with the consultants throughout the planning process to ensure that potential stakeholders participated in the planning process including reviewing the draft and final versions of the plan. The Richmond Regional Planning District Commission received a FEMA Pre-Disaster Mitigation program grant to support the 2017 plan update and contracted with Dewberry Consultants, LLC, on behalf of all participating jurisdictions, to update the plan during 2016 – 2017.

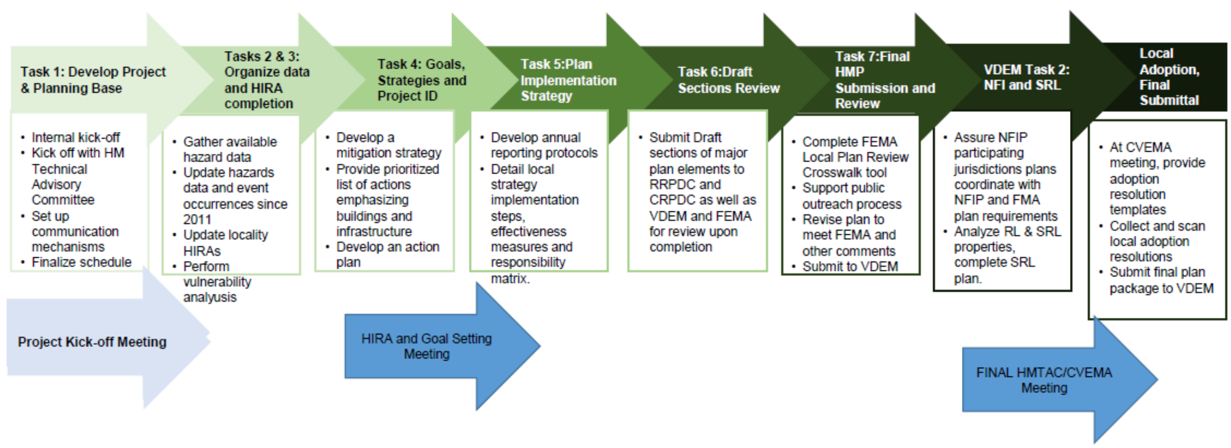

Figure 3-1 Mitigation Plan Update Process

The plan update followed a traditional mitigation plan update process initiated with a regional resiliency meeting on July 12, 2016, then a HMP update kick-off meeting, draft updating of the capability analysis, community profile and HIRA during August and September, 2016 while the HIRA was being updated. During late October 2016, the draft HIRA was presented to the HMTAC and new goals mirroring the Central Virginia Emergency Management Alliance priorities were developed.

Local meetings were conducted in November and December to create 2017 – 2022 mitigation actions responsive to the HIRA update. Outreach was conducted seeking comments on the draft HIRA during December, 2016 using a variety of media outlets and three meetings were conducted. The final plan was drafted, made available through a variety of media outlets, and submitted to VDEM for review. Stakeholder engagement was encouraged through invitations to meetings, newsletter updates, and the outreach process throughout the project beginning with the July 12, 2016 resiliency workshop. Localities also engaged stakeholders at the community level, inviting discussion whenever possible.

For the Richmond and Crater regions, the regional Planning District Commissions are composed of local jurisdictional elected officials such as members of county boards of supervisors, town council members, city council members, their appointees and chief administrative official such as the county/city/town administrator/manager. The majority of members for both the Richmond and Crater PDCs are elected offices. For all land development activity, these are the officials who make final land development decisions, approve their comprehensive plans and ultimate adoption of the 2017 Richmond-Regional – Crater PDC Multi-Regional Hazard Mitigation Plan Update. Throughout the HMP Update process, beginning with application for final support through a VDEM/FEMA Hazard Mitigation Assistance grant, each respective local jurisdiction has been updated on plan development progress in monthly PDC reports and at monthly PDC meetings. The approval responsibility of these elected officials connects the plan update, which they adopt upon FEMA conditional approval, to local comprehensive plan, zoning change and land use development decisions, which they also approve.

3.1 The Hazard Mitigation Technical Advisory Committee

The PDCs convened a HMTAC comprised of representatives of each participating jurisdiction and non-governmental stakeholders. The HMTAC worked with the Dewberry team and provided input at each key stage of the planning process, including reviewing the format and content of the previous plan and making decisions on what information to carry forward into the 2017 plan update. HMTAC members responded to surveys detailing plan implementation and mitigation capabilities; updated their 2011 plan actions; participated in HMTAC kick-off and HIRA/Goal Setting meetings; organized and participated in local meetings with PDC representatives to create a comprehensive menu of 2017 – 2022 mitigation actions which respond to identified priority hazard risks, reviewed document drafts and supported outreach efforts. Appendix E contains the record of changes that documents how each section in the 2011 plan was updated in the 2017 plan. Efforts to involve city, county, and town departments and community organizations that might have a role in implementation of the mitigation actions or policies included invitations to attend meetings and serve on the HMTAC, access to the project website where files could be accessed and shared among the committee, e-mail updates, mitigation action development workshops, numerous outreach events and opportunities for input and comment on all draft deliverables.

The PDCs are grateful for the professionalism, dedication, knowledge and guidance of those who served on the HMTAC throughout the planning process and their representative departments and organizations. Table 3-1 lists contributing HMTAC members.

Table 3-1. Hazard Mitigation Technical Assistance Committee

Name	Jurisdiction/ Organization	Department	Title
Zach Trogden	Charles City County	Administration	County Administrator
Emily Ashley	Chesterfield County	Emergency Management	Deputy Coordinator of Emergency Management
Heather Barrar	Chesterfield County	Planning	Principal Planner
Beverley Brandt	City of Colonial Heights	Emergency Management	Colonial Heights Fire and Emergency Medical Services (EMS) Manager
Heather S. Hunnicutt	Town of Claremont	N/A	Clerk/Treasurer
Ken Ryals	City of Emporia	Emergency Management	Emergency Management Coordinator
Benjamin Ruppert	City of Hopewell	Emergency Management	Emergency Services Coordinator
Brian Sturdivant	City of Petersburg	Emergency Management	Fire Chief
Mark Milazzo	City of Petersburg	Emergency Management	Division Chief / Deputy Emergency Coordinator
Anthony McLean	City of Richmond	Emergency Management	Emergency Management Coordinator
Bill Lawson	City of Richmond	Emergency Management	Emergency Management Planner
Jonet Prevost-White	City of Richmond	Community Development	Operations Manager
Mark Bittner	Crater PDC	Planning and IT	Director of Planning and Information Technology
Dennis Morris	Crater PDC	N/A	Executive Director
Dennis E. Hale	Dinwiddie County	Fire Department	Director of Public Safety

Table 3-1. Hazard Mitigation Technical Assistance Committee

Name	Jurisdiction/ Organization	Department	Title
Bill MacKay	Goochland County	Fire and EMS	Chief
Reggie Owens	Greensville County	Emergency Management	Emergency Management Coordinator
Corey Beazley	Hanover County	Fire and EMS	Fire/EMS Lieutenant
Anna M. McRay	Henrico County	Emergency Management	Deputy Coordinator of Emergency Management
Rick Opett	New Kent County	Fire and EMS	Fire Chief
Curt Nellis	Powhatan County	Department of Emergency Management	Emergency Management Coordinator
Donald Hunter	Prince George County	Emergency Management	Deputy Emergency Coordinator
Ed Snyder	Richard Bland College		Emergency Management
Martha Sickle	Richmond Regional PDC	N/A	Executive Director
Jackie S. Stewart	Richmond Regional PDC	Administration	Project Manager
Kathy Robins	Richmond Regional PDC	Administration	Senior Emergency Management Planner
Leigh Medford	Richmond Regional PDC	Planning	GIS Coordinator
Sarah Stewart	Richmond Regional PDC	Planning	Environmental Planner
Chuck Gates	Richmond Regional PDC	Administration	Deputy Executive Director
Ervin H. Jones	Surry County	Emergency Management	Interim Emergency Services Coordinator
Eddie Vick	Sussex County	Public Safety	Public Safety Coordinator
Vandy Jones III	Sussex County	Administration	Deputy County Administrator
Danielle Progen	VDEM	Region I	All Hazards Planner, Region I
Lori Dachille	VDEM	Region I	Chief Regional Coordinator Region 1
Invited			

Table 3-1. Hazard Mitigation Technical Assistance Committee

Name	Jurisdiction/ Organization	Department	Title
Hon. George L. Edwards	Town of Claremont	N/A	Mayor
Hon. Yvonne Pierce	Town of Dendron	N/A	Mayor
Kathleen Mayes	Town of Waverly	Administration	Clerk
Hon. Arthur G. Elliott, Jr.	Town of Jarratt		Safety Officer
Hon. Charles T. Mansfield	Town of McKenney		Mayor
Hon. F. R. Jackson, Jr.	Town of Stony Creek	N/A	Mayor
Hon. Will M. Gwaltney, Jr.	Town of Surry		Mayor
Hon. C. Winston Britt	Town of Wakefield		Mayor
Hon. Walter J. Mason	Town of Waverly		Mayor

Table 3-2. Resiliency and Mitigation Partners

Name	Organization	Title
Garet Prior	Town of Ashland	Senior Planner
Ralph (Joe) Emerson	Henrico County Planning Department	Director
Stephen Yon	Henrico County Public Works Department	Director
Arthur Petrini	Henrico County Public Utilities Department	Director
Anthony McDowell	Henrico County Division of Fire	Chief
Humberto Cardounel	Henrico County Division of Police	Chief
W.M. Cox	Henrico County Division of Police	Assist. Chief, Administration
A.J. Gordon	Henrico County Division of Police	Homeland Security Liaison

Table 3-2. Resiliency and Mitigation Partners

Name	Organization	Title
David Gunn	Henrico County Department of Public Works	Floodplain Manager
Mary Beth Danuser	Henrico County Department of Planning	GIS Technician
David Calkins	Henrico County Health Department	Emergency Planner
James Beazley	Dominion Virginia Power	Governmental Liaison
Gray Corbett	Central VA Regional Healthcare Coalition	Hospital Coordinator
Andrew Slater	Central VA Regional Healthcare Coalition	Manager
Debby Byrd	Goochland County Community Development	Assistant Director
Todd Kilduff	Goochland County	Director of Utilities & Assistant County Administrator
Gary Fisher	Goochland County	Building Official
Dan Schardein	Goochland County	Deputy County Administrator
Ralph Sheldon	Powhatan County	Building Official
Ed Howland	Powhatan County	Planner & Zoning Manager
David Dameron	Powhatan County	Zoning Administrator
Jason Overstreet	Powhatan County	GIS Coordinator
Ramona Carter	Powhatan County	Director of Public Works
Johnny Melis	Powhatan County	Utilities Manager/Recovery Debris Manager
Steve Chidsey	Hanover County	Deputy Director Public Works
Mike Deiter	Hanover County	Chief Engineering Public Works
Robby Dawson	Chesterfield County	Assistant Fire Chief Community Risk Reduction
Jerry Netherland	Chesterfield County	Police Department Captain
George Hays	Chesterfield County	Utilities Director
David Pritchard	Chesterfield County	Special Projects Manager County Administration
Heather Barrar	Chesterfield County	Planning Department Principal Planner

Table 3-2. Resiliency and Mitigation Partners

Name	Organization	Title
Chris Workman	Chesterfield County	Environmental Engineering – Inspections and Floodplain Manager
Scott Smedley	Chesterfield County	Director of Environmental Engineering
Kathleen Thompson	Chesterfield County	CDGB Budget Coordinator
Allan Carmody	Chesterfield County	Finance Director
James Worthy	Chesterfield County	Director Parks and Recreation
Tammy Ebner	Chesterfield County	Senior GIS Analyst

During July, August and October, 2016 the HMTAC held three meetings and supervised work on the area's mitigation plan. The HMTAC members coordinated and consulted with other entities and stakeholders to identify and delineate natural hazards within the local jurisdictions and to assess the risks and vulnerability of public and private buildings, facilities, utilities, communications, transportation systems, and other vulnerable infrastructure. In addition, the individual HMTAC members met with PDC planners and the consultant to review program capabilities, 2011 mitigation action status and to identify/update 2017 jurisdictional mitigation actions.

In developing the mitigation plan, a majority of necessary communication occurred through telephone calls and e-mails. The HMTAC and Dewberry chose this avenue, rather than meetings, to best accommodate budgets and schedules. A project website was hosted by the Richmond Regional PDC to document draft review and outreach material sharing. Table 3-3 documents meeting dates and their purposes. Attendance lists may be found in Appendix A.

Table 3-3. Hazard Mitigation Technical Advisory Committee Meetings

Date	Summary of Discussions
July 12, 2016	**Richmond Regional – Crater PDC Resilience Workshop:** This regional workshop, sponsored by FEMA Region III and the two planning district commissions, addressed resiliency challenges and opportunities for the central Virginia Region. Many tie-ins to hazard mitigation, including climate change, increased impact of severe storms, floodplain management, and mitigation projects were discussed in plenary presentations and by small break-out groups Many attendees are also members of the HMTAC or were involved in meetings on the local government level to determine 2011

Table 3-3. Hazard Mitigation Technical Advisory Committee Meetings

Date	Summary of Discussions
	mitigation action status, current mitigation program capability, planning processes and to develop new 2017 – 2022 mitigation actions.
August 5, 2016	**Hazard Mitigation Plan Update Project Kick-off Meeting:** Described planning process. Obtained commitment to the project and schedule. Validated list of hazards and rankings from previous plan. Discussed previous plan structure and content; decision was made to retain structure and general level of content. Discussed update process and role of HMTAC members, project schedule and desired plan outcomes.
October 26, 2016	**HIRA Results and Goals Update Meeting:** Presented results of the HIRA and after lengthy discussion concurrence to review and augment critical facilities listing keeping datasets in redacted Appendix. Reviewed and modified goals from previous plan and decided to incorporate Central Virginia Emergency Management Alliance goals. Discussed process for updating previous mitigation actions and developing new actions. Need for at least two public meetings was discussed with Richmond Regional and Crater PDCs agreeing to coordinate.
October 26 – December 5, 2016	Held individual jurisdiction meetings with counties, cities and the Town of Ashland to discuss hazard mitigation strategies. Other towns communicated with via email or calls.
TBD - 2017	**Final Project Meeting:** A **c**ombined HMTAC and the Central Virginia Emergency Management Alliance (CVEMA) meeting will outline adoption procedures for the local plan adoption process and implementation schedule. Note: Will include in a CVEMA meeting (date TBD) based on VDEM-FEMA conditional plan approval.

Participation in various plan development activities is summarized in Table 3-4 and is based on meeting sign-in sheets, photos and knowledge of the project manager. Meeting sign-in sheets are included in Appendix A; not all participants signed in, especially for the Kick-off and HIRA meetings.

Table 3-4. Jurisdiction Participation in the HMP Update Planning Process

Jurisdiction/ Organization	Resiliency Workshop	Kick-off Meeting	Capability Survey/2011 Action Status	Data Provided	HIRA Meeting	Mitigation Actions Meeting	Outreach Activities	Final Meeting TBD (after conditional FEMA Approval)
Charles City County			X	X		X		

Table 3-4. Jurisdiction Participation in the HMP Update Planning Process

Jurisdiction/ Organization	Resiliency Workshop	Kick-off Meeting	Capability Survey/2011 Action Status	Data Provided	HIRA Meeting	Mitigation Actions Meeting	Outreach Activities	Final Meeting TBD (after conditional FEMA Approval)
Chesterfield County	X	X	X	X	X	X	X	
City of Colonial Heights	X	X	X	X	X	X	X	
City of Emporia			X	X		X		
City of Hopewell		X	X	X	X	X	X	
City of Petersburg			X	X		X	X	
City of Richmond	X	X	X	X	X	X	X	
Crater PDC	X	X	X	X	X	X	X	
Dinwiddie County		X	X	X	X	X		
Goochland County	X	X	X	X		X	X	
Greensville County		X	X	X	X	X		
Hanover County	X	X	X	X		X		
Henrico County	X		X	X	X	X	X	
New Kent County		X	X	X		X	X	
Powhatan County	X	X	X	X	X	X		
Prince George County		X	X	X	X	X	X	
Richmond Regional PDC	X	X	X	X	X	X	X	
Surry County			X	X		X		
Sussex County		X	X	X		X		
Town of Ashland	X	X	X	X		X		
Town of Claremont			X			X		
Town of Dendron								
Town of Waverly								
Town of Jarratt								
Town of McKenney			X	X		X		

Table 3-4. Jurisdiction Participation in the HMP Update Planning Process

Jurisdiction/ Organization	Resiliency Workshop	Kick-off Meeting	Capability Survey/2011 Action Status	Data Provided	HIRA Meeting	Mitigation Actions Meeting	Outreach Activities	Final Meeting TBD (after conditional FEMA Approval)
Town of Stony Creek								
Town of Surry								
Town of Wakefield								
Town of Waverly								
VDEM	X	X	N/A		X	N/A		

3.2 Public Participation and Stakeholder Input

Three public meetings were advertised broadly throughout the combined PDC region using traditional news print media, press releases, web postings and social media such as Twitter and Face Book. The purpose of these meetings, internet and press engagement was intended to garner interest and receive comment on the draft hazard identification, risk assessment and vulnerability analysis. In particular, public participation was designed to gather information on threats of most concern. In addition, the meetings were publicized on the Planning District Commissions' websites and a variety of local jurisdiction websites. Appendix A lists media sources that advertised the meetings and includes sample screenshots of the website advertisements, photos and other outreach materials.

Meetings were conducted as follows:

Monday, December 13
6 p.m. to 8 p. m.
Appomattox Regional Library
209 East Cawson Street
Hopewell VA 23860

Friday, December 16
10 a.m. to 2 p.m.
Richmond Regional PDC
9211 Forest Hill Ave, Suite 200
Richmond VA 23235

Monday, December 19
6 p.m. to 8 p.m.

Libbie Mill Library
2100 Libbie Lake East Street
Henrico VA 23230

A brief overview of the plan update process was given to attendees as well as information on changes to risk and vulnerability. Citizen input on areas of concern and ideas for future projects to reduce the impact of natural disasters were sought. Meeting sign-in sheet scans may be found in Appendix A.

The December 13, 2016 Appomattox Regional Library meeting was conducted in Hopewell. There were no citizen stakeholders in attendance but the following HMTAC members were present:

- Chesterfield County Planning
- Hopewell Emergency Management
- Colonial Heights Emergency Management
- Richmond Regional PDC Planner
- Crater PDC Executive Director
- Dewberry – project consultant

At the Richmond Regional PDC December 16, 2016 meeting, Richmond Regional PDC staff were in attendance along with:

- City of Richmond representatives from Emergency Management, Public Utilities, and the Fire Marshall departments
- Prince George County Fire and Emergency Management
- Chesterfield County Emergency Management and
- A citizen who had relocated from Florida state government supporting mitigation who was interested in how the RR-C regional conducted its plan update.

The third and final meeting was conducted at the Henrico County Libby Mill Library on December 19, 2016. In attendance were:

- Richmond Regional PDC Planners
- Henrico Emergency Management
- New Kent Fire and Rescue
- Three citizens interested in the planning process and acquisition of their flood-prone property.

Additional information about the plan, process, study area, and schedule was posted and updated on the project website at www.richmondregional.org/HMP.

The hazard mitigation plan also was discussed at several Richmond Regional and Crater Planning District Commissions meetings, which were advertised and open to the public. A project-specific brochure describing the process and outcomes was developed and made available to the public at meetings and on the PDC website. The brochure was also provided to jurisdictions for local distribution. Efforts were also made to keep the public informed through multiple media means like press releases, Facebook, Twitter, Next Door and emergency management newsletters.

Neighboring jurisdictions were invited to review and provide input into the plan through the Virginia Association of Planning District Commissions which was distributed statewide. Additionally, outreach was directed at these specific planning district commissions:

- Southside Planning District Commission,
- Commonwealth Regional Council,
- Thomas Jefferson Planning District Commission,
- George Washington Regional Commission,
- Middle Peninsula Planning District Commission,
- Hampton Roads Planning District Commission,
- Region 2000 Commission, and
- West Piedmont Planning District Commission.

Comments received from the Crater Planning District Commission and the Region 200 Commission were incorporated into the revised draft plan.

3.3 Incorporation of Existing Plans and Studies

The Richmond-Crater Multi-Regional Hazard Mitigation Plan update incorporates information from a number of other plans, studies, and reports. These documents include:

- 2013 Virginia State Hazard Mitigation Plan, VDEM.
- 2012 Commonwealth of Virginia Emergency Operations Plan, VDEM
- Virginia Department of Conservation & Recreation (DCR) climate reports
- Virginia Employment Commission Economic Data
- Virginia Department of Forestry wildfire data and reports
- Landslide Incidence and Susceptibility in the Conterminous United States, U.S. Geological Survey (USGS).

- Risk Mapping, Assessment, and Planning (Risk MAP) Report, Chowan River Basin, Virginia, May 2011, FEMA.
- Gap Analysis Report, Central Virginia Capabilities Assessment, September 2010, Center for Naval Analysis
- Risk Baseline Analysis, Central Virginia Capabilities Assessment, June 2010, Digital Sandbox.
- FEMA TEIF 2.0 Analysis 2014 and 2016
- Jurisdictional Comprehensive and Emergency Operations Plans
- USDA Census of Agriculture
- 2010 US Census Bureau and UVA Walden Cooper Institute population data
- 2010 – 2014 American Community Survey population estimates

Information about how these plans and studies were incorporated into in Sections 4.0, 5.0, and 6.0 is in those sections where relevant and more specific data sources and information is cited. Full reference information is provided in Section 9.0, References.

3.4 Method and Schedule for Keeping the Plan Current

The progress of plan implementation, including the monitoring schedule, evaluating progress, success and lessons learned, and updates is included in Section 8.0 Monitoring.

4 Community Profile

4.1 Introduction

The Richmond Regional PDC and the Crater PDC are comprised of 26 local jurisdictions, as follows.

- Charles City County
- Chesterfield County
- City of Colonial Heights
- Dinwiddie County
- City of Emporia
- Greensville County
- Goochland County
- Hanover County
- Henrico County
- City of Hopewell
- New Kent County
- City of Richmond
- City of Petersburg
- Powhatan County
- Prince George County
- Surry County
- Sussex County

Towns:

- Ashland
- Claremont
- Dendron
- Jarratt
- McKenney
- Stony Creek
- Surry
- Wakefield
- Waverly

This area encompasses approximately 4,018 square miles and is bordered generally by Fluvanna, Cumberland, Amelia, Nottoway, and Brunswick Counties to the west; Louisa, Spotsylvania, Caroline, King and Queen, and King William Counties, as well as the Pamunkey River to the north; James City, Newport News, Isle of Wight, and Southampton Counties as well as the James and York Rivers to the east; and the State of North Carolina to the south.

Based on total land mass, Dinwiddie County is the largest jurisdiction at 507 square miles. The Cities of Emporia and Colonial Heights are the smallest jurisdictions in the area at around seven square miles each (excluding the towns), while Charles City County is the smallest county at 183 square miles.

The location of the Richmond-Crater region within the Commonwealth of Virginia is depicted in Figure 4-1.

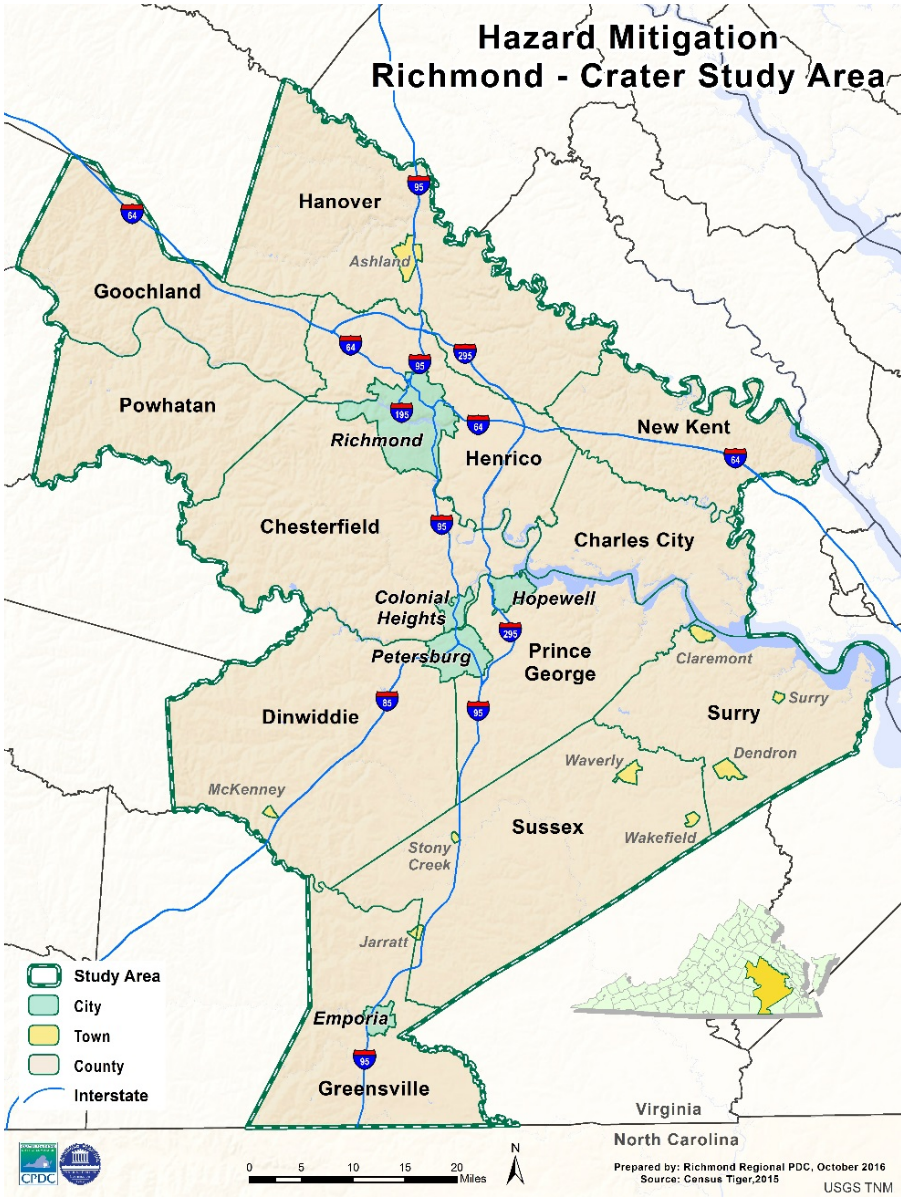

Figure 4-1 Map of Richmond-Crater Region

4.2 Physiography

The Richmond-Crater region is divided between two distinct physiographic regions, the Piedmont and the Coastal Plain, which are divided by the Fall Line. The Piedmont is characterized by deeply weathered, poorly exposed bedrock and a rolling topography. The Fall Line is the easternmost extent of rock-filled river rapids, the point at which east-flowing rivers cross from the hard, igneous, and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the flat Coastal Plain. The areas of the region in the Coastal Plain are gently dissected by streams but can be locally quite rugged where short, high-gradient streams have incised steep ravine systems.[1] The Cities of Richmond, Petersburg, and Emporia lie approximately at the Fall Line, which is where the James, Appomattox, and Meherrin Rivers, respectively, become unnavigable west of the Fall Line.[2]

Elevations in the Richmond-Crater region vary from just at sea level to 500 feet above sea level.[3] Generally, the western portions of the region are at higher elevations.

4.3 Hydrology

The Richmond-Crater region lies within three major watersheds: the James, the York, and the Chowan. The James watershed spans 10,236 square miles, is the largest watershed in Virginia, and is fed mainly by the James River, Appomattox River, Maury River, Jackson River, and Rivanna River. The York watershed covers a much smaller area with a drainage basin of 2,669 square miles. Its main tributaries are the York River, Pamunkey River, and Mattaponi River. The Chowan River basin spans 3,675 square miles and is comprised of the Nottaway River, Meherrin River, and Blackwater River. Additional rivers include the Blackwater River, Chickahominy River, and North Anna River. The James River flows through the City of Richmond. The Meherrin River runs through the center of the City of Emporia while the Appomattox goes through the City of Petersburg. The City of Hopewell is located at the confluence of the Appomattox and James Rivers.

There are also several large creeks that run through the region. Stony Creek passes through the center of the Town of Stony Creek. Swift Creek forms the northern boundary of the City of Colonial Heights.

4.4 Climate

The present-day climate of Virginia is generally classified as humid subtropical but within-state variation of temperatures, precipitation, and length of growing season is dramatic.[4] Average temperatures in the region are about 76 degrees Fahrenheit in the summer and 39

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[1] "The Natural Communities of Virginia: Classification of Ecological Community Groups (Version 2.4)," Virginia Department of Conservation and Recreation, accessed July 18, 2011, http://www.dcr.virginia.gov/natural_heritage/ncintro.shtml.

[2] "Physiographic Regions of Virginia," Virginia Places, accessed July 18, 2011, http://www.virginiaplaces.org/regions/physio.html.

[3] FEMA. *Flood Insurance Study. Charles City County, VA, Unincorporated Areas.* September 5, 1990.
FEMA. *Flood Insurance Study. Powhatan County, VA, Unincorporated Areas.* March 1978.

[4] "The Natural Communities of Virginia: Classification of Ecological Community Groups (Version 2.4)," Virginia Department of Conservation and Recreation, accessed July 18, 2011, http://www.dcr.virginia.gov/natural_heritage/ncintro.shtml.

degrees in the winter. Average annual rainfall is around 43 inches. Average snowfall ranges from 12 to 17 inches annually.

4.5 Land Use and Development Trends

The jurisdictions in the Richmond-Crater region vary dramatically from primarily rural to urban, sometimes within the same jurisdiction. While the Cities of Colonial Heights, Emporia, Hopewell, Petersburg, and Richmond have typical urban/suburban development patterns, most of the counties are rural in character. Charles City, Dinwiddie, Goochland, Greensville, Hanover, New Kent, Powhatan, Prince George, Surry and Sussex Counties are mainly rural with some pocketed areas of suburban development. About 20% of Hanover County is planned suburban development with the remainder for rural residential and agricultural uses. Chesterfield and Henrico Counties and the City of Richmond are more suburban and urban in character.

In Virginia, the authority for land use planning and land use regulations resides at the local level. As required by the Code of Virginia, all jurisdictions in the Richmond-Crater region maintain local Comprehensive Plans that include a land use element and manage land development through zoning and subdivision regulatory ordinances.

In addition to local authority, state and regional programs and processes encourage regional coordination when planning for land use, transportation, economic and environmental matters. For example, the urbanized area of the Richmond-Crater region constitutes two regional transportation planning organizations for federal programs: the Richmond Regional Transportation Planning Organization and the Tri-Cities Metropolitan Planning Organization. As required by federal code, these organizations regularly update a long range regional transportation plan that includes population, housing, and employment projections in the urbanized area and considers land use trends. Most population in the Richmond-Crater region lives within the urbanized area. Projections reflect the expectation that this pattern will persist. The Richmond and Crater Regions also have Comprehensive Economic Development Strategies (CEDS). Analysis of population and employment data are foundational to the development of the CEDS, as to their annual updates over successive years.

For future updates to the Richmond-Crater Multi-Regional Hazard Mitigation Plan, the RRPDC and Crater PDC will perform a high-level analysis of regional and local plans with the goal of maximizing the reduction of risk exposure across the region. An overview of the region will be complemented with focused inspection on areas of concern. These areas of concern will be defined as areas of notable hazard concern given trends related to pace of development, mitigation capacity, risk knowledge and education, etc. This analysis will utilize population, housing, and employment data from PDC initiatives, such as socioeconomic data developed for the regional traffic demand model in the urbanized area, American Community Survey data from the US Census Bureau, and other authoritative sources.

4.5.1 Charles City County

Charles City County is a rural community located between the more urban areas of Richmond and Williamsburg-Newport News metropolitan areas. The county has a wealth of historic homes and other sites reflecting its pre-European settlement history and more than 400 years of post-European settlement. The county is heavily forested with small residential communities scattered throughout. As of 2014, about 80% of the county was used for agricultural or forestry purposes or was otherwise in a natural state.[5] Development tends to be clustered at road intersections or along the James and Chickahominy Rivers. Much of the undeveloped land is in large tracts under single ownership.

The county is divided into three magisterial districts. Almost half of the population is concentrated in the Harrison District that covers the western portion of the county. Most of the commercial and industrial development is also located in the western part of the county. About one-third of the population lives in the central portion of the county, in the Tyler District. The remaining population is in the Chickahominy District.

Most of the housing stock in Charles City County is single-family homes. Given trends in surrounding areas and the rapid increase in the cost of stick-built homes, it is likely the number of manufactured homes in Charles City County will continue to increase.

Forests cover approximately 73% of the County's land area. The majority of the forests, about 75%, is owned by private landowners. In 2007, accessible forest area accounted for 67% of the total available land.[6] Land used for rural residential and public/semi-public uses accounted for the difference.

A Dominion Virginia Power substation provides electricity to the county, located on Chambers Road off Roxbury Road (Rout 106). Two power substations provide electricity to the county. Efforts are underway to ensure that the courthouse and municipal complex are on both grids.

Charles City County seeks to preserve its rural character by establishing development controls which direct growth to neighborhood residential areas within centralized development centers. This breaks from the historic growth pattern, which encourages sprawl and consumes agriculture and farm lands, thereby relieving the pressure on agriculture and forest lands, leading to more orderly and attractive development patterns

[5] "Forest Inventory Data Retrieval (2002-2007)," Virginia Department of Forestry, August 26, 2009, http://www.dof.virginia.gov/resinfo/FIA_2007_StandardTables.htm.

and allowing for efficient use of tax dollars. Transportation growth is anticipated to become focused due to this new policy of directing growth within development centers.

Commercial development is very low in Charles City County when compared to neighboring localities. Commercial land within Charles City County typically consists of country stores with gas pumps, antique shops, garages, greenhouses, banks, marinas, and retail and professional services. Charles City County desires to encourage commercial growth, primarily in the development centers.

Light and heavy industrial growth is expected to continue, especially in light of the expansion of Ft. Lee.

From 2010 to 2020, the region and the state are expected to grow by 15 percent and 10 percent, respectively according to estimates by the Virginia Economic Commission (VEC). The county's population is expected to increase by seven percent between 2010 and 2020, approximately half of the projected growth rate for the region and 78 percent of the projected rate for the state. Based on VEC projections, the county's population is expected to increase by eight percent between 2020 and 2030 and six percent between 2030 and 2040. The total state population is projected to grow at the rate of 9 percent between the time periods 2020 to 2030 and 2030 to 2040.

The Virginia Employment Commission develops projections for non-agricultural employment in the state. Charles City County's industrial makeup is dynamic. Certain industries deplete to negligible levels, while other industries grow, as market conditions vary. Mining is one such industry, which was expected to fall by 92 percent by 2010. However, other industries such as construction are expected to increase in growth through 2020. This is to be expected, as increases in population spur growth in construction because a growing populace requires a greater amount of buildings, homes, and amenities.

The median household income in Charles City County significantly increased from 2000 to 2010 from $39,476 to $47,093, respectively. While there has been consistent growth for county incomes, they have also stayed below the state levels. As reported by the most recent U.S. Census, household income statistics for the county for 2010 were lagging when compared to the state figures. The state as a whole maintained more than twice the percentage of incomes over $100,000 than the county. Median income for county residents was $47,093 while the state figure was higher at $63,302.

4.5.2 Chesterfield County

Chesterfield County has been split into numerous small areas for planning purposes and the development pattern varies immensely between these areas. Portions of the county are built out at suburban densities while other portions of the county remain undeveloped and rural. For instance, the western part of the Southern and Western Planning Area is designated as “rural conservation,” meaning that uses should be restricted to large-lot residential, forestry, or agriculture. Closer to the City of Richmond, however, the development intensity increases. In this area, the Midlothian Turnpike corridor continues to be one of the county’s prime locations for planned light industrial, commercial, and office uses.

Leapfrog development has characterized the Central Area, creating a disjointed development pattern. The types of development in the Central Area have included single-family subdivisions, scattered multi-family complexes, and small- to medium-sized shopping areas often along highway corridors, large employment centers, industrial parks, and an airport. This area is experiencing rapid growth, particularly west of U.S. Route 10.

Significant commercial and industrial development has occurred in the Eastern Area in recent years, and this trend is expected to continue. The Eastern Area also has a great deal of residential development, often adjacent to older commercial-strip zoning and uses. This pattern is particularly seen along U.S. Route 10.

A dominant theme of the 2015 Comprehensive Plan is a commitment to maintain a strong and growing economic base in Chesterfield County. New and existing business and industrial development provides diverse employment opportunities and revenue, and is vitally important in providing the types of services that promote a high quality of life in the county.

Since the 19th century, development patterns have been greatly influenced by the changing transportation and public utilities networks. Traditionally, the economic development base consisted primarily of large manufacturing and chemical industries. Today, the economic base has been enhanced by development of a variety of commercial and corporate office uses providing a range of services and employment opportunities for the county and region. The Richmond Regional Planning District Commission projects that Chesterfield County will have approximately 166,000 jobs by 2035, an increase of 47 percent over 2010.

Chesterfield County is a community committed to promoting and maintaining a high quality of life for all citizens and employers. As such, it is important that the county’s neighborhoods and business corridors be maintained in the highest quality possible and stabilized to ensure continued vitality. The public sector’s role for ensuring long term stability and supporting a high quality of life is to provide equitable distribution and efficient allocation of public resources. Provision of equitable public services will promote private investment and reinvestment in aging and maturing areas.

Between 2010 and 2035, the population is projected to grow by approximately 460,000 people (45% increase), at an average annual growth rate of 1.8 percent. More specifically, the 19 and under age group will increase by an estimated 32,000 people (35% increase); the 60-79 age group will have the largest numeric increase, growing by an estimated 44,000 persons (100% increase); and the 80-plus age group will increase an estimated 16,000 persons (200% increase). While the pace of development slowed during the recession, residential and retail business growth extended along the Midlothian Turnpike and Hull Street western corridors. During the past several years the rapid development pace has increased.

4.5.3 City of Colonial Heights

Colonial Heights is located at the Fall Line, or where the Coastal Plain meets the Piedmont. The city shows a linear development pattern along U.S. Route 1. Residential uses, mainly single-family detached homes, dominate the city, comprising almost 50% of the land use. Recent residential development has come in the form of planned unit developments. Planned unit developments allow for subdivision design flexibility and a mix of housing types. Public sewer is available to most of the developed area. There are six homes along Swift Creek Lane and Pondola Lane that, because of their low-lying location, would be cost-prohibitive to run sewer lines to.

The amount of commercial and business uses have been increasing in recent years. For instance, Southpark Mall Regional Shopping Center, which is accessible from I-95, was built in the past 30 years. Industrial development is limited to the Colonial Heights Industrial Park. About 29% (1,625 acres) of the city is not developed, but the majority of the undeveloped land (983 acres) is unbuildable because of site constraints such as the presence of wetlands, floodplains, or steep slopes.

Land use patterns are generally well established in Colonial Heights, and there is minimal need for significant land use changes. However, there is limited vacant land available for development within the city. There is a need to create regulations to minimize land use conflicts that exist between residential and nonresidential uses. Consider reinstating and expanding the Boulevard grant program to include funding to provide buffer and improve the visibility from the neighborhood.

Economic development opportunities need to be provided on top of those that already exist. There is also a necessity to provide additional opportunities for the development of new housing units; particularly housing that meets the need of the growing elderly population.

There is minimal need for additional public facilities; however, there may be need for additional public parks and open spaces in specific sections of the City that are currently underserved. Where possible, Colonial Heights will incorporate transitional land uses between higher activity uses, such as commercial, to lower activity uses such as single-family neighborhoods with less intense commercial or higher density residential uses, and create a mixture of recreational, commercial and residential along the river as recommended in the Appomattox River Corridor Plan.

The City of Colonial Heights has experienced continued growth for more than 50 years. The most significant growth period for the City was between 1950 and 1960. This was due, in part, to the 1954 and 1957 annexations. The City continued to grow at a relatively fast pace until the 1980s when the population stabilized. With the exception of a slight decrease in population in the 1990s, the City's population has continued to grow, although at a slightly slower pace. It is estimated that the City will continue to grow over the next 30 years.

The City is expected to become more racially diverse over this time. The African American population is expected to increase from 2010 to 2040 by 226%. The Asian population is estimated to increase by 163%. This is not a trend that is exclusive to Colonial Heights; according to the U.S. Census Bureau, it is estimated that by 2060 the non-Hispanic white population is projected to peak in 2024, at 199.6 million nation-wide, up from 197.8 million in 2012. Unlike other race or ethnic groups, however, its population is projected to slowly decrease, falling by nearly 20.6 million from 2024 to 2060.

Of the 11,562 people employed in the City of Colonial Heights, Retail Trade is the top employment industry with 28% of workers, followed by Accommodations and Food Service at 17% with Health Care and Social Assistance coming in third with 13 percent. According to the Virginia Employment Commission (VEC), between 2010 and 2020, there will be 3,009 new Health Care and Social Assistance jobs in the Crater District (cities of Colonial Heights, Emporia, Hopewell and Petersburg and the counties of Charles City, Chesterfield, Dinwiddie, Greensville, Prince George, Surry and Sussex). This industry shows the highest projected growth followed by Retail Trade with 1,146 new jobs for that same time period. Therefore, it is no surprise that of the top 10 occupations expected to grow in the Crater District between 2010 and 2020, eight are related to the medical health field.

4.5.4 Dinwiddie County

Dinwiddie County, like many of the jurisdictions in the Crater Planning District, is divided by the Fall Zone into two physiographic provinces, the Piedmont and the Coastal Plain. The major rivers that flow through this area, the Appomattox and Nottoway, occupy narrow floodplains with only minor meandering. The portion of the county in the Coastal Plain tends to be flat and swampy, which deters development.

The county has grown in three distinct areas. The first area is along major highways such as River Road, U.S. Route 1, and U.S. Route 460. Such development occurs individually or in small strips. Clusters of development are also located in the fringe parts of the Town of McKenney and existing villages and crossroads such as Dinwiddie Courthouse and Sutherland areas. Finally, as the City of Petersburg has expanded, development has begun to cluster in its outskirts in the northeastern part of the county. Approximately 40% of county residents live in this portion of the county. It is also one of the areas where public utilities are available. Residential development patterns include single-family and duplex units, apartment complexes, and manufactured housing parks.

In Dinwiddie County, commercial development tends to occur near residential development. Most of the commercial establishments are located in the northeastern section of the county. In addition, a few businesses are located in the Courthouse area, while travel service facilities such as gasoline stations, motels, and restaurants are located mainly along U.S. Routes 1 and 460. The county has an industrial park at the municipal airport. There is also some industrial presence in the Town of McKenney.

Most of the open space land in Dinwiddie County is under the ownership of timber companies. It is estimated that 244,049 acres of land, or 73% of the county's land area, are in some sort of timber production. The timber stands are mainly located in the western half of the county.

Future growth will be centered in the urban Northeastern Area of the county and scattered throughout the rest of the county. There is concern that farmers will find it difficult to continue using their land for agricultural purposes as development increases.

According to the Bureau of the Census, the increase for Dinwiddie County during the decade of 2000 to 2010 was about 14.2% or 3,468 persons. Review of preliminary Census data shows that about three-fourths of this population increase were white persons.

Future population growth in the County will be highly dependent on future economic growth in Dinwiddie County and the Petersburg Metropolitan Area. According to the latest population projections prepared by the VEC, Dinwiddie County's 2010 population was expected to be 28,874. By 2020 the County's population will be 33,075. Projections often overly depend on past trends and fail to take several factors into account. These factors include residential and economic development and the availability of public water and sewage facilities in the northeastern section of the County. Given the level of development observed in the past few years in Dinwiddie County, the actual population increase in Dinwiddie County from 2000 to 2020 is expected to surpass the State's projections for growth.

Employment in the agricultural, forestry and fishing, construction, services, wholesale trade, retail trade, and finance, insurance, real estate sectors grew from 2000 to 2010 while employment in the manufacturing and government sectors declined during the same period. Sixty-three percent of persons employed in the County work at an establishment employing between 20-249 persons. Only 10 percent of employed persons work for businesses that employ four or less persons. 3,585 persons live and work in the County. Another 7,729 persons commuted out of the County to work while 3,984 persons from other localities commuted into the County to work.

Dinwiddie County is the home to a limited number of industrial concerns. However, its industrial community boast some well-known firms such as Gerdau Steel, Vulcan, Tindall (concrete beams), Walmart Distribution Center, Lemac Corporation, and an Amazon.com Fulfillment Center. The County is in the process of developing a regional industrial park in northeastern Dinwiddie County at a site located at the intersection of I-85 and V.A. Route 460. The development has received significant funding from the Virginia Tobacco Indemnification and Community Revitalization Commission. This site will be the home of the Amazon.com facility dealing with shipping products that have been bought online.

4.5.5 City of Emporia

The City of Emporia is located along the Meherrin River at the Fall Line. Due to the city's location in two physiographic provinces, the slope of its waterways varies between 10 feet per mile and 1 foot per mile.

Emporia has been the historic trade center for Greensville County. It is the county seat and provides travel services for drivers on I-95. As of 2010, most of the land (57.4%) within the city limits was undeveloped. About 26% of this land had site constraints such as floodplains or steep slopes that prevented it from being developed. Of the developed portions of the city, most land was in residential use. Single-family detached homes are the most common type of residential construction in the city, though there are multi-family units scattered throughout. Many of the higher-density units are concentrated in the northeastern section of the city. New residential development is occurring in the southwest part of the city.

Industrial uses are the second most common type of development in Emporia. These uses tend to be concentrated near major transportation routes, such as adjacent to railroad tracks and near the Meherrin River Dam. There are three main retail areas. One is north of the river and is made up of a part of the central business district and the Emporia Shopping Center. The second is south of the river and is comprised of the other part of the central business district and the area near the courthouse. The third area is at the intersection of I-95 and U.S. Route 58, which is the site of a large shopping center.

The Emporia comprehensive plan states that demand for development will continue along its traditional pattern. Single-family homes will continue to be in demand as will auto-oriented commercial uses. The plan notes a focus on downtown revitalization and a desire to discourage rampant strip development.

Though the population of Emporia has fluctuated between 5,300 and 6,000 since 1980, current projections show growth beyond 6,000 to 7,622 by 2040. This would represent a 29% increase in population from the 2010 Census count. By comparison, the rate of growth between 1980 and 2010 was -2.5%. Using the existing average household size (2.25), this growth represents a demand for 775 new housing units by 2040.

The largest increases in population are projected to occur between the 10-19, 30-39 and 70-79 age brackets. These brackets represent families with children and seniors. Future housing in the city will need be focused on housing with access to quality schools and affordable and diverse forms of elderly housing. These housing types may range from assisted living centers for the more active, independent seniors to full-service retirement homes with nursing and medical facilities. A growing elderly population will create demand for specialized types of health care, social, and human services. In addition, both families and seniors benefit from access to parks and recreational opportunities.

Heavily traveled corridor growth has fueled strip development along Route 58 and Market Drive. These developments have negatively impacted Emporia's traditional commercial centers in the downtown areas. However, the growth of regional retail and travel services also benefit the city. Many people traveling along I-95 view Emporia as a destination City and one which is able to provide goods and services required by travelers. In order to take advantage of this unique title, the City should emphasize its travel services through rigorous marketing campaigns.

Over the next twenty years, industrial growth will continue to play an important role in shaping Emporia's future. This will be particularly true of the City's surrounding environs, where larger, more favorable sites for industry are generally located. Although Emporia enjoys a diverse economy, growth prospects for the surrounding area will hinge on the community's ability to retain and attract industry.

4.5.6 Goochland County

Goochland is located approximately 30 miles west of downtown Richmond, 45 miles east of Charlottesville, and 105 miles south of Washington, D.C. Goochland County is still mostly rural and has open land that is well-suited to agriculture and forestry operations. Development has been concentrated in the eastern part of the county. These development pressures are beginning to affect the preservation of open space and important environmental features.

Since the 1970s, Goochland County has been using zoning and the comprehensive plan to implement the village concept. These land use tools have been the impetus in shaping development that supports the county's goals of preserving open space and retaining rural character. In the ideal village concept, new development is directed toward established villages and away from rural and agricultural lands.

The comprehensive plan states that the Weldon Cooper Institute projects growth at 1.75% annually but the County anticipates a higher growth rate in part due to the attractiveness of the county due to its school system, rural atmosphere but proximity to western Henrico County amenities and businesses located in the West Creek Industrial Development. Weldon Cooper projects the 2040 population to be more than 27,500 persons. Due to the national recession, building permits were at their lowest recorded rate during 2005 through 2011 but from 2011 to 2013 increased by 184%.

The Plan states a goal to have balanced development that contributes to the welfare of the community and preserves its rural character through:

- High quality commercial, industrial, and employment hubs
- Vibrant, healthy villages that respect the character of each community
- High quality residential development that is compatible with adjacent land uses
- Preserved natural, cultural, and historic resources
- Viable agricultural and forestry resources that are important components of the local economy

4.5.7 Greensville County

Rolling hills give way to flat land midway through Greensville County, which is bisected by the Fall Line and I-95. Floodplains are wide in the eastern part of the county, accounting for almost half of the land in that part of Greensville. The county's population is primarily clustered around the City of Emporia, which is located in the center of Greensville County. Another population cluster is in the Towns of Jarratt and Purdy. There is some residential development scattered along the primary roads and highways in the county. Mobile homes account for more than 20% of the housing stock.

Future growth is determined by Steep slopes, drainage patterns, wetlands, and flood plains that dictate the amount and nature of development in the County. Growth areas are expected in the Emporia fringe area and along the I-95/U.S. Route 301 corridor. The county plans to implement an urban services district in which capital improvements will be focused. The urbanized parts of the county are currently served by the Greensville County Water and Sewer Authority.

Existing infrastructure systems and services provided by the County for the current populations are adequate but any population increase will require additional services from the county ranging from schools, social services, infrastructure, emergency response and public safety. The Virginia Employment Commission has estimated relatively small population growth during the next 25 years.

4.5.8 Hanover County and the Town of Ashland

Hanover County is located on the northern edge of the Richmond metropolitan area. Agricultural uses dominate the land use map of Hanover County. As of 2007, 31% of land use was dedicated to farm use. Developed areas cluster along the I-95 corridor and within the eastern portion of the county north of I-295. These developed areas tend to be residential in nature in addition to several large concentrations of industrial uses.

The Hanover County/Town of Ashland Comprehensive Plan states a growth goal of:

> *Building on the central County Vision, Hanover County will be known as a community that exemplifies orderly growth and development of both residential and non-residential uses to accommodate existing and future residents while encouraging and promoting commerce. Infrastructure and services necessary to support residential and commercial growth will be expanded in a timely manner to ensure the provision of necessary and adequate services, while maintaining a distinct suburban and agricultural identity.*

Hanover County/Town of Ashland has used a phased growth plan to shape development within the county. All residential designations are contained within the Suburban Service Area boundaries. Throughout the remainder of the county – the rural area – residential development can occur at a density no greater than one dwelling unit for every 10 acres. Several proposed mix-use residential developments on former farms have recently been met with mixed reaction from residents, along with a proposed "village" redevelopment in the western Montpelier community. Hanover's strong school system and relatively low residential property taxes continue to attract residential development.

Business development in general has continued within the major road corridors of the county, with the majority of new businesses being located in proximity to U.S. Route 360 in the eastern part of the county.

The Plan documents the growth management objectives based on proactive use and service zones intended to inform decision makers. The following assumptions form the basis for future demographic projections and demands on the use of land:

(1) **Population Growth**: The average annual growth rate for the period 2012-2032 will range from 1.5 percent to 2.5 percent per year a. For calculation purposes, the plan will assume an average annual growth rate of 1.5% per year b. Based on the 2010 U.S. Census, it assumed the average residential occupancy is 2.68 persons per household

(2) **Suburban/Rural Residential Distribution**: To plan for future growth, it is assumed 70 percent of future residential growth will occur within the Suburban Service Area (SSA), while the remaining 30 percent will occur in the planned rural portions of the County located outside the SSA

(3) **Suburban Density**: Average residential density for the suburban service area will be 3 dwelling units per acre

The Town of Ashland is located in the heart of Hanover County. Established in 1858, the early growth of the town was fueled by the railroad. In more recent times, Randolph-Macon College and I-95 have influenced the town's development. The town is approximately 7 square miles. Ashland is largely developed, so an emphasis is placed on community stabilization and preservation. A FEMA Flood Insurance Rate Map (FIRM) exists for the area annexed by the town in 1996.

4.5.9 Henrico County

According to Henrico County's 2010 Land Use Plan, the majority of the land area of the county was vacant. Portions of this land are undevelopable as they include floodplains and other sensitive areas. As of 2007, out of the approximate land area of 188, 000 acres, 11% was used for farming. Development tends to be concentrated in "mid-town" with re-development of the Willow Lawn shopping center and the new Libbie Place mixed use complex and in the West End in the Short Pump – Glen Allen area with continued residential and retail growth along with a new Virginia Commonwealth University medical outpatient facility located at Short Pump Mall, redevelopment at Willow Lawn and the northern area of the County and expanded residential and retail development in the "East End." The County's 2026 Comprehensive Plan, the most recent available through an online search, predicts population forecasts which are then used as the basis for estimating the demand for housing units and nonresidential land and building area. Because the population is forecasted to grow by more than 117,000 people by 2030, the estimates for housing unit forecasts show a demand for over 48,600 new housing units by 2030. These estimates reflect structure type and not ownership. Single-family attached units include townhouses and condominiums, while apartments are included in multi-family units.

Of the developed portions of the county, residential land uses (21%) dominate followed by public or semi-public uses. The planning department has predicted that demand for retail, residential, and office space will be concentrated in the western portion of the county while industrial demand will be primarily in the eastern portion but significant residential development continues in the eastern portion of the county and a new retail shopping center opened along Laburnum Avenue during the plan update period.

4.5.10 City of Hopewell

The City of Hopewell falls entirely within the Coastal Plain (close to the western edge of the province) and the area governed by the Chesapeake Bay Preservation Act. The steepest slopes in the county can be found along the James and Appomattox Rivers. The city is more than 400 years old and has a significant number of historic buildings and other resources.

Residential uses dominate the land use pattern of the city. Single-family homes are the main housing type, though there are some multi-family units such as apartments, townhomes, and condominiums. Much of the housing was built in the 1900s for workers. Five large subdivisions have been built since 2000.

Industrial uses are found in the northeastern part of the city along the James River and Bailey Creek. The vacant industrial land is owned by existing businesses and is reserved for their future growth. According to the comprehensive plan, a large part of the industrial development is in the floodplain.

The amount of vacant land in the city is not enough to meet future demands for growth. Infill development and redevelopment of existing parcels will have to be pursued. As of 2010, there was limited vacant land available at the new I-295 interchange for commercial development. One goal of the City is to promote industrial development through a commercial business park but available land is limited. Significant residential structures are being converted to business uses in core village areas. Most residential “development” is infill.

4.5.11 New Kent County

Rural land uses dominate New Kent County’s landscape. Commercial centers are located at Bottoms Bridge, Providence Forge, and Eltham, all of which are complemented by nearby residences. There are smaller clusters of residential and commercial development at Lanexa, Barhamsville, and Quinton. New Kent Courthouse has few commercial uses but is a center for government and institutional uses with residences interspersed and nearby. Another mixed-use center, was anticipated for the Kentland development surrounding Colonial Downs which has been slow to materialize due to the closing of Colonial Downs and the recession. Several golf course residential communities and vineyards have proven attractive to residential development and have brought festival events to the county.

Residential development is clustered in a number of subdivisions of various types, but is also widely scattered along rural roads. The bulk of residential development is located in the western third of the county. Areas around Lenexa and the Descend Creek Reservoir have the greatest concentration in the eastern part of the county.

The 2012 comprehensive plan calls for concentrating development in mixed-use village centers. The exception is industrial uses, which should take advantage of the large amount of vacant property along I-64 and U.S. Route 33. According to U.S. Forest Service data from 1991, New Kent forests today cover 98,183 acres in the County representing 72% of the total land mass. Today forests cover 70% of the total county land cover. The County experienced the highest rate of growth from 2000 to 2010 in the region; nearly 37%. The Virginia Employment Commission projects continued population increase in the County, to 23,671 by 2020 and 29,496 by 2030.

4.5.12 City of Petersburg

The City of Petersburg has a finite amount of land for growth as annexation of county land is not an option. Developable land is limited by Chesapeake Bay Preservation Act requirements and other physical site constraints. About 3,586 acres are available for future development (about 70% of the vacant land). Land use fragmentation is a major issue in Petersburg with incompatible uses often located side by side. Petersburg has shown steady population loss in the 1990, 2000, and 2010 Census. However, the same chart shows an increase in population between 2010 and 2020 with continued increases through 2040.

The city has two distinct residential patterns. The first is found in the "Old City," north of I-85. A mix of residential types (e.g., single family, multi-family, and duplexes) is found here. Newer developments, mainly suburban subdivisions, have sprung up south of I-85. Some infill of single-family homes and duplexes has also been seen.

Commercial development has occurred along the major thoroughfares leading from the central business district. There has been commercial infill development, and a new shopping center has been built on U.S. Route 301. A marina is planned for the area between the I-95 Bridge and the U.S. Route 1/301 bridge.

Industrial uses can be found along the Appomattox River in the central business district. New industrial parks have also been built in the southwest (near I-85 and U.S. Route 604) and southeast (I-95 and Route 632) parts of the city.

4.5.13 Powhatan County

Powhatan County is one of the fastest growing localities in the Richmond region with a population of 28,031 based on the Annual Estimates by the Population Division of the U.S. Census Bureau. In spite of the growth trends, the county strives to maintain rural character by encouraging residential development at low densities – one dwelling per five acres with higher densities allowed only where public utilities may be provided. The county has also experienced commercial and industrial growth along U.S. Route 60 where public utilities are available. With the opening of Route 288, the county should continue to experience growth across all use types in the coming years.

For several decades the county grew steadily and by the 1990's dramatic growth and development had occurred. The county's population grew from just over 15,000 to over 22,000 by 2000. The last eight years have shown continued and remarkable growth with an annual average of 300 new homes approved. Most of the new development since 2000 has occurred in large-lot (5-acre) subdivision in pockets throughout the county. With more dense residential development occurring in Scottville near the Courthouse Village, and in Founder's Bridge east of Route 288 in the 711 Village. The majority of recent commercial growth has occurred along the U.S. Route 60 Corridor, and in the 711 Corridor Overlay District east of Route 288. Additional growth has been accommodated through lot splits throughout the county. Agricultural activities have decreased and most agriculture is limited to smaller family farms with some emerging niches like vineyards, green houses, or equestrian related facilities. Silviculture is still practiced within the county but the strongest contribution to the economy is government employment. Using data and forecasts from the Virginia Employment Commission, population is forecasted to grow from slightly over 27,000 as of 2006 to almost 46,000 in 2030. This represents a seventy percent increase. When average household sizes and vacancy rates are applied, this population growth will require 6,500 –7,000 new housing units. Similarly, employment forecasts were also prepared. Employment within Powhatan County is forecasted to grow from almost 6,500 as of 2006 to almost 11,500 in 2030. This represents over a seventy-five percent increase.

4.5.14 Prince George County

During the past 50 years, Prince George County has seen growth despite annexations by the Cities of Petersburg and Hopewell. The county's residents are concentrated in the Prince George Planning District, which is the northwest portion of the county between the two cities.

Approximately 89% of the county is forested or in crop production. The Virginia Department of Forestry estimates that roughly 74% of the total land area is forested, some of which is commercially owned. The remaining 11% of land is dominated by residential development. Single-family homes comprised about 74% of the housing stock followed by manufactured homes that accounted for about 12%. Most of the single-family homes are found in subdivisions near the two cities. The remainder of the residential development is scattered throughout the county. Commercial development occurs primarily as strip development along major routes.

Prince George County prosperity is intertwined with Fort Lee. In 2005, Fort Lee experienced the largest growth ever in Prince George County under the United States Congress Base Realignment and Closure (BRAC) Commission's directives to combine specific Army and Air Force training operations at Fort Lee. In the end, 1.5 billion federal tax dollars were spent to create approximately 6.5 million square feet of new space on post to include Army and Air Force headquarters, new classroom buildings, fitness and dining facilities, new military barracks, a new 1000 room high-rise hotel and new single-family and 22 multi-family housing units. BRAC transformed Fort Lee into a major military facility in Prince George County while other parts of the country lost both federal government revenue and jobs.

The daily population on Fort Lee rose from about 32,000 to 48,000 between 2005, the start of BRAC, and the completion of the BRAC construction projects in 2011. Military personnel came from all across the South to Fort Lee- from Redstone Arsenal, Alabama; Lackland Air Force Base, Texas; Aberdeen Proving Ground, Maryland; as well as from Alexandria and Fort Eustis, Virginia. In January 2009, the combined Sustainment Center of Excellence Headquarters was opened and transformed Fort Lee into the third largest Army training installation in the country. In July 2009, the Army Logistics University was opened and it began offering more than 200 courses and training 2300 military and civilian students on a daily basis both in logistics and military management techniques.

As in 1990, the 2005 BRAC expansion at Fort Lee provided a real boost to the Prince George economy and overall the entire region's economy. BRAC expansion in Prince George helped to sustain both the civilian contractors and the military suppliers during the recession that was brought on by the financial and residential mortgage crisis across the country. Prince George County received federal impact aid funding that assisted in the construction a new county library and assisted in the construction of a new elementary school to help educate the influx of the new military dependent students into the County school system. Federal funds were utilized to make the necessary traffic improvements in Prince George County surrounding Fort Lee such as new traffic lights, turn lanes and other road improvements, all necessary to our national defense and indirectly improving the quality of life for Prince George County residents.

Population projections prepared by the Virginia Employment Commission (VEC) predicted a population of 36,000 in 2003 and in 2010 the actual population of Prince George County was 35,725. Population projections for 2020 and 2030 by the University of Virginia's Weldon Cooper Center for Public Service are estimated to be 39,000 and 41,800 in Prince George County. The population projection for the County by the VEC for 2030 is 63,420.

4.5.15 City of Richmond

Land use patterns are long established and have been reinforced by city planning efforts. The city is mostly developed with limited space for new development. Residential uses dominate the city with commercial service centers spread throughout. Open spaces can also be found throughout the city.

Industrial uses are concentrated in several areas: I-95/James River corridor, west of Jefferson Davis highway to the CSX railroad, Scott's Addition and Hermitage Business parks, Manchester, Rocket's Landing and the Shockoe Valley. Scott's Addition has seen a recent resurgence since the 2011 Plan update with formerly industrial buildings converted to microbreweries, restaurants, apartments and condominiums. Residential development, restaurants and the addition of a large national microbrewery expansion at Rocket's Landing has revitalized a former abandoned industrial area on the north bank of the James River east of the Fall Line.

Since the last plan update, significant re-development and re-purposing has occurred in the Scott's Addition neighborhood north of Broad Street and west of Boulevard. The area is now characterized with a thriving micro-brewery, winery, restaurant, and apartment and condominium economy especially attractive to young, new residents. Hardywood Park microbrewery was one of the first new businesses in this area; other microbreweries have followed.

Manchester, once a separate city, has seen an uptick of revitalization perhaps started with Legend microbrewery 19 years ago. A continued influx of artisans, warehouse to condominium conversions and residential restorations, new businesses and new construction in-fill continue to support neighborhood revitalization. Rocket's Landing, in the eastern part of the city adjacent to the Henrico County border, has been revitalized with a multi-use residential development and the new eastern United States Stone Brewery complex.

Future development efforts will focus on redeveloping blighted and vacant properties. In addition, planning efforts are underway to stabilize declining neighborhoods as well as replace the Diamond baseball complex creating new development in the Boulevard corridor. The Redskins training complex, nearby, has attracted some economic activity during the three to four weeks the team conducts its summer training camp each summer. Particular attention is focused on minimizing conflicts between residential and non-residential uses.

4.5.16 Surry County

Surry County is a rural county characterized by a rolling topography that gradually becomes more level in the eastern portions of the county. Seventy-five percent of the county is forested. Traditionally, forestry and agricultural land uses have supported the majority of employment but have experienced recent decline. Surry County is the location of the Surry Power Station, a nuclear power plant built in 1972 which is the County's main employer.

About 25% of the county lies within the area regulated by the Chesapeake Preservation Act. The county has a floodplain overlay district and relies on its floodplain management ordinance and the Uniform State Building Code to restrict development in the floodplain.

Large tracts of land are generally not available for development. The dominant development trend is the subdivision of farms into large lots. This development trend may create an inefficient land development pattern. The majority of the county is zoned agricultural-residential. Concern is expressed in the (year) comprehensive plan about the county's lack of legal authority to control manufactured home siting in the agricultural-residential district. Considering that the majority of new housing units are manufactured homes, the county is concerned about a decrease in the property tax base. The Cobham Magisterial District has seen the majority of recent growth in single-family home development.

Some pressure exists to develop along the James River shoreline. Currently, the towns of Claremont, Sunken Meadow, and Scotland Wharf have the largest concentration of development along the James River. These areas were heavily impacted by James River surge and wind damage during 2003's Hurricane Isabel. The comprehensive plan calls for future development to be concentrated in and around the historic towns and crossroads that already exist in the county.

4.5.17 Sussex County

Sussex County is primarily rural with agriculture and forestry dominating land use. Forests, agriculture, and residential uses account for more than 79% of the county. The topography is slightly rolling or relatively level with some marsh areas. The Towns of Jarratt, Stony Creek, Wakefield, and Waverly are located in Sussex County.

The county has experienced a population decline since 1950. In addition, the median age has increased since the 1960s. The majority of housing in the county is single-family detached homes. The number of manufactured homes has risen dramatically since 1990. Manufactured homes accounted for 58% of building permits issued between 1990 and 1996. In 1990, manufactured homes accounted for only 24% of the housing stock; by 1996, that percentage had risen to 40%. Most residential development is in subdivisions or as strips along the highway. This pattern preserves land for agricultural and forestry uses.

The Future Land Use Map shows a large portion of the county, including the floodplains, classified for conservation uses. Large lot, residential development is allowed in this area as is agricultural, forestry, and passive recreation. In addition, the plan calls for development to be concentrated in existing community hubs instead of scattered throughout the county.

4.6 Population

The total population of the jurisdictions included in the Richmond-Crater region was 1,200,670, as of the 2010 U.S. Census. Between 2010 and 2014, New Kent County saw the greatest increase in population with a growth rate of 4.1%. Conversely, the City of Emporia experienced a population decline of 4.1%, per 2014 American Community Survey (ACS) data. Table 4-1 shows population by jurisdiction, the associated change rate, and population projections for each jurisdiction to the year 2040. The Richmond-Crater region is anticipated to grow by nearly 25% between 2014 and 2040. This growth is not projected to be evenly distributed across all jurisdictions. Some localities, such as Chesterfield County, New Kent County, and Goochland County, are projected to grow at rates greater than 30%. Other localities, such as Greensville County, City of Petersburg, Sussex County, Surry County, and City of Colonial Heights, are projected to see population losses between 2014 and 2040. Table 4-1 details the population by jurisdiction for the Richmond-Crater region.

Table 4-1. Population by Jurisdiction

Jurisdiction	Estimated Population 2014	Percentage Change in Population 2010–2014	Projected Population 2040	Percentage Change in Population 2014-2040
Charles City County	7,154	-1.4%	7,710	7.8%
Chesterfield County	324,337	2.6%	435,294	34.2%
City of Colonial Heights	17,542	1.0%	16,955	-3.3%
Dinwiddie County (incl. Town of McKenney)	27,993	0.0%	34,080	21.7%
City of Emporia	5,682	-4.1%	6,586	15.9%
Goochland County	21,627	-0.4%	29,174	34.9%
Greensville County (incl. Town of Jarratt)	11,911	-2.7%	11,404	-4.3%
Hanover County (incl. Town of Ashland)	100,689	0.8%	127,780	26.9%
Henrico County	314,878	3.0%	399,966	27.0%
City of Hopewell	22,375	-1.0%	23,482	4.9%
New Kent County	19,187	4.1%	30,964	61.4%
City of Petersburg	32,439	0.1%	28,613	-11.8%
Powhatan County	28,193	0.5%	35,854	27.2%
Prince George County	36,792	3.0%	42,640	15.9%
City of Richmond	211,063	3.4%	250,600	18.7%
Surry County (incl. Towns of Claremont, Dendron, Surry)	6,885	-2.5%	6,403	-7.0%
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	11,923	-1.4%	10,563	-11.4%

Sources: 2014 American Community Survey (ACS); 2010 Decennial Census; Weldon Cooper Center for Public Service, March 2017

4.6.1 Race and Sex

According to 2015 TIGER U.S. Census Bureau data, the majority of the population in the Richmond-Crater region was reported to be of a single race (98.1%). Of the total population reporting one race, 59.4% (712,965) were White and 3.2% were Asian (38,832). The percentage of the population reporting as Black or African American is about 30.4% (364,459), higher than the average for Virginia (19.7%). Only 5.1% of the population (61,110) were reported to be of Hispanic origin.

4.6.2 Language

About 7.6% (89,764) of the residents in the Richmond-Crater region were foreign-born according to 2015 TIGER U.S. Census bureau data. This statistic indicates there may be a significant portion of the community that might require special consideration when developing hazard reduction and outreach strategies for the community.

4.6.3 Age

Another type of special needs group is characterized by age. The 2015 TIGER U.S. Census Bureau data shows that about 6% (72,482) of the population in the Richmond-Crater region is under the age of five while approximately 26% (308,903) is under the age of 20. Additionally, approximately 12% (141,190) of the population is age 65 and above. These figures are similar to the state averages, with the exception of the 65 and over population, being 2.2% below the state average (14.2%).

4.6.4 Education

Data from the 2015 TIGER census estimates shows that about 82% (964,450) of residents in the region graduated from high school and more than 26% (304,789) hold bachelor's degrees or higher. These numbers, coupled with the population characteristics described in the previous paragraph, are important to keep in mind when developing public outreach programs. The content and delivery of public outreach programs should be consistent with the audiences' needs and ability to understand complex information.

The City of Emporia and Sussex County have some of the lowest percentages of people with high school diplomas, while Chesterfield County and Hanover County have the highest. The latter two jurisdictions also have the highest percentage of people with college degrees. The City of Petersburg and the City of Hopewell have the smallest percentage of people with college degrees.

4.6.5 Income

As of 2014, the average median household income in the Richmond-Crater region was approximately $54,620, about 16% less than the state average ($64,792) according to the U.S. Census. Twelve of the seventeen jurisdictions have median household incomes below the state average. About 14.6% (approximately 175,300) of residents within the Richmond-Crater study area live below the poverty line. This rate is slightly lower than that of the national rate of 14.8% in 2014 and above the state rate of 11.8%. These numbers may indicate that a significant portion of the population will not have the resources available to them to undertake mitigation projects that require self-funding. As of 2015, the national rate was reported as 13.5%.

Income levels between the jurisdictions included in the Richmond-Crater region vary greatly. Table 4-2 shows the breakdown by jurisdiction. As the table illustrates, the City of Richmond has significantly lower median incomes while Greensville County has a significantly higher poverty rate than the rest of the region.

Table 4-2. Income Characteristics by Jurisdiction

Jurisdiction	Median Household Income, 2014	Persons Living Below Poverty, 2014
Charles City County	$48,088	13.60%
Chesterfield County	$72,514	7.20%
City of Colonial Heights	$52,529	10.60%
Dinwiddie County (incl. Town of McKenney)	$52,328	13.70%
City of Emporia	$30,240	34.60%
Goochland County	$82,460	6.20%
Greensville County (incl. Town of Jarratt)	$38,933	20.00%
Hanover County (incl. Town of Ashland)	$77,550	5.50%
Henrico County	$61,438	11%
City of Hopewell	$39,156	17.70%
New Kent County	$73,030	5.40%
City of Petersburg	$33,927	27.50%
Powhatan County	$75,447	5.40%
Prince George County	$61,071	10.10%
City of Richmond	$41,331	25.50%
Surry County (incl. Towns of Claremont, Dendron, Surry)	$51,527	11.40%
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	$36,972	22.50%

Sources: 2014 American Community Survey (ACS), 2010 Decennial Census

4.7 Housing

As of 2015, there were 493,778 housing units in the study area according to the TIGER U.S. Census. The majority of the housing units are found in Henrico and Chesterfield Counties. About 70.1% of residents own their own homes, higher than the national average of 62.2% or the state average of 66.7%. The average, however, is skewed by the significantly lower rate of homeownership in the cities of Emporia, Hopewell, Petersburg and Richmond. Table 4-3 illustrates the housing characteristics of each jurisdiction in the Richmond-Crater region. When considering mitigation options, special attention should be given to the difference in capabilities between owners and renters.

Table 4-3. Housing Characteristics by Jurisdiction

Jurisdiction	Housing Units 2014	Housing Units in Multi-unit Structures 2014	Homeownership Rate 2014	Median Value of Owner-Occupied Housing Units 2014
Charles City County	3,263	1.4%	87.1%	$145,600
Chesterfield County	124,384	14.1%	79%	$225,400
City of Colonial Heights	7,817	18.3%	66.9%	$169,900
Dinwiddie County (incl. Town of McKenney)	11,504	3.5%	77.5%	$152,000
City of Emporia	2,722	26.7%	49.2%	$96,700
Goochland County	8,726	0.7%	92.5%	$307,600
Greensville County (incl. Town of Jarratt)	4,118	3.1%	74%	$82,500
Hanover County (incl. Town of Ashland)	39,026	8.2%	84.3%	$269,300
Henrico County	133,795	28.5%	67.4%	$223,500
City of Hopewell	10,185	29.5%	49.8%	$121,900
New Kent County	7,612	0.4%	88.1%	$240,800
City of Petersburg	16,475	33.5%	52%	$109,800
Powhatan County	10,195	1.0%	89.7%	$281,400
Prince George County	12,136	12.5%	70.9%	$196,300
City of Richmond	99,123	42.6%	47.3%	$192,400
Surry County (incl. Towns of Claremont, Dendron, Surry)	3,478	4.1%	73.4%	$166,900
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	4,201	7.4%	65.1%	$111,2000

Source U.S. Census Bureau, State and County Quick Facts.

4.8 Business and Labor

The diversity of the region is reflected in the business sector. While the Richmond-Crater region is home to eight Fortune 500 companies, the outlying area is primarily rural with limited commercial development. The Fortune 500 companies in the region are:

Table 4-4. Richmond-Crater Region Fortune 500 Companies

Fortune 500 Company	2016 Rank	Locality
Altria Group	149	Henrico County
Performance Food Group	185	Henrico County
CarMax	191	Goochland County
Dominion Resources	243	Richmond
WestRock	251	Richmond
Owens & Minor	291	Hanover County
Genworth Financial	306	Henrico County
Markel	476	Henrico County

The sectors with the most employees in the Richmond-Crater region were:

- Health care and social assistance
- Retail trade
- Finance and insurance
- Accommodation and food services
- Manufacturing
- Construction
- Professional, scientific, and technical services
- Other services (except public administration)
- Administrative and Support and Waste Management
- Remediation Services
- Wholesale trade

Sectors with the largest annual payrolls were:

- Finance and insurance
- Health care and social assistance
- Professional, scientific, and technical services Manufacturing
- Retail trade
- Wholesale trade
- Construction
- Administrative and Support and Waste Management and Remediation Services
- Other services (except public administration)
- Accommodation and food services

According to profiles developed by the Virginia Economic Development Partnership, major employers in the Richmond-Crater region are listed by County and City below. Note that the sale of ten MARTIN'S Food Markets to Publix will shift some workers in the grocery sector as the stores are converted to Publix during the next 18 months.

Charles City County:

- Atlantic Bulk Carrier Corp.
- Branscome, Inc.
- Charles City Forest Products Inc.
- Chesapeake Engineering Corp.
- Envelopes Only, Inc.
- U.S. Remodelers Inc.
- Warrior Xpress

Chesterfield County:

- Alstom Power, Inc.
- Amazon.com
- Bon Secours Richmond Health System
- Capital One Service, Inc.
- Campofrio Food Group America
- Defense Supply Center Richmond
- E.I. DuPont de Nemours & Co., Inc.
- Food Lion, Inc.
- Hill PHOENIX, Inc.
- Honeywell International, Inc.
- HCA Virginia Health System
- MARTIN'S Food Markets
- Northrup Grumman Corporation
- Sabra Dipping Company
- The Kroger Company
- United Parcel Service
- Vangent, Inc.
- Wal-Mart Stores, Inc.

Dinwiddie County:

- Amazon.com
- Central State Hospital
- Gerdau AmeriSteel
- Richard Bland College
- Tindal Concrete Company
- Wal-Mart Stores, Inc.

Goochland County:

- Branscome, Inc.
- Capital One
- Hermitage Country Club
- Kinloch Golf Club
- Lee Highway Paving Corp.
- Performance Food Group
- The Richmond Country Club, Inc.
- Virginia Farm Bureau

Greensville County and City of Emporia:

- Ashland Chemical
- Beach Mold & Tool, Inc.
- Bell Nursery, USA, LLC.
- Boar's Head Provisions Company, LLC.
- Creative Playthings, Ltd.
- Deerfield Correctional Center
- Emporia/Greensville Manor
- Food Lion, Inc.
- Franklin Braid Manufacturing Company
- Georgia Pacific Corporation
- Greensville correctional Center
- Greensville County Public Schools
- iLuka Resources, Inc.
- Oran Safety Glass, Inc.
- Paul D. Camp Community College
- PNC Trucking
- Quality culvert, Inc.
- Sadler Enterprises
- Southampton Memorial Hospital
- Southern Virginia Regional Medical Center
- SteelFab of Virginia, Inc.
- Toll Integrated Systems, Inc.
- Valley Proteins, Inc.
- Wal-Mart Stores, Inc.

Hanover County:

- Acosta Sales & Marketing
- AMF Bowling Companies, Inc.
- Bell Nursery, LLC.
- Bon Secours Memorial Regional Medical Health Care Center
- Food Lion

- Green Top
- Hanover County Government
- Hanover County School System
- Kings Dominion
- Kroger
- MARTIN'S Food Market
- Media General
- Overland Contracting
- Owens and Minor
- Randolph-Macon College
- Sales Mark
- SuperValu
- The Home Depot
- Tyson Farms, Inc.
- Walmart
- White Birch/The Bear Island Paper Company
- Woodfin Oil

Henrico County:

- Altria Group, Inc.
- Anthem Blue Cross and Blue Shield
- Bank of America, N.A.
- Capital One Service, Inc.
- Cadmus Communications, Inc.
- Dominion Resources
- Fareva USA
- G.E.
- Genworth
- Hamilton Beach Brands
- Henrico Doctors Hospital Parham Campus
- Kraft Foods, Inc.
- Markel Corporation
- McKesson Medical-Surgical
- Mondelez Foods, Inc.
- Pfizer Pharmaceuticals
- Saint Mary's Hospital of Richmond, Inc.
- Sun Trust Banks, Inc.
- The Brink's Company
- Verizon Virginia, Inc.

City of Hopewell:

- Ashland Aqualon Functional Ingredients
- E.I. DuPont De Nemours & Co.
- Evonik Industries
- Honeywell
- John Randolph Hospital
- Smurfit Stone Container Corporation
- West Rock

New Kent County:

- AHS Cumberland Hospital
- Allied Pallet Company, Inc.
- CCCT Transportation LLC
- Colonial Downs
- Comfort Keepers 160
- Curtis Contracting Company
- Direct Wood Products Inc.
- Interior Specialty Construction, Inc.
- JC Pallet Co.
- New Kent County School System

City of Petersburg:

- Boar's Head Provisions
- Brenco Incorporated
- Custom T's
- Southside Regional Medical Center
- Temple-Inland Container

Powhatan County

- Central Virginia Bank
- Colony Construction
- County of Powhatan
- Elizabeth Randolph Lewis YMCA
- Food Lion
- Ellis M. Palmore Lumber, Inc.
- Kidzalat
- Powhatan Correctional Center
- Powhatan County School Board
- M. P. Barden & Sons Inc.
- Moslow Wood Products
- PIEtech

- Powhatan Correctional Center
- Powhatan County School Board
- R.C. Goodwyn & Sons Inc.
- Rapid Manufacturing
- TDU Concrete
- Wal-Mart

Prince George County

- Ace Hardware Corp.
- Ancos
- Food Lion, Inc.
- Fort Lee Army Base
- Goya Foods
- Hopewell Hardwood Sales, Inc.
- LMR (Logistical Management Resources, Inc.)
- Marc bric
- MetL-Span Inc.
- Nolan
- Oakly Logistics
- Perdue
- Reinhart Food Service
- Retro Insulation
- Service Center Metals, Inc.
- Standard Motor Products, Inc.
- Sterling Gelatin
- U.S. Merchants

City of Richmond:

- Altria Group
- Chippenham Medical Center
- Commonwealth of Virginia State Agencies
- Dominion Resources, Inc.
- Fareva
- Federal Reserve Bank of Richmond
- International Paper Company
- Maxxim Medical, Inc.
- Overnite Transportation Company
- Pfizer
- Sun Trust Banks, Inc.
- UPS Freight
- VCU Health System
- Virginia Commonwealth University
- Verizon Virginia, Inc.

- Virginia Commonwealth University

Surry County:

- Dominion Virginia Power
- Fluor Daniel
- S. Wallace Edwards & Sons, Inc.
- Seward Lumber Co. Inc.
- Windsor Mill

Sussex County:

- McGill
- Murphy Brown
- Virginia Department of Corrections
- Virginia Diner

4.9 Transportation

The Richmond-Crater region is located at a crossroads of transportation within the state of Virginia. Rail lines radiate outward from Richmond in all directions. Both passenger (Amtrak) and freight (CSX, Richmond, Fredericksburg & Potomac, and Norfolk Southern) services are available in the Richmond-Crater region. The region is served by the Richmond International Airport and numerous general aviation facilities, including the Emporia/Greensville Regional Airport, Chesterfield County Airport, Dinwiddie County Airport, Hanover County Municipal Airport, New Kent Airport, Petersburg Municipal Airport, and the Wakefield Municipal Airport. The Richmond International Airport exceeded all past volume in 2015 and then exceeded 2015's flight and passenger traffic in 2016 following years of non-competitive fares which drove travelers to Washington DC-area airports.

As described before, a number of rivers run through the Richmond-Crater region. They include the James River, the North and South Anna Rivers, the Pamunkey River, the Chickahominy River, and the York River. The James River is navigable by large ships up to the eastern portion of the City of Richmond at the Fall Line. It is served by the Port of Richmond. While the City of Richmond has developed an extensive portion of its waterfront along the James River as open space or commercial, the majority of riverfront property in the study area is undeveloped or is developed as low-density residential.

City Point Port is located in the City of Hopewell and the Port of Richmond is within a mile of the region. The Chickahominy River traverses Henrico, New Kent and Charles City counties and joins the James River at the eastern boundary of Charles City County. New

Kent and Charles City Counties feature several drinking water reservoirs managed by the Newport News Watershed Authority. The Crater Planning area lies within two major watersheds – the James and the Chowan. The majority of the planning area falls in the Chowan River basin. This basin spans 3,675 square miles and is comprised of the Nottoway River, Meherrin River, and Blackwater River.

Numerous rivers flow through the Crater Planning area including the James River, Appomattox River, Blackwater River, Meherrin River, and Nottoway River. The Meherrin River runs through the center of the City of Emporia while the Appomattox goes through the City of Petersburg. The City of Hopewell is located at the confluence of the Appomattox and James Rivers.

In addition, several large creeks such as Stony Creek, which passes through the center of the Town of Stony Creek, run through the planning area. Swift Creek is impounded for the Swift Creek Reservoir in Chesterfield County and downstream to the east forms the northern boundary of the City of Colonial Heights.

Several interstates intersect the Richmond-Crater region. Interstate 64 is an east-west route extending from Norfolk to Staunton, Virginia. Interstate 95 and I-85 are north-south routes, with I-95 being the primary route along the East Coast extending from Maine to Florida and I-85 the main route between Richmond and Atlanta, Georgia. In addition, Richmond is encircled by I-195, I-895 (a toll road), and I-295 which begins north of Richmond in Henrico County, passing through Charles City County, extending through the City of Hopewell to the City of Petersburg, providing an alternative to I-95. Interstate I-95 continues to be upgraded, including bridge improvements and other minor paving and shoulder improvements/repairs. A number of large U.S. highways also service the region. They include: U.S.-460, U.S.-58, U.S.-250, U.S.-522, U.S.-33, U.S.-1, U.S.-301/SR 2, U.S.-360, and U.S.-60. The state road network is extensive throughout the region. Some of the major routes include SR-6, SR-10, SR-54, SR-156, SR-288, SR-249, SR-155, and SR-5. U.S. 460 connects the City of Petersburg area with Norfolk and the ports of Hampton Roads, and U.S. 58 passes through the City of Emporia along Virginia's southern border. Henrico County is the only county in the region that maintains its own roads. In addition, the City of Richmond maintains its own road network.

4.10 Infrastructure

4.10.1 Electric

The Richmond-Crater region is served by six electricity providers: Central Virginia Electric Cooperative, Dominion Virginia Power, Mecklenburg Electric Cooperative, Prince George Electric Cooperative, Rappahannock Electric Cooperative, and Southside Electric Cooperative.

The western portions of New Kent County are on a "looped" scheme for electricity. If one portion of this area were to lose power, it could regain power rather easily because it is tied into the system. Virginia Power has not found it to be cost-effective to institute a similar system in the eastern portion of the county and therefore this area is prone to electrical outages.

Two power substations provide electricity to Charles City County. Efforts are underway to ensure that the courthouse and municipal complex are on both grids. In addition, Ingenco, located at the landfill, provides electricity to the power grid.

Powhatan County is served by Dominion Virginia Power (61%) and Southside Electric Cooperative (39%). Power outages primarily occur here because of ice or wind storms. Most of the Southside Electric grid is powered by one substation in the county, and the majority of the Virginia Power feeds that serve the county enter on two distribution lines from substation(s) in Chesterfield.

4.10.2 Natural Gas

Natural gas is provided to the region by the City of Richmond, Columbia Gas of Virginia, and Virginia Natural Gas.

4.10.3 Telephone

Local telephone service is provided throughout Greater Richmond by Verizon Communications Inc. AT&T and Cavalier Telephone are the largest competitive providers. An extensive fiber optic network with digital switching capability and Synchronous Optical Network (SONET) self-healing fiber optic rings insures uninterrupted service. Special Access Services (DS1, DS3, OC-12 and OC-48) are available throughout the area. Verizon can provide dual capacity. Major long-distance carriers include AT&T, Verizon, and Sprint.

4.10.4 Public Water and Wastewater

In the region, public water and wastewater treatment is available in the City of Richmond and Hanover (including the Town of Ashland), Henrico, New Kent, and Powhatan Counties. Public water is also provided by the Appomattox River Water Authority, Chesterfield County, Dinwiddie County Water Authority, City of Emporia, Greensville County Water and Sewer Authority, Town of Jarratt, Town of McKenney, Petersburg and Dinwiddie Water Authority, City of Petersburg, Prince George County, City of Richmond, Town of Stony Creek, Surry County, Sussex Service Authority, and Virginia American Water Company. Private well and septic systems serve Charles City and Goochland Counties. Portions of Hanover, Henrico, and New Kent Counties are also served by private systems.

The Powhatan Courthouse complex, including the 911 center and the junior high school, is served by a private water system. The system relies on pumps and has no generator back-up. Following Hurricane Isabel, the loss of electrical power serving the water system in the Courthouse area had a significant negative impact on Powhatan County's ability to continue to serve the evacuation shelter and the 911 center.

4.10.5 Television

Cable television service is provided within the Richmond-Crater region by Verizon FIOS, Verizon, Comcast and Cox Communication along with satellite and internet providers.

4.10.6 Internet

Level 3 serves Greater Richmond with an independent local and national fiber network. PAETEC (formerly US LEC) offers business customers an extensive line of voice, data, and IP services. Richmond providers of High-Speed Broadband Internet also include EarthLink, Cavalier, Cox Communications, Comcast, and Verizon FiOS. Wireless service providers include T-Mobile, Verizon Wireless, AT&T, and Sprint. Voice over IP providers include Verizon, Vonage and Lingo

5 Hazard Identification and Risk Assessment

The Crater Planning District Commission (PDC) and the Richmond Regional PDC, on behalf of the jurisdictions which comprise their regions, have updated the 2011 Hazard Identification and Risk Assessment (HIRA) to serve as a guide to all communities in the regions when assessing potential vulnerabilities to natural hazards. When initialing developing the plan in 2005, and updating it in 2011 and 2017, every effort was made to gather input from all aspects of the project area communities to ensure that the results of this analysis are as accurate as possible. Regional hazard and vulnerability maps are presented in this section. Appendix G contains localized maps for each jurisdiction.

The Crater PDC region includes four cities, six counties, and eight incorporated towns. The Richmond Regional PDC region includes one city, seven counties, and one incorporated town. Charles City and Chesterfield counties are members of both the Richmond Regional and Crater PDCs. The analysis in this section of the plan addresses risks and vulnerabilities to all the cities, counties and towns in the region; results are presented on a variety of scales such as regional, county/city or county/city/town to best illustrate the available data.

The purpose of the HIRA is to:

- Identify what hazards could affect the planning regions.
- Profile hazard events and determine what areas and community assets are the most vulnerable to damage from these hazards.
- Estimate losses and prioritize the potential risks to the community.

The first step, hazard identification, identifies all natural hazards which the Hazard Mitigation Technical Advisory Committee felt might affect the PDCs. The hazards are ranked to determine what hazards are most likely to impact region’s communities. Hazards determined to have significant impact are analyzed in the greatest detail to determine the magnitude of future events and the vulnerability of the community and its critical facilities. Hazards that receive a moderate impact ranking are analyzed with available data to determine the risk and vulnerability to the specified hazard. The limited impact hazards are analyzed using the best available data to determine the risk to the community.

5.1 Critical Facilities

NOTE: Specific information about critical facilities has been redacted from this public copy of the plan to address public safety concerns. This information is available to public safety officials in a redacted Appendix G.

A critical facility is defined as a facility in either the public or private sector that provides essential products and services to the general public; is otherwise necessary to preserve the welfare and quality of life in the community; or fulfills important public safety, emergency response, and/or disaster recovery functions.

For the 2017 update, the Richmond Regional and Crater PDC staffs worked with members of the HMTAC to identify the following types of structures that are considered critical facilities:

- **Public Safety:**

  Police, Emergency Operations Centers, Sheriff, Fire, Correctional Facilities, and Emergency Management

- **Infrastructure:**

  Cell towers, fuel storage, pumping stations, water and wastewater treatment facilities, and transportation structures

- **Government Facilities:**

  Courthouses and judicial facilities, government offices and facilities

- **Medical Facilities:**

  Hospitals, nursing facilities, rehabilitation centers and outpatient centers

- **Education:**

  K – 12 public schools, colleges and universities, technical schools

This information was compiled for the region and used in the hazard analysis as well as for the vulnerability analysis and development of 2017 – 2022 regional and local mitigation actions.

5.2 Land Cover and Land Use

Based on the U.S. Geological Survey (USGS) National Land Cover Data (NLCD), there are nine main land cover definitions with the majority in the “developed” categories that include developed open space, low intensity, medium intensity, and high intensity development.

Land use was available for the majority of the communities in the Richmond PDC but not in the Crater PDC. As a result, most of the discussion is based on current land cover from NLCD. For the communities that provided land use data or where it was included in community comprehensive plans, future land use and development trends are described in detail in Section 4.0, Community Profile. The development trends described in the

Community Profile section should be considered in mitigation actions and future updates to this plan.

5.3 Data Limitations

To gain a full understanding of the hazards, an extensive search of historic hazard data was completed. This data collection effort used meetings with local community officials, existing reports and studies, state and national datasets, and other sources. A comprehensive list of sources used for this plan can be found in Section 9.0 of the plan update.

Whenever possible, data has been incorporated into a Geographic Information System (GIS) to aid analysis and develop area-wide maps for depicting historical hazard events, hazard areas, and vulnerable infrastructure. Critical facility data has been collected from local jurisdictions and has been supplemented from FEMA's loss estimating software, Hazus.

In accordance with FEMA's mitigation planning guidance, the results of this study are based on the best available data. The amount of detailed data regarding the location of structures, characteristics of facilities, and other community-related data varies from jurisdiction to jurisdiction. For instance, Charles City County had structure point information that provides an approximate location of the structure while other jurisdictions had building footprint data (except the City of Colonial Heights) which was used for the flood TEIF 2.0 analysis.

Recognizing this inconsistency in detailed local data, one ongoing strategy included as part of this mitigation plan, is to look for opportunities to increase the quality of data so that it can in turn, be used to provide better hazard assessments.

Information from the National Climatic Data Center's (NCDC) Storm Event Database was used to inform the weather-related hazard analysis. The NCDC receives storm data from the National Weather Service (NWS), which in turn receives it from a variety of sources, which include but are not limited to: county, state, and federal emergency management officials, local law enforcement officials, Skywarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry, and the general public. An effort is made to use the best available information, but because of time and resource constraints, information from these sources may be unverified by the NWS. Therefore, the recurrence intervals and other historical analysis presented may not be 100% accurate but instead are based on best available data. In addition, there may be discrepancies in data reporting between jurisdictions that have similar experience or exposure to hazards (e.g., neighboring localities such as Charles City and New Kent counties). Also, data is only available at a county or regional level for some hazard events including winter storms and droughts. A particular drought or winter storm event in the NCDC database may contain property or crop loss dollar figures, but the single event record may contain multiple counties with no indication of how the dollar damages were distributed. In these instances, lacking better data, the loss figures were "normalized" by spreading losses in equal proportions to all counties listed in the event record.

The damages entered into the NCDC Storm Events database portray how much damage was incurred in the year of the event. Due to inflation and the changing value of money, the values of damages incurred have been adjusted so that they reflect their worth in 2016. This process was done by obtaining information from the Bureau of Labor Statistics, which provides a yearly index of Consumer Prices. Each value was multiplied by the index of its year of occurrence and subsequently divided by the index value in 2016, the target year.

After the data was normalized, inflation accounted for, and summary statistics calculated, the data was annualized to be able to compare the results on a common system. In general, this was completed by taking the parameter of interest and dividing by the length of record for each hazard. The annualized value should only be used as an estimate of what can be expected in a given year. Property and crop damage, and the number of events were all annualized in this fashion, on a per-jurisdiction basis.

Also, the NCDC events are only as valid as they are reported. Not all events are reported, and some may only be reported without damage estimates, injury, or death reports. It is important to note that this database is only an estimate of damages, which is why most figures are annualized to represent and estimate damages that could occur over the course of a year.

Another data limitation was the lack of wildfire damage estimates by jurisdiction after 2010. VDOF tracked wildfire damage in several ways for the 2010 and 2011 seasons; thereafter only occurrence and acreage burned annually was available.

5.4 Hazard Identification

5.4.1 Types of Hazards

Although all types of disasters are possible for any given area in the United States, the most likely hazards that could potentially affect the communities in the planning regions were determined through research and analysis conducted for the 2011 Hazard Mitigation Plans and discussion with community officials. The hazard categories were reviewed again during the 2017 plan update and it was agreed that they still represent the main types impacting the region. These hazards include:

- Landslides
- Shoreline erosion
- Droughts
- Flooding
- Earthquakes
- Hurricanes
- Sinkholes
- Wind

- Tornadoes
- Wildfires
- Winter weather
- Thunderstorms
- Extreme heat

In addition, the HMTAC included mass evacuation to the list of hazards to be considered in the plan as was done in 2011.

5.4.2 Planning Considerations

Hazards were ranked based on analysis conducted for the 2011 update, consideration of the hazard analysis presented in the March 2013 Virginia State Hazard Mitigation Plan, input from the 2017 HMTAC, and a new analysis performed for the 2017 update to determine what hazards might have the largest impact on their communities. The results are summarized in Table 5-1. As a result of this analysis, the hazards were broken down into four distinct categories which represent the level of consideration they will receive throughout the planning process. These categories are *Significant, High, Moderate, Limited,* and *None*. For the 2017 update rankings only the categories of *Significant*, *Moderate*, or *Limited* were used. Certain hazards were not addressed or did not need any updating as a result of the infrequency of occurrence and/or limited impact.

Table 5-1. Planning Consideration Levels by Hazard Type for 2017 Update

Hazard Type	2011 Planning Consideration Level	Commonwealth of Virginia 2012 HIRA Hazard Ranking	2017 HMTAC Preliminary Ranking	2017 HIRA Ranking Analysis**
Flooding	Significant	High	Moderate	Moderate
Wind*	Moderate	Medium-High	High	Limited
Tornado*	Moderate	Medium-High	High	Significant
Hurricane*	Moderate	Not ranked	High	Significant
Winter weather	Moderate	Medium-High	High	Moderate
Thunderstorms* (including Hail and Lightning)	Moderate	Negligible	High	Moderate
Droughts (with Extreme Heat)*	Moderate	Droughts = Medium Extreme Heat = Negligible	Limited	Limited
Mass evacuation	Moderate	Not ranked – Discussed in other	Limited	Limited

Table 5-1. Planning Consideration Levels by Hazard Type for 2017 Update

Hazard Type	2011 Planning Consideration Level	Commonwealth of Virginia 2012 HIRA Hazard Ranking	2017 HMTAC Preliminary Ranking	2017 HIRA Ranking Analysis**
		Commonwealth of Virginia emergency operations plans		
Wildfires	Limited	Medium	Limited	Limited
Earthquakes	Limited	Medium-Low	Limited	Limited
Landslides/shoreline erosion*	Limited	Landslide = Medium-Low Erosion = Negligible	Limited	Limited
Karst	Limited	Low	Limited	Limited

* Some event types were combined (Droughts/Heat and Landslide/Erosion) or separated (Wind/Tornado and Hurricanes/Thunderstorms) from other plans and votes to accommodate the 2017 HMTAC's current concerns for their regions.

** Ranking analysis explained in section Analysis and Data Sources.

Because some of the hazards included in the hazard identification analysis are similar, some hazards will be discussed simultaneously later in this analysis. For instance, the Wind section includes hurricanes, other tropical disturbances, and thunderstorm winds while tornadoes were evaluated in their own section. A detailed discussion of the potential hazards that have been identified as *Significant* and *Moderate* events is provided in the sections that follow. A brief discussion of the *Limited* events is also included.

5.4.3 Analysis and Data Sources

Table 5-2 provides a list of the natural hazards, the analysis type and data source included in this plan. In order to focus on the most critical hazards that may affect Planning District communities, hazards assigned a level of *Significant* or *Moderate* will receive the most extensive attention in the remainder of the planning analysis, while those with a *Limited* planning consideration level will be assessed in more general terms. The hazards with a planning level of *None* will not be addressed in this plan. It should also be noted that all sources, especially the NCDC and National Weather Service, only include events that are reported and may not include all events. However, they provide good databases and can help provide a better picture to help understand and mitigate damages.

Table 5-2. HIRA Overview – Hazards, Analysis and Data Source

Hazards	Analysis	Data Sources
Flooding	Covered by HIRA flood analysis	FEMA Digital Flood Insurance Rate Map (DFIRM), Q3, and FIRM Mapping; HAZUS census block values; NCDC; TEIF 2.0 analysis
Hurricanes	Covered by HIRA flood and hurricane wind analysis	FEMA DFIRM, Q3, and FIRM Mapping and American Society of Civil Engineers Design Wind Speed Maps, FEMA HAZUS model; NCDC; National Hurricane Center
Wind	Covered by HIRA hurricane wind analysis	FEMA HAZUS model; NCDC
Winter storms	Covered by HIRA winter storm analysis	NCDC; NWS; PRISM Climate Group; VDOT; IEM
Droughts	Covered by HIRA drought analysis	NCDC; U.S. Drought Monitor; U.S. Census Bureau 1990 Water Source Data
Tornadoes	Description and regional maps	NCDC; Severe Weather Data GIS Data; VDEM
Wildfires	Covered by HIRA wildfire analysis	VDOF; NCDC
Earthquakes	None, due to infrequency of occurrence	USGS
Landslides/ shoreline erosion	None, due to infrequency of occurrence	USGS; NCDC

The final analysis for the HIRA Ranks were established using the following Criteria in Table 5-3. This table shows what scores were given and the criteria needed to get these scores. This was based on a FEMA Hazard Priority Ranking Criteria and modified to include what information was available at the time of publishing this document.

Table 5-3. Hazard Priority Ranking Criteria for Richmond and Crater Regions

Probability	Score	Vulnerability	Score	Maximum Impact (Annual Damages)*	Score	Warning Time	Score
Unlikely - No documented NCDC occurrences with	0.5	Limited Rank by 2017 HMTAC Preliminary Ranking	1	No NCDC data found to evaluate. Does not mean there was no damages.	0	**Extended** - Three days or more	1

Table 5-3. Hazard Priority Ranking Criteria for Richmond and Crater Regions

<table>
<tr><th>Probability</th><th>Score</th><th>Vulnerability</th><th>Score</th><th>Maximum Impact (Annual Damages)*</th><th>Score</th><th>Warning Time</th><th>Score</th></tr>
<tr><td>annual probability < 0.01</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Somewhat Likely - Infrequent occurrence with at least one NCDC documented event and annual probability between 0.5 and 0.01</td><td>1</td><td rowspan="2">Moderate Rank by 2017 HMTAC Preliminary Ranking</td><td rowspan="2">2</td><td rowspan="3">Based on NCDC data, score award by percent of total annual damages done by event. Hazard receive their percent of points from 0.01 to 3 max)</td><td rowspan="3">0.01 - 3</td><td>Limited - 2 days</td><td>2</td></tr>
<tr><td>Likely - Frequent occurrence with at least some NCDC documented events and annual probability between 1 and 0.5</td><td>1.5</td><td>Minimal - 1 day</td><td>2</td></tr>
<tr><td>Highly Likely - Common events with annual probability > 1</td><td>3</td><td>High Rank by 2017 HMTAC Preliminary Ranking</td><td>3</td><td>No Notice - < 24 Hours</td><td>3</td></tr>
</table>

After scores were assigned to each hazard, the scores were then summed together and divided by 4 (because there were four categories) to find the average score. Scores between 2.5 and 3.0 were given “significant,” 2.0 to 2.5 were assigned “moderate,” and everything less than 2 were assigned “limited.” These scores, ranks, and assigned categories for each hazard type are shown in Table 5-4. The final ranking in order from most significant to limited are shown in Table 5-5.

Table 5-4. HIRA Priority Ranking Analysis

Hazard Type	Probability\History	Vulnerability	Maximum Impact (Annual Damages)	Warning Time	2017 Analysis Score	2017 Ranking Category
Drought	3	1	2.23	1	1.81	Moderate
Earthquake	0.5	1	0	3	1.13	Limited
Flood	3	2	1.94	2	2.24	Moderate
Hurricanes	3	3	3.00	2	2.75	Significant
Karst	0.5	1	0	3	1.13	Limited
Landslide	0.5	1	0	3	1.13	Limited
Mass Evacuation	0.5	1	0	1	0.63	Limited
Thunderstorm	3	3	1.34	2	2.34	Limited
Tornado	3	3	1.92	3	2.73	Significant
Wildfire	0.5	1	0	3	1.13	Limited
Wind	1.5	3	0.68	2	1.79	Limited
Winter	3	3	1.33	1	2.08	Limited

Table 5-5. HIRA Priority Analysis Rank

Hazard Category	Rank Score	Rank	Rank Category
Hurricanes	2.75	1	Significant
Tornado	2.73	2	Significant
Thunderstorm	2.34	3	Moderate
Flood	2.24	4	Moderate
Winter	2.08	5	Moderate
Drought	1.81	6	Limited
Wind	1.79	7	Limited
Wildfire	1.13	8	Limited
Earthquake	1.13	8	Limited

Table 5-5. HIRA Priority Analysis Rank

Hazard Category	Rank Score	Rank	Rank Category
Landslide	1.13	8	Limited
Karst	1.13	8	Limited
Mass Evacuation	0.63	12	Limited

From this analysis, hurricane and tornado events seem to be the most significant types of hazards for the study region. Thunderstorm, flood, and winter events were determined to be moderate events, with everything else being labeled as limited. It should be noted that wildfire, earthquake, landslide, karst, and mass evacuation events were not included in the NCDC database. This does not mean that they did not happen or cause damages, but were given 0 scores as a maximum threat because there was no data to confirm what percent of damages that they may have caused.

5.5 Major Disasters

Twenty-two major disasters have been declared which included at least one county or city within the planning region since 1965. Numerous "emergency declarations have also been declared supporting federal reimbursement for emergency categories of the Public Assistance Program. One third of the events were hurricane disasters, one quarter were associated with severe storms, one fifth were snow and ice related, a few drought and flood disasters, and several unique events were included like a West Nile Virus disaster declared on May 30, 2000, support for Hurricane Katrina evacuees and the Louisa Earthquake which impacted Goochland County. It should be noted that flooding is often included in severe storm, hurricane, and coastal storm disasters.

A summary of the total events declared and what kinds are shown in Appendix B – HIRA. Appendix B-2 lists the presidentially declared disasters that have occurred in the Richmond-Crater region planning districts since disaster and emergency records supplemented with federal disaster declarations up to 2011. It should be noted that flooding and wind damages are sometimes described within a description of a hurricane, tropical depression or severe storm event. The appendix further details the disaster events and dates which where each of the communities in the planning regions were impacted by these disasters.

5.6 Flooding

5.6.1 Hazard Profile

A flood occurs when an area that is normally dry becomes inundated with water. Floods may result from the overflow of surface waters, overflow of inland and tidal waters, or mudflows. Flooding can occur at any time of the year, with peak hazards in the late winter and early spring. Snowmelt and ice jam breakaway contribute to winter flooding, and seasonal rain patterns contribute to spring flooding. Torrential rains from hurricanes and tropical systems are more likely to occur in late summer. Development of flood-prone areas tends to increase the frequency and degree of flooding.

The most significant natural hazard to affect the region historically has been flooding but the flood hazard risk was reduced to "moderate" in the 2017 analysis based on more current data and lower flood occurrence during the past five years as well as more sophisticated flood vulnerability analysis using TEIF 2.0. The region is relatively flat, falling in the Piedmont and Coastal Plain regions. The western portion of the study area is characterized by a more rolling topography but the part east of the Fall Line can be locally quite rugged where short, high gradient streams have incised steep ravines. Several rivers flow through the region including the James, York, Pamunkey, Chickahominy, Appomattox, and North Anna Rivers. Numerous creeks crisscross the study area.

Much of the flooding in the region is the by-product of hurricanes and tropical storms. Flooding also may occur following a period of intense or sustained rainfall. The floods caused by Tropical Storm Gaston in 2004 are characteristic of this type of flooding. The intense rainfall combined with the inability of the City of Richmond's storm water system to handle the increased flow led to a great deal of damage in the Shockoe Bottom area. The duration of flood events vary depending on the specific characteristics of the rain event. Floodwaters generally recede rapidly after the rain event has ended, but can last from a few hours to a few days.

5.6.2 Magnitude or Severity

A flood occurs when an area that is normally dry becomes inundated with water. Floods may result from the overflow of surface waters, overflow of inland and tidal waters, or mudflows. Flooding can occur at any time of the year, with peak hazards in the late winter and early spring. Snowmelt and ice jam breakaway contribute to winter flooding, while seasonal rain patterns contribute to spring flooding. Torrential rains from hurricanes and tropical systems are more likely in late summer. Development of flood-prone areas tends to increase the frequency and degree of flooding.

Flooding can range from minor street flooding to widespread inundation along and near waterways. Flood-producing storms can occur throughout the year. Historically, the most common months for significant flooding have been August and September, the height of the hurricane season. Floods pick up chemicals, sewage, and toxins from roads, factories, and farms; therefore, any property affected by a flood may be contaminated with hazardous materials. Debris from vegetation and human-made structures may also become hazardous following the occurrence of a flood. In addition, floods may threaten water supplies and water quality, as well as initiate power outages.

If a significant flood event occurs, there is a potential for a variety of secondary impacts. Some of the most common secondary effects of flooding are impacts to infrastructure and utilities, such as roadways, water service, and wastewater treatment. Many of the roadways in the Planning District are vulnerable to damage due to floodwaters. The effect of flood damages to roadways can limit access to areas, cutting off some residents from emergency services as well as other essential services.

Floods typically are characterized by frequency, for example the “1%-annual chance flood,” commonly referred to as the “100-year” flood. While more frequent floods do occur, as well as larger events that have lower probabilities of occurrence, for most regulatory and hazard identification purposes, the 1%-percent annual chance flood is used. Detailed flood data were available as Digital Flood Insurance Rate Maps (DFIRMs) for jurisdictions within the FEMA defined floodplain. This is discussed in more detail in Section 5.6.6.

Flood damage to property and populations can be devastating, both emotionally and financially. Flood damage to businesses could result in loss of income, wages, and tax revenues. Buildings, including homes and critical facilities, are susceptible to damage and sometimes collapse as a result of a severe flood. Floods pick up chemicals, sewage and toxins from roads, factories, and farms. Property affected by the flood may be contaminated with hazardous materials and present a health and safety risk to residents and occupants. Debris from vegetation and man-made structures also may be hazardous to drivers and pedestrians. In addition, floods may threaten water supplies and water quality, as well as initiate power outages and create health issues such as mold. Other effects include outbreaks of disease, widespread animal illnesses, disrupted utilities, water pollution, fires, washed out roads and culverts, and formation of sinkholes.

Secondary Effects

Flooding can pose some significant secondary impacts to the area where the event has taken place. Some of the impacts to consider include infrastructure and utility failure, impacts to roadways, water service and wastewater treatment. Flooded roadways can cause congestion on alternative routes and lengthen travel times for emergency vehicles and school buses. Businesses that are flooded may sustain damage to the structure and its contents, resulting in economic losses from business downtime often due to business impacts as well as lost utilities preventing operation. These impacts are usually localized in the region.

5.6.3 Hazard Areas

The portions of the planning region most susceptible to flooding are those directly adjacent to the area's major waterways. However, flooding can occur along the smaller tributaries throughout the area.

Land use information was available for the Richmond PDC. Based on analysis conducted for the 2006 and 2011 plans, the dominant land use inside floodplains was determined. Much of the land in the region's floodplains is designated for agricultural uses. Some localities, however, allow residential uses within agriculture areas. Agriculture is the dominant land use in Charles City, Dinwiddie, Goochland, Greensville, Hanover, New Kent, Powhatan Counties, Prince George, Surry and Sussex Counties. Henrico and Chesterfield Counties floodplain land use is mostly park or buffered residential and the Cities of Richmond' and Petersburg is industrial or park.

5.6.4 Hazard History

Table 5-6 includes descriptions of major flood events in the region. Events have been broken down by the date of occurrence and, when available, by individual community descriptions. Historical events pre-dating the 2011 plan update can be found in Appendix B. Some events which received national and state attention, such as 2012's Hurricane Sandy, had little flood effect on the area and did not receive a major disaster declaration so is not listed. When no community-specific description is given, the general description applies to the entire region.

Table 5-6. History of Flood Events and Damages, 2011–2016

Date	Damages
August 27, 2011	Hurricane Irene impacted the area with heavy rainfall and gusty winds which knocked power out to millions of people in the area. It took electrical crews several days to fully restore power in the planning area. Irene originated east of the Lesser Antilles and tracked north and northwest into the western Atlantic. The hurricane reached Category 3 intensity with maximum sustained winds of near 120 mph at its strongest point. The hurricane made an initial U.S. landfall in the eastern portions of the North Carolina Outer Banks on August 27, 2011 as a Category 1 hurricane. The storm then tracked north/northeast along the coast slowly weakening before making its final landfall in Brooklyn, New York on August 28 as a high-end tropical storm. Rainfall totals with the hurricane ranged from around two inches in western sections of the planning region to 5 to 9 inches in eastern sections closest to the coast. At its closest pass, Irene brought sustained winds of 30 to 45 mph with gusts of 60 to nearly 70 mph to the planning area. The winds downed power lines and trees throughout the area. A man was killed when a tree fell on his home near Colonial Heights.

Table 5-6. History of Flood Events and Damages, 2011–2016

Date	Damages
	(Source: National Weather Service/Wakefield Office)
September 4, 2011	Tropical Storm Lee moved inland along the Mississippi/Louisiana Gulf Coast on September 4, 2011. The remnants of the weakening storm tracked northeast, producing rainfall over a wide swath extending from the Gulf Coast to New England. Rainfall totals generally ranged from 4 to 8 inches in the planning area with the heaviest totals falling just east of Interstate 95. The rain fell on soils saturated only days earlier with Hurricane Irene's passage. The result was widespread flooding, particularly over the eastern sections of the planning region. Gusty winds in thunderstorms knocked down trees that had already been weakened from the hurricane resulting in thousands of power outages. (Source: National Weather Service/Wakefield Office)
October 1, 2015	The combination of upper divergence and lift east of the closed low, and a strong persistent low level flow off the Atlantic and associated low level moisture convergence and isentropic lift, along with a plume of tropical moisture getting entrained into the system, provided a band of heavy rain showers and a few thunderstorms that at times trained over the same areas and persisted for many hours. The heaviest rain occurred from the Columbia vicinity, southeastward across lower Richland Co, Sumter Co, Calhoun Co, Clarendon Co and lower Orangeburg Co. The heaviest rainfall occurred late Saturday night Oct 3rd into the morning hours of Sunday Oct 4th. At times, rainfall rates of 2" inches per hour affected those locations for several hours. This heavy and persistent rainfall occurred over urban areas where runoff rates were high, and over grounds already wet from recent rains. This heavy rainfall caused numerous roadway and bridge closings due to dam failures, along with culvert and pipe washouts across the region. Numerous lifesaving swift water rescues were performed. In general, a significant gradient in rainfall amounts occurred in our CWA, with 1-2 inches west of the Savannah River, 2-4 inches just on the east side of the Savannah River, with amounts ramping up to around 10 inches eastward into West Central Midlands, with 10-20 inches from Columbia SE across the Eastern Midlands. The NWS had been advertising this very heavy rainfall and flooding potential well in advance of the event. During this event, Columbia Metro Airport set a new record for both the greatest one and two day rainfall totals: • Greatest 1-day rainfall…. 6.71 inches set on October 4, 2015 • Old 1-day rainfall record….. 5.79 inches set on July 9, 1959 • Greatest 2-day rainfall….. 10.28 inches set on October 3-4, 2015 • Old 2-day rainfall record….. 7.69 inches set on August 16-17, 1949 (Source: National Weather Service)
*History from 1771-2010 in Appendix B-3	

Table 5-7 provides the number and damage costs of recorded flood events by jurisdiction. (It should be noted that these results represent only those events recorded by the NCDC storm events database for flood; therefore, smaller localized events are not included in the historic table in Appendix B or Table 5-7.) Some of the events listed in the table may be regional in nature, impacting multiple jurisdictions. Significant hurricane events resulting in flooding have been included although it should be noted that some minor hurricanes may have resulted in flooding but may not have been recorded in the NCDC as flood events; see the hurricane/wind section for information on those events. Chesterfield (22) and Surry (16) Counties have the highest number of flood events and while Greensville County had over $1M in property damages.

Table 5-7. Flood Damage to Property and Crops, 1993 - 2016

Jurisdiction	Flood Events	Property Damages	Crop Damages
Charles City County	7	-	-
Chesterfield County	22	$287,458	$2,986
City of Colonial Heights	5	$71,663	-
Dinwiddie County (incl. Town of McKenney)	8	$12,223	$3,285
City of Emporia	3	-	-
Goochland County	5	$38,818	$11,944
Greensville County (incl. Town of Jarratt)	13	$1,065,175	-
Hanover County (incl. Town of Ashland)	9	$158,993	$25,082
Henrico County	3	-	-
City of Hopewell	6	$71,663	
New Kent County	14	$109,340	-
City of Petersburg	14	$141,487	-
Powhatan County	10	$38,966	-
Prince George County	10	-	-
City of Richmond	14	$94,711	-
Surry County (incl. Towns of Claremont, Dendron, Surry)	16	$64,535	$37,014
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	15	$265,726	$62,187
Totals	**174**	**$2,420,758**	**$253,890**

Source: National Climatic Data Center.

5.6.5 Hydrology

The Richmond-Crater region lies within three major watersheds – the James, Chowan, and York. The James watershed spans 10,236 square miles, the largest in Virginia. The

Chowan River basin spans 3,675 square miles. The York watershed covers a much smaller area with a drainage basin of 2,669 square miles. Numerous rivers flow through the region including:

- James
- York
- Appomattox
- Blackwater
- Meherrin
- Pamunkey
- Chickahominy
- North Anna
- Nottoway

The James River runs directly through the City of Richmond. The Meherrin River runs through the center of the City of Emporia, while the Appomattox flows through the City of Petersburg. The City of Hopewell is located at the confluence of the Appomattox and James Rivers.

In addition, several large creeks such as Stony Creek, which passes through the center of the Town of Stony Creek, run through the region. Swift Creek forms the northern boundary of the City of Colonial Heights. Figure 5-1 illustrates the location of the major watershed boundaries for the region.

In 2009, the U.S. Army Corps of Engineers (USACE), Norfolk District, completed a stream and rain gauging network study within the Chowan River Basin. The study identified gauging station needs that would improve flood forecasts by the NWS. An additional study in 2009 evaluated water resource issues, such as environmental restoration, flood risk management, navigation, and water quality. These two studies helped to determine Risk Mapping, Assessment, and Planning (Risk MAP) program activities implemented in the Chowan River Basin. The three Risk MAP activities included:

- Assessment of basin flood hazard data.
- Establishment of local community officials' knowledge and understanding of flood risk management concepts and increasing public awareness of flood hazards and the National Flood Insurance Program (NFIP).
- Support to state and local governments to engage in risk-based mitigation planning.[6]

The Chowan River Basin report provides an in-depth assessment of the river basin and mitigation activities for understanding flood risk. Areas of concern are highlighted throughout the report; this should be used to further facilitate mitigation actions in this plan.

[6] Risk Mapping, Assessment and Planning (Risk MAP) Report. Chowan River Basin, Virginia. By USACE, Norfolk District for FEMA Region III. Final May 5, 2011.

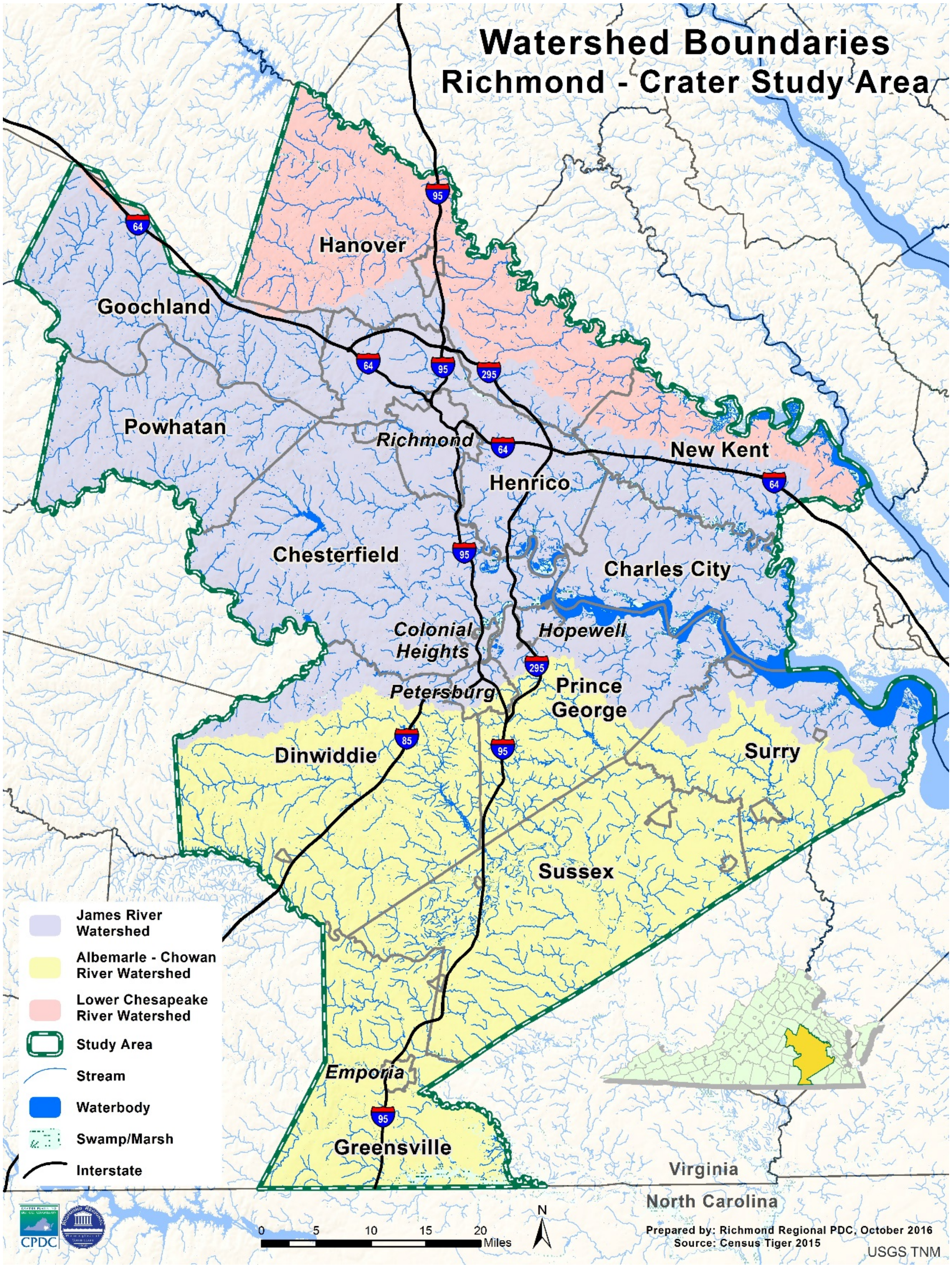

Figure 5-1. Map of Watershed Boundaries

5.6.6 Flood Maps

FEMA, through the NFIP, has developed Flood Insurance Rate Maps (FIRMs) that identify flood zones through detailed hydrologic and hydraulic studies. Flood zones represent the areas susceptible to the 1% annual chance flood (100-year flood) and the 0.2% annual chance flood (500-year flood). In most places in the region, there is little to no difference in the 100-year and 500-year floodplain. Whenever possible, FEMA also determines a base flood elevation (BFE) for the 100-year floodplain, which is the calculated elevation of flooding during this event. The BFE is a commonly used standard level for determining flood risk and managing potential floodplain development. Although each specific flood event is different, these maps provide a more definitive representation of the highest flood risks in the communities.

Since the 2010 analysis, FEMA's Digital Flood Insurance Rate Maps (DFIRMs) were updated and adopted so that most of the region's FIRMs are in digital format. This data was made available by VDEM as an export of the National Flood Hazard Layer (NFHL), preliminary DFIRMs and digitized FIRMs. The NFHL dataset is a compilation of effective DFIRM databases and Letters of Map Change. The NFHL is updated as studies become effective and extracts are made available to the public monthly. The preliminary DFIRMS that have been made available through FEMA and become the governing maps for the locality once adopted by the local government elected body and labeled as "effective." For jurisdictions where the digital FIRMs were not available from FEMA, this plan uses digitized versions of these maps supplied by VDEM. These are used to get a general sense of where flooding occurs for those locations and have not been attributed with the flood zones. For local planning and flood enforcement, localities use the effective flood data from FEMA. Figure 5-2 shows the extent of the mapped floodplains in the region.

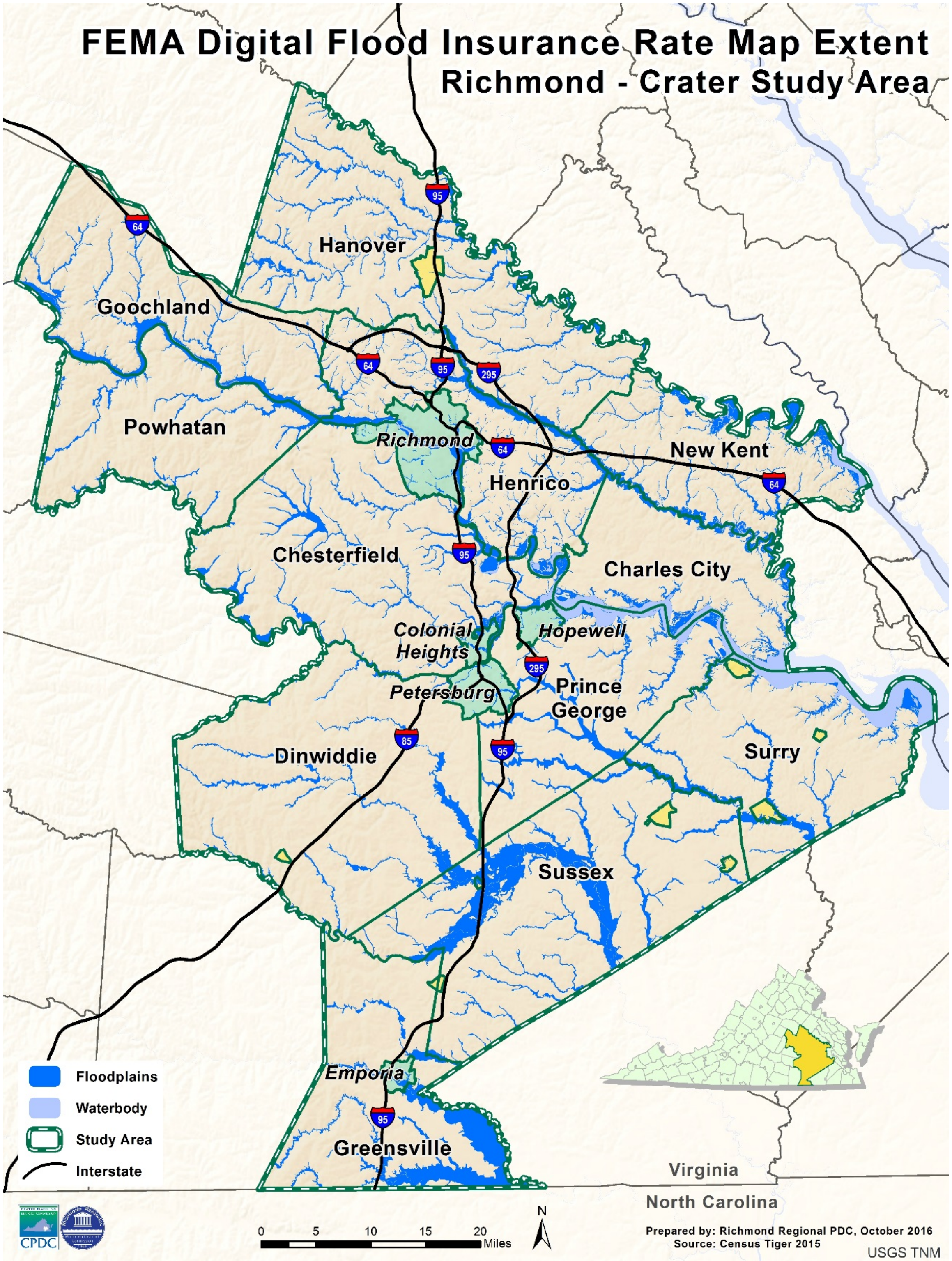

Figure 5-2. FEMA Digital Flood Insurance Rate Map Extent

5.6.7 National Flood Insurance Program

Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary.

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 through 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.

In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the nation's floodplains. Mapping of flood hazards creates broad-based awareness of these hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.

Floodplain management regulations are the cornerstone of NFIP participation. Communities that participate in the NFIP are expected to adopt and enforce floodplain management regulations. These regulations apply to all types of floodplain development and ensure that development activities will not cause an increase in future flood damages. Buildings are required to be elevated at or above the BFE. It should be noted that Chesterfield, Goochland, and Powhatan Counties all have very strong floodplain management programs.

Table 5-8 shows the dates that each of the jurisdictions were identified with Flood Hazard Boundary Maps (FHBM), the date the first Flood Insurance Rate Maps (FIRMs) became effective, the date of the current FIRMs used for insurance purposes, and the date the community entered into the NFIP. This table also shows the FIRM source that was used for the flood analysis.

Table 5-8. Communities Participating in the NFIP as of April 27, 2017

County/City Name	Jurisdiction Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
Charles City County	Charles City County	01/17/75	09/05/09	07/06/15	09/05/90
Chesterfield County	Chesterfield County	01/10/75	03/16/83	12/18/12	03/16/83
City of Colonial Heights	City of Colonial Heights	06/14/74	09/02/81	08/02/12	09/02/81
Dinwiddie County	Dinwiddie County	11/15/74	01/17/79	06/16/11	01/17/79
	Town of McKenney	-	*06/16/11*	*(NSFHA)*	*11/20/81*
City of Emporia	City of Emporia	07/23/76	02/02/89	07/07/09	09/30/77
Goochland County	Goochland County	02/21/75	03/01/79	12/02/08	03/01/79
Greensville County	Greensville County	12/20/74	09/29/78	07/07/09	09/29/78
	*Town of Jarratt**	*07/30/76*	*10/08/82*	*07/07/09(M)*	*10/08/82*
Hanover County	Hanover County	12/13/74	09/02/81	12/02/08	09/02/81
	Town of Ashland	*05/24/74*	*12/02/08*	*12/02/08*	*05/26/78*
Henrico County	Henrico County	11/22/74	02/04/81	12/18/07	02/04/81
City of Hopewell	City of Hopewell	06/14/74	09/05/79	07/16/15	09/05/79
New Kent County	New Kent County	01/31/75	12/05/90	08/03/15	12/05/90
City of Petersburg	City of Petersburg	05/31/74	03/16/81	02/04/11	03/16/81
Powhatan County	Powhatan County	09/13/74	09/15/78	02/06/08	09/15/78
Prince George County	Prince George County	01/24/75	05/01/80	06/02/15	05/01/80
City of Richmond	City of Richmond	12/06/74	06/15/79	07/16/14	06/15/79
Surry County	Surry County	12/06/74	11/02/90	05/04/15	11/02/90
	Town of Claremont	*04/04/75*	*11/02/90*	*05/04/15*	*10/16/90*
	*Town of Dendron***	*11/15/74*	*11/02/90*	*04/02/09*	*12/02/92S*
	*Town of Surry***		-	-	-

Table 5-8. Communities Participating in the NFIP as of April 27, 2017

County/City Name	Jurisdiction Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
Sussex County	Sussex County	06/09/78	03/02/83	07/07/09	03/02/83
	Town of Stony Creek	*08/09/74*	*09/16/82*	*07/07/09*	*09/16/82*
	Town of Wakefield	*08/26/77*	*07/23/82*	*07/07/09(M)*	*03/12/14*
	*Town of Waverly***	-	-	-	-

*Town of Jarratt is listed in Greensville County in the FEMA Community Status Book Report
**Town not in FEMA Community Status Book Report
Source: http://www.fema.gov/cis/VA.html

As of June 30, 2016, there were 3,423 flood insurance policies-in-force in the region, accounting for 3.3% of the total policies in the Commonwealth. These policies amounted to more than $929 million in total insurance coverage. Approximately 1,327 claims have been filed, accounting for $21.6 million in payments. The City of Richmond makes up 49% of the total claims payments followed by Henrico County (14%) and Chesterfield County (12%). Table 5-9 shows NFIP policy statistics for each of the participating jurisdictions in the region.

Table 5-9. NFIP Policy and Claim Statistics by Jurisdiction

County/City Name	Jurisdiction Name	Policy Statistics (as of 06/30/2016)		Claim Statistics (01/01/1978 – 06/30/2016)	
		Policies-In-Force	Insurance In-Force	Total Claims	Total Payment
Charles City County	Charles City County	20	$6,320,700	7	$42,606
Chesterfield County	Chesterfield County	864	$231,463,100	175	$2,580,112
City of Colonial Heights	City of Colonial Heights	112	$27,581,600	79	$1,061,117
Dinwiddie County	Dinwiddie County	39	$10,729,600	2	$11,979
	Town of McKenney	-	-	-	-
City of Emporia	City of Emporia	38	$5,400,900	10	$6,060
Goochland County	Goochland County	47	$14,506,100	12	$137,267
Greensville County	Greensville County	17	$3,630,900	4	$26,145
	Town of Jarratt	-	-	-	-
Hanover County	Hanover County	177	$51,675,300	23	$253,608

Table 5-9. NFIP Policy and Claim Statistics by Jurisdiction

County/City Name	Jurisdiction Name	Policy Statistics (as of 06/30/2016)		Claim Statistics (01/01/1978 – 06/30/2016)	
		Policies-In-Force	Insurance In-Force	Total Claims	Total Payment
Hanover County (continued)	*Town of Ashland*	*44*	*$13,629,600*	*3*	*$4,655*
Henrico County	Henrico County	986	$246,491,700	240	$2,978,970
City of Hopewell	City of Hopewell	26	$7,607,000	11	$101,018
New Kent County	New Kent County	119	$34,367,100	29	$488,862
City of Petersburg	City of Petersburg	137	$38,183,500	76	$481,948
Powhatan County	Powhatan County	30	$8,480,000	1	$4,867.3
Prince George County	Prince George County	94	$25,420,500	27	$223,737
City of Richmond	City of Richmond	586	$183,772,500	515	$10,666,886
Surry County	Surry County	25	$7,135,400	40	$1,172,614
	Town of Claremont	*16*	*$4,319,800*	*38*	*$1,273,693*
	Town of Dendron	-	-	-	-
	Town of Surry	-	-	-	-
Sussex County	Sussex County	24	$5,016,700	12	$47,630
	Town of Jarratt	-	-	-	-
	Town of Stony Creek	*22*	*$3,653,500*	*23*	*$96,039*
	Town of Wakefield	-	-	-	-
	Town of Waverly	-	-	-	-
Region Total		**3,423**	**$929,385,500**	**1,327**	**$21,659,816**
Virginia Total		**104,766**	**$26,627,973,200**	**44,762**	**$637,755,766.40**

5.6.8 FEMA Repetitive Loss and Severe Repetitive Loss Properties

A repetitive loss (RL) property is a property that is insured under the NFIP and has filed two or more claims in excess of $1,000 each, within a 10-year period. Nationwide, RL properties constitute 2% of all NFIP insured properties, but are responsible for 40% of all NFIP claims. Mitigation for RL properties is a high priority for FEMA, and the areas in which these properties are located typically represent the most flood prone areas of a community.

The identification of RL properties is an important element to conducting a local flood risk assessment, as the inherent characteristics of properties with multiple flood losses strongly suggest that they will be threatened by continual losses. RL properties are also important to the NFIP, since structures that flood frequently put a strain on NFIP funds. Under the NFIP, FEMA defines an RL property as “any NFIP-insured property that, since 1978 and regardless of any change(s) of ownership during that period, has experienced: a) four or more paid flood losses; or b) two paid flood losses within a 10-year period that equal or exceed the current value of the insured property; or c) three or more paid losses that equal or exceed the current value of the insured property." A primary goal of FEMA is to reduce the numbers of structures that meet these criteria, whether through elevation, acquisition, relocation, or a flood control project that lessens the potential for continual losses.

According to FEMA, there are currently 14 RL properties within the Richmond-Crater region accounting for 66 losses. The specific addresses of the properties are maintained by FEMA, VDEM, and local jurisdictions, but are deliberately not included in this plan as required by law.[7] More than $1.61 million has been paid in total repetitive losses on 66 losses with an average claim of $48,400. This is a decline of about 87% since the 2011 plan but represents the ten-year rolling period eliminating Hurricane Isabel and Gaston losses. Table 5-10 shows the total number of properties, total number of losses experienced, and losses paid for all of the communities within the planning region. The majority of the RL properties are residential.

A severe repetitive loss (SRL) property has: a) at least four NFIP claims payments of more than $5,000 each, with the cumulative amount of such claims payments exceeding $20,000; or b) at least two separate claims payments with the cumulative amount exceeding the market value of the building. Chesterfield County has one SRL property, City of Colonial Heights as two, Henrico County has five, Prince George County has one, and the Town of Claremont has one. Compared to previous mitigation plans, there are significantly less RL and SRL properties as of 2017 than were in the 2011 plan due to the rolling ten-year period of the FEMA-provided lists.

[7] NFIP repetitive loss data is protected under the federal Privacy Act of 1974 (5 U.S.C. 552a) which prohibits personal identifiers (i.e., owner names, addresses, etc.) from being published in local mitigation plans.

Table 5-10. NFIP Repetitive and Severe Repetitive Loss Property Claim Information

Property Type	Jurisdiction Name	RL Buildings	RL Losses	Total Payments	Property value	SRL Buildings	Number of Claims	Building Payments	Average Claim	Property Value
	Charles City County	-	-	-	-	-	-	-	-	-
Residential	Chesterfield County	1	4	$70,732.52	$373,439.00	1	4	$70,732.52	$17,683.13	$374,439.00
Residential	City of Colonial Heights	2	10	$217,911.69	$1,000,000.00	2	10	$217,911.69	$43,552.34	$1,000,000.00
	Dinwiddie County	-	-	-	-	-	-	-	-	-
	City of Emporia	-	-	-	-	-	-	-	-	-
	Goochland County	-	-	-	-	-	-	-	-	-
	Greensville County	-	-	-	-	-	-	-	-	-
	Hanover County	-	-	-	-	-	-	-	-	-
	Town of Ashland	-	-	-	-	-	-	-	-	-
Residential	Henrico County	6	40	$956,563.38	$2,018,327.00	5	40	$956,563.38	$138,203.73	$1,585,330.00
	City of Hopewell	-	-	-	-	-	-	-	-	-
	New Kent County	-	-	-	-	-	-	-	-	-
	City of Petersburg	-	-	-	-	-	-	-	-	-

Table 5-10. NFIP Repetitive and Severe Repetitive Loss Property Claim Information

Property Type	Jurisdiction Name	RL Buildings	RL Losses	Total Payments	Property value	SRL Buildings	Number of Claims	Building Payments	Average Claim	Property Value
	Powhatan County	-	-	-	-	-	-	-	-	-
Residential	Prince George County	1	4	$72,822.55	$253,076.00	1	4	$72,822.55	$18,205.64	$253,076.00
Commercial	City of Richmond	2	4	$113,231.76	$27,500.00	-	-	-	$28,307.94	-
	Surry County	-	-	-	-	-	-	-	-	-
Residential	Town of Claremont	1	4	$176,688.15	$204,365.00	1	4	$176,688.15	$44,172.04	$204,365.00
	Sussex County	-	-	-	-	-	-	-	-	-
	Town of Stony Creek	-	-	-	-	-	-	-	-	-
	REGIONAL TOTAL	**13**	**66**	**$1,607,950.05**	**$3,876,707.00**	**10**	**62**	**$1,494,718.29**	**$290,124.82**	**$3,417,210.00**

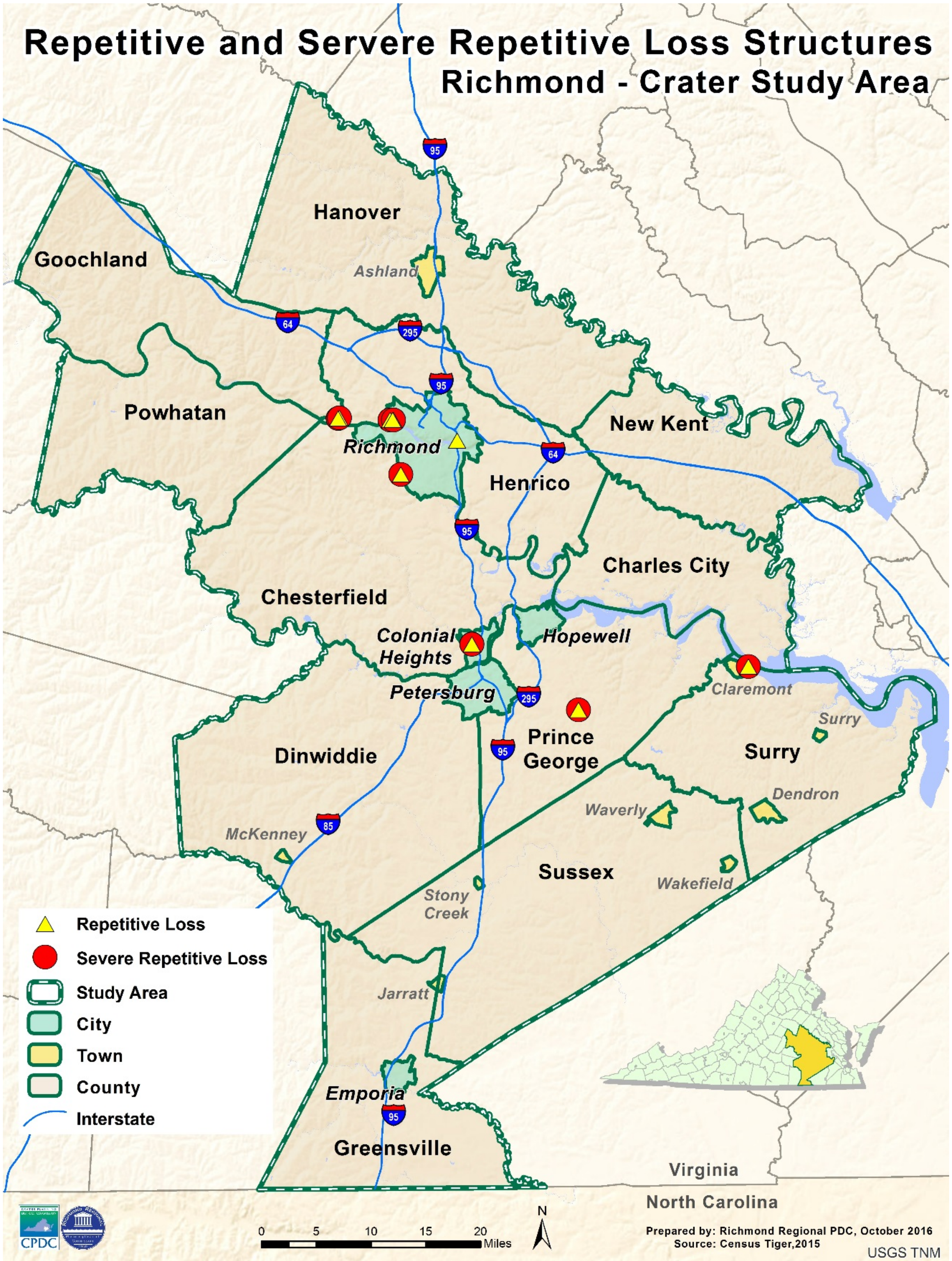

Figure 5-3. Repetitive and Severe Repetitive Loss Properties

5.6.9 Vulnerability Analysis

Probability

Floods typically are characterized by frequency, for example, the "1%-annual chance flood," commonly referred to as the "100-year" flood. While more frequent floods do occur, in addition to larger events that have lower probabilities of occurrence, for most regulatory and hazard identification purposes, the 1%-annual chance flood is used.

Impact and Vulnerability

Flooding impacts a community to the degree that it affects the lives of its citizens and overall community functions. Therefore, the most vulnerable areas of a community will be those most affected by floodwaters in terms of potential loss of life, damages to homes and businesses, and disruption of community services and utilities. For example, an area with a highly developed floodplain is significantly more vulnerable to the impacts of flooding than a rural or undeveloped floodplain where potential floodwaters would have less impact on the community.

A number of factors contribute to the relative vulnerabilities of certain areas in the floodplain. Development, or the presence of people and property in the hazardous areas, is a critical factor in determining vulnerability to flooding. Additional factors that contribute to flood vulnerability range from specific characteristics of the floodplain to characteristics of the structures located within the floodplain. The following is a brief discussion of some of these factors and how they may relate to the area.

Flood depth: The greater the depth of flooding, the higher the potential for significant damages.

Flood duration: The longer duration of time that floodwaters are in contact with building components, such as structural members, interior finishes, and mechanical equipment, the greater the potential for damage. Floodwaters may linger because of the low relief of the area, but the degree varies.

Velocity: Flowing water exerts force on the structural members of a building, increasing the likelihood of significant damage. A 1-foot depth of water, flowing at a velocity of 5 feet per second or greater, can knock an adult over and cause significant scour around structures and roadways.[8]

Elevation: The lowest possible point where floodwaters may enter a structure is the most significant factor contributing to its vulnerability to damage due to flooding. Data on the specific elevations of structures in the Richmond-Crater region has not been compiled for use in this analysis.

Construction type: Certain types of construction are more resistant to the effects of floodwaters than others. Masonry buildings, constructed of brick or concrete blocks, are

[8] FEMA. *Principles and Practices for Retrofitting Flood Prone Residential Buildings* (FEMA 259). July 2014.

typically the most resistant to flood damages simply because masonry materials can be in contact with limited depths of water without sustaining significant damage. Wood frame structures are more susceptible to flood damage because the construction materials used are easily damaged when inundated with water. The type of construction throughout the Planning District varies from area to area.

Risk Methodologies

Several methods were used to quantify vulnerability due to flooding. The following sections highlight risk and potential losses to structures, risk to critical facilities, and jurisdictional risk based on census blocks. The risk analyses completed in the 2011 mitigation plan should be referenced for comparison, but has not been kept for the flood, wind, and critical facilities evaluations. These have been updated and expanded based on best available data (structures, DFIRMs, and Census Block data). Appendix B provides a detailed summary of the analysis completed and the accompanying GIS files. This data should be referenced for specific information on structures and critical facilities at risk, and for use in potential mitigation projects.

The section on Structures at Risk for the 2010 plan was based on 10% greater than the average house value by census block; as a result, the values presented most likely underestimated vulnerability since only residential housing units were accounted for. For the 2017 analysis, a new methodology called Total Exposure in Floodplain (TEIF) version 2.0 was used. This TEIF 2.0 methodology uses the effective SFHA with building footprint, tax assessed value, and estimated contents value provided by the jurisdictions to find the annualized estimated losses from floods. These values were then generalized to 1000 ft^2 blocks to highlight potential loss areas and not target individual structures.

The section on Critical Facilities at Risk for the 2010 plan was based on data compiled from the PDCs and supplemented with HAZUS-MH, ESRI, and U.S. census data; this data was not maintained and is thought to be out of date. The 2017 plan update uses only data furnished by the localities supplemented with state databases and does not include data from HAZUS-MH, ESRI, or the U.S. Census. The Richmond Regional PDC was able to create a critical facility GIS layer, with jurisdictional input, that best represents their critical facilities. The same critical facility risk analysis was performed for the update as in the original plan. The resulting figures may be found in redacted Appendix I for local emergency management and regional planning purposes.

TEIF 2.0 Revised Analysis for 2017 Update

In support of FEMA's RiskMAP Program, FEMA endeavored to produce national-level flood risk analyses to estimate the potential losses from flooding across the Lower 48 states. This effort occurred circa 2009/2010 and produced a product known as the 2010 AAL Study Results. The 2010 AAL Study and its associated results were intended to be a mechanism for FEMA - as well as local stakeholders - to assist in the prioritization of flood mitigation activities across the lower 48 states. Further information on the 2010 AAL Results and its use in RiskMAP Risk Assessments can be viewed in Guidance for Flood Risk Analysis and Mapping (May 2014). Notably, there were some problem areas within FEMA Region III in which the Hazus software was unable to produce valid results for the 2010 AAL Study in certain coastal areas. Lack of estimated flood damages limited the Region's ability to assess potential damage across the entirety of the regional geography. Consequently, FEMA Region III considered alternative methodologies which brought about the concept of Total Exposure in Floodplain (TEIF). The TEIF 1.0 approach was created during 2012 in FEMA Region III and a more refined enhanced method of TEIF 2.0 has been used since 2015 based on the availability of local data and local hazard mitigation plan update cycle. Each analysis type performed over recent years seeks to transcend the previous and as noted, fill analysis gaps where such gaps may exist. Chronologically the first analysis performed was the FEMA AAL Project, then TEIF1.0 and finally TEIF2.0.

FEMA Region III has performed the TEIF 2.0 analysis to help local jurisdictions supplement Hazard Mitigation Plans as well as general hazard mitigation planning efforts. A primary assumption of the planning process is that FEMA, states and local jurisdictions have limited resources and not all issues can be solved at the same time; consequently, way to define priorities (i.e. ranking) is a valuable tool to the planning process. TEIF 2.0 is an analysis methodology that estimates the exposure or replacement value of buildings that are exposed to the Special Flood Hazard Area (SFHA) and subsequently rank the estimated (or) potential losses based on what is exposed to flooding in the special flood hazard area.

The TEIF 2.0 methodology uses building footprints from local jurisdictions to subsequently disperse total replacement values of buildings at the census block-level in FEMA's Hazus software & corresponding Hazus stock data products. The TEIF methodology divides or apportions building replacement values by proportionate methods (area of each respective building footprint). For example if a census block is known to have $1M of value associated with all buildings and there are a total of ten (10) buildings in the census block - each building having the same exact size – a proportional distribution would dictate that each building has a value of $100,000. After Hazus values are dispersed to the building footprints, the buildings that intersect the SFHA can be identified and the portions (or percent area) of buildings that are within the floodplain can be calculated. Ultimately, the dispersed replacement values can be tallied (or summarized) for the dollar value associated with each respective building that is entirely or partially in the floodplain. These values are then generalized into 1000 ft^2 blocks to comply with regulations [9] and not target individual structures or building owners.

In Table 5-11, individual jurisdictions were evaluated and ranked in the study area using the TEIF 2.0 revised analysis (except for City of Colonial Heights, which did not have building footprints at time of analysis). The City of Richmond has the highest flood risk estimated at nearly $217M in damages. The flood maps for the TEIF 2.0 results can be found in Appendix B.

[9] Federal Privacy Act of 1974 (5 U.S.C. 552a) which prohibits personal identifiers (i.e., owner names, addresses, etc.) from being published in local mitigation plans.

Table 5-11. TEIF 2.0 (Oct 2016) Flood Risk

County/City	Jurisdiction	Annual Flood Risk	RANK [3]
Richmond City	Richmond city	$216,860,946.07	1
Henrico	Henrico County	$192,425,423.55	2
Chesterfield	Chesterfield County	$148,205,562.76	3
Petersburg City	Petersburg City	$87,017,560.55	4
Hanover	Hanover County	$61,441,447.65	5
Colonial Heights City	Colonial Heights City	$56,748,000.00 [2]	6
Hopewell City	Hopewell City	$38,315,100.27	7
New Kent	New Kent County	$26,067,007.09	8
Emporia City	Emporia City	$24,920,647.06	9
Prince George	Prince George County	$24,254,929.53	10
Sussex	Sussex County	$22,090,235.97	11
Sussex	Stony Creek Town	$18,266,774.55	12
Hanover	Ashland Town	$14,059,819.51	13
Dinwiddie	Dinwiddie County	$13,507,442.21	14
Goochland	Goochland County	$12,715,952.30	15
Surry	Surry County	$7,735,588.38	16
Powhatan	Powhatan County	$7,674,751.05	17
Greensville	Greensville County	$6,613,369.74	18
Surry	Claremont town	$6,330,052.27	19
Charles City	Charles City County	$2,833,653.27	20
Sussex	Wakefield Town	$301,433.37	21
Sussex	Waverly Town	$0.00	22
Dinwiddie	McKenney Town	$0.00	22
Sussex	Jarratt Town	$0.00	22
Surry	Dendron Town	$0.00	22
Surry	Surry Town	$0.00	22

[1] FEMA Region III - TEIF 2.0 October 2016. Value represents estimated loss to buildings only; value does not include estimated loss to contents or any other element.

[2] TEIF 2.0 not performed in Colonial Heights because GIS Building Footprints were not available; value is based on Hazus Level 1 depth grid creation per discharge analyses where, flow discharges are from FEMA Flood Insurance Study (FIS 510039V000A Revised: August 2, 2012) and ground data utilized includes 10m National Elevation Dataset (NED) Digital Elevation Model (DEM) obtained October 2016.

[3] RANK- this is NOT a statewide rank only internal to Crater-Richmond PDC's.

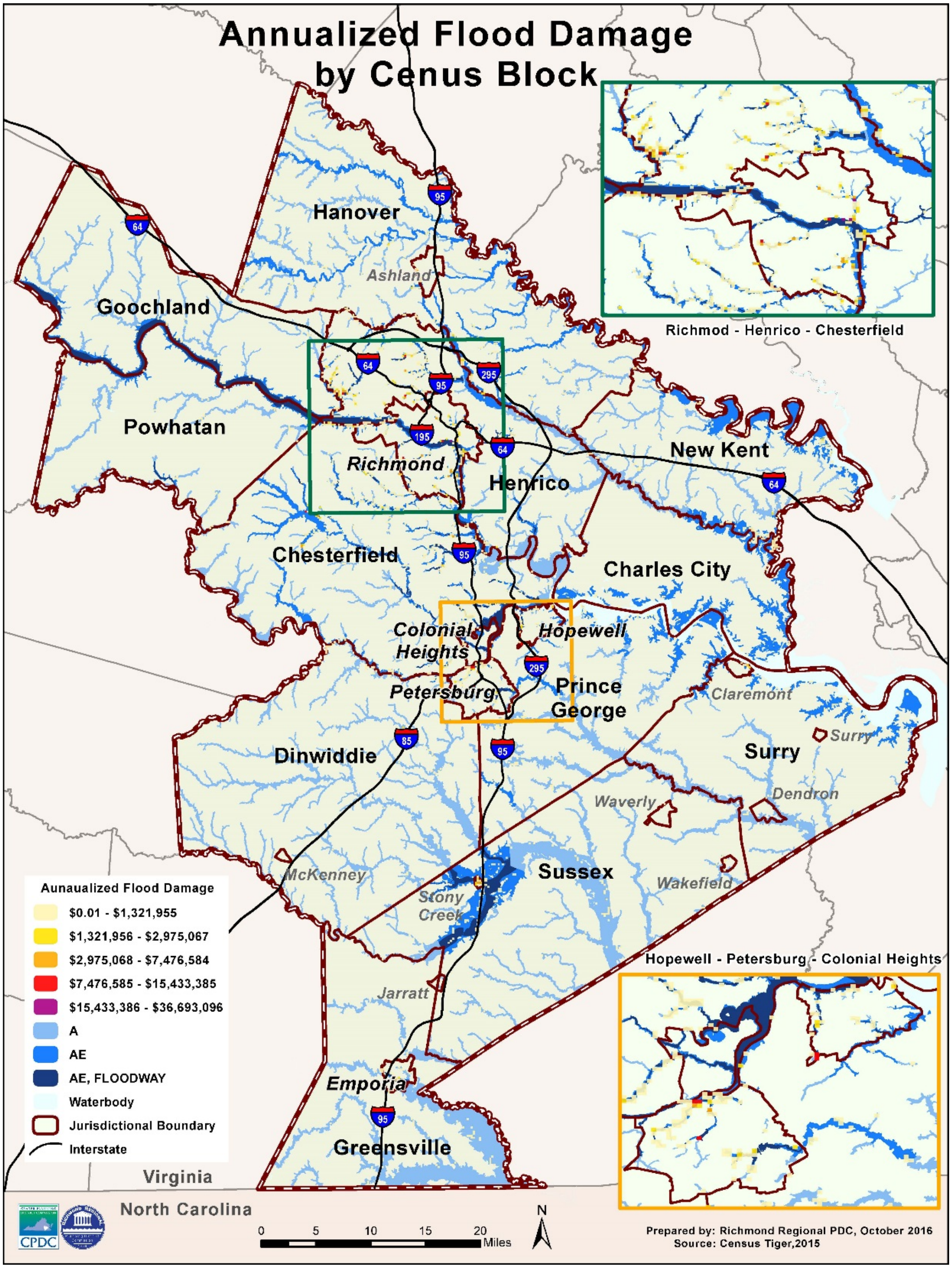

Figure 5-4. FEMA Flood Zones

Annualized NCDC Events and Damages

For comparison, the National Climatic Data Center (NCDC) flood events have been annualized and summarized in Table 5-12. Based on past occurrences, the region can expect $2.67 million in property damages as compared to the estimated $6.5 million based on the TEIF analysis.

Recurrence intervals can be estimated using the number of flood occurrences over a period of time. According to the NCDC database, there have been 174 recorded flood events for the region that have caused notable floods in the past 17 years, for a flood recurrence interval of approximately 14.5 events per year, with each event averaging about $333,000 in property and around $34,900 in crop damages, for a total of about $367,900 in damages. Greensville, Sussex, and Chesterfield Counties will likely experience the most flooding events for the region.

Table 5-12. Annualized Flood Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.29	$0	$0	$0
Chesterfield County	0.92	$287,458	$2,986	$290,444
City of Colonial Heights	0.21	$71,663	$0	$71,663
City of Emporia	0.33	$12,223	$3,285	$15,508
City of Hopewell	0.13	$0	$0	$0
City of Petersburg	0.21	$38,818	$11,944	$50,761
City of Richmond	0.54	$1,065,175	$0	$1,065,175
Dinwiddie County	0.38	$158,993	$25,082	$184,075
Goochland County	0.13	$0	$0	$0
Greensville County	0.25	$71,663	$47,776	$119,439
Hanover County	0.58	$109,340	$0	$109,340
Henrico County	0.58	$141,487	$0	$141,487

Table 5-12. Annualized Flood Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
New Kent County	0.42	$38,966	$0	$38,966
Powhatan County	0.42	$0	$0	$0
Prince George County	0.58	$94,711	$63,618	$158,329
Surry County	0.67	$64,535	$37,014	$101,548
Sussex County	0.63	$265,726	$62,187	$327,913
Total	**7.27**	**$2,420,758**	**$253,890**	**$2,674,649**

Source: National Climatic Data Center.

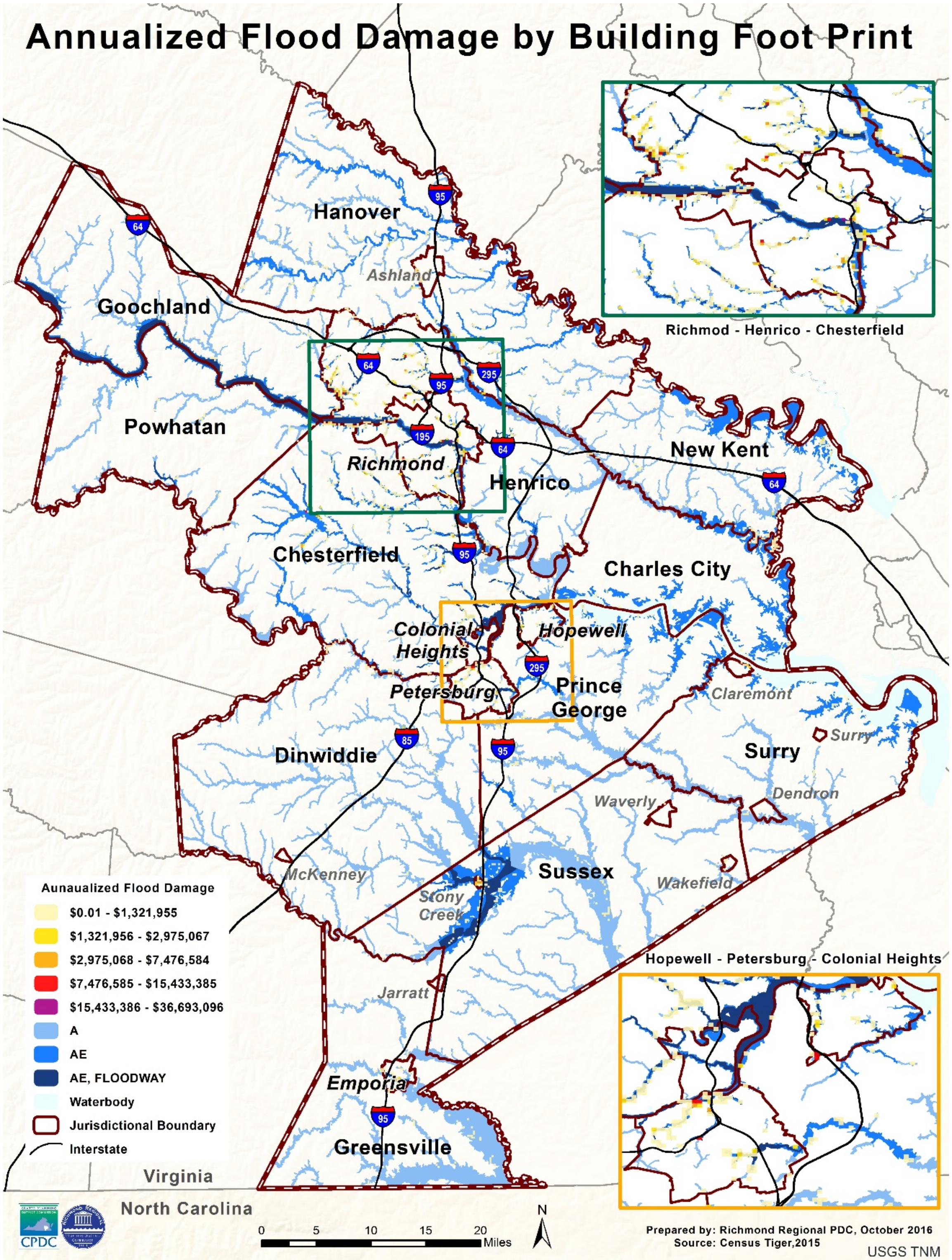

Figure 5-5. Annualized Flood Damage by Building Footprint

5.7 Wind (including Hurricanes and Thunderstorms)

Wind can be one of the most destructive forces of nature. Strong winds can erode mountains and shorelines, topple trees and buildings, and destroy a community's critical utilities and infrastructure. The analysis in this section focuses on hurricane and tropical storm winds as the most likely type of widespread wind hazards to occur in the region, though more localized damage from high winds also can be caused by straight-line wind events, thunderstorms, and tornadoes. Thunderstorms are capable of producing multiple hazards, including flooding rainfall, hail, cloud-to-ground lightning, and damaging wind. The most frequent hazards associated with severe thunderstorms in the region are excessive winds often leading to power outages and localized flooding often due to inadequate drainage or storm water management. (See Flood section) and damaging wind gusts that are analyzed in this section. Hail and lightning are analyzed in the Thunderstorm section.

5.7.1 Hazard Profile

A tropical cyclone is the generic term for a low pressure, non-frontal synoptic scale low-pressure system over tropical or sub-tropical waters with organized convection and definite cyclonic surface wind circulation. Tropical cyclones rotate counterclockwise throughout the Northern Hemisphere Depending on strength, these weather systems are classified as hurricanes or tropical storms. They are called tropical depressions when wind speed is less than 39 mph, but become tropical storms when their wind speeds are between 39 mph and 73 mph. When wind speeds reach 74 mph the system is classified as a hurricane. Tropical cyclones involve both atmospheric and hydrologic characteristics, such as severe winds, storm, surge flooding, high waves, coastal erosion, extreme rainfall, thunderstorms, lightning, and, in some cases, tornadoes. Storm surge flooding can push inland, and riverine flooding associated with heavy inland rains can be extensive. High winds are associated with hurricanes, with two significant effects: building damage and power outages due to airborne debris and downed trees.

The hurricane season in the North Atlantic runs from June 1 until November 30, with the peak season between August 15 and October 15. The average hurricane duration after landfall, is 12 to 18 hours. Wind speeds may be reduced by 50% within 12 hours after the storm reaches land. Tropical storms are capable of producing great amounts of in a short period of time. The region experienced more than 12 inches of rain historically during Tropical Depressions Camille, Isabel and Gaston over a short duration. Hurricanes also can spawn tornadoes.

Storm surge flooding can push inland as was experienced in Claremont and Sunset Beach in Surry County during Hurricane Isabel. Riverine and urban flooding associated with heavy inland rains can be extensive. Many areas of the Coastal Plain region are flat, and intense prolonged rainfall tends to accumulate without ready drainage paths. High winds associated with hurricanes can have two significant effects: 1) widespread debris from damaged and downed trees and damaged buildings, and 2) power outages.

Extreme wind events pose a danger because they can result in localized or widespread power outages, property damage, and falling trees. Mobile homes can be particularly vulnerable to the high winds, especially if improperly installed. Injury or death to people can result from falling objects or flying debris. Extreme wind events can also blow over tractor trailers on the highway and make driving difficult in a high-profile vehicle or lightweight vehicle. They can turn trash cans, lawn and patio furniture, and other property into projectiles resulting in further property damage.

Most deaths in extreme wind events are caused by trees falling onto cars or homes. Dead trees or trees weakened by drought, disease, rotting, or pest infestations are the most susceptible to falling.

Secondary Hazards

Secondary hazards from a hurricane event could include high winds, flooding, high waves, and tornadoes. Once inland, the hurricane's band of thunderstorms produces torrential rains and may produce tornadoes. A foot or more of rain may fall in less than a day causing flash floods and mudslides. The rain eventually drains into the large rivers which may still be flooding for days after the storm has passed. The storm's driving winds can topple trees, utility poles, and damage buildings. Communication and electricity can be lost for days and roads can be impassable due to standing water, fallen trees and debris. Local businesses can be closed for extended periods of time due to building and content damage, loss of utilities, and transportation challenges.

Hurricane Damage Scale

Hurricanes are categorized by the Safer-Simpson Hurricane Damage Scale.

5.7.2 Magnitude or Severity

The strength of a hurricane is classified according to wind speed using the Saffir-Simpson Hurricane Damage Scale. This scale is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf in the landfall region. Table 5-13 provides a description of typical damages associated with each hurricane category.

Table 5-13. Saffir-Simpson Hurricane Damage Scale

Hurricane Category	Sustained Winds (mph)	Damage Potential	Description
1	74–95	Minimal	Minimal damage to unanchored mobile homes along with shrubbery and trees. There may be pier damage and coastal road flooding, with storm surge 4–5 feet above average.
2	96–110	Moderate	Moderate damage potential to mobile homes and piers, as well as significant damage to shrubbery and trees with some damages to roofs, doors, and windows. Impacts include flooding 2-4 hours before arrival of the hurricane in coastal and low-lying areas. Storm surge can be 6–8 feet above average.
3	111–130	Extensive	Extensive damage potential. There will be structural damage to small residences and utility buildings. Extensive damage to mobile homes and trees and shrubbery. Impacts include flooding 3-5 hours before the arrival of the hurricane cutting off the low-lying escape routes. Coastal flooding has the potential to destroy small structures, with significant damage to larger structures as a result of the floating debris. Land that is lower than 5 feet below mean sea level can be flooded 8 or more miles inland. Storm surge can be 6–12 feet above average.
4	131–155	Extreme	Extreme damage potential. Curtain wall failure as well as roof structure failure. Major damage to lower floors near the shoreline. Storm surge generally reaches 13–18 feet above average.
5	> 155	Catastrophic	Severe damage potential. Complete roof failure on residence and industrial structures, with complete destruction of mobile homes. All shrubs, trees, and utility lines blown down. Storm surge is generally greater than 18 feet above average.

5.7.3 Hazard History

Figure 5-6 shows how the frequency and strength of extreme windstorms vary across the United States. The map was produced by FEMA and is based on 40 years of tornado history and more than 100 years of hurricane history. Zone IV, the darkest area on the map, has experienced both the greatest number of tornadoes and the strongest tornadoes. As shown by the map key, wind speeds in Zone IV can be as high as 250 mph. Most of the planning region falls within Zone II (winds up to 160 mph) and is considered to be susceptible to hurricanes.

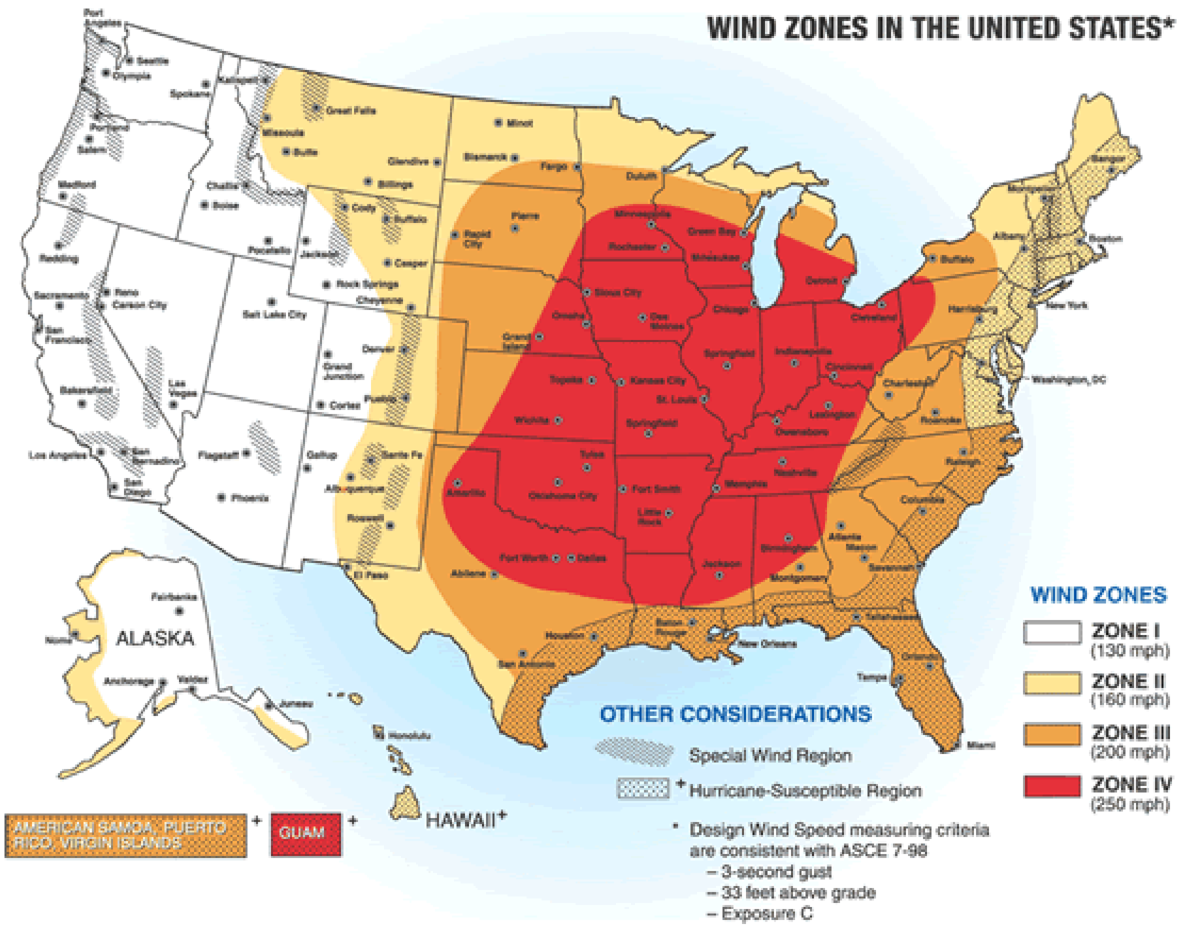

Figure 5-6. Wind Zones in the United States

Source: FEMA

The region is categorized by the American Society of Civil Engineers in its *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) as located in a 90-mph wind zone, based on a 50-year recurrence interval. Based on ASCE 7, the potential wind speed for an event with a 100-year recurrence interval was estimated to be 107% of the 50-year wind speed, or 96.3 mph. The Virginia Uniform Statewide Building Code requires a 90 mph minimum design wind speed.

High wind events have occurred in every portion of the region. There are no proven indicators to predict specifically where high winds may occur, and wind events can be expansive enough to affect the entire area. The counties on the eastern side of the region are marginally closer to the coast and might experience higher wind speeds from tropical storms or hurricanes that make landfall on the Virginia coast.

Based on NCDC historical data dating back to the mid-1990s, there have been two deaths and 35 injuries in the region that have resulted from wind, and approximately eight deaths that have resulted from hurricanes. Table 5-14 includes descriptions of tropical storm and hurricane events in the region, of which there are several. Events have been broken down by the date of occurrence and when available, by individual community descriptions. When no community-specific description is available, the general description applies to the entire region. Although NCDC and VDEM were the primary source of general descriptions, other sources are referenced where more specific information was available.

Table 5-14. History of Wind Events and Damages, 2011–2016

Date	Damages
August 27, 2011	Hurricane Irene – See full description in Flood section.
September 4, 2011	Hurricane Lee – See full description in Flood section.
June 29, 2012	A devastating line of thunderstorms known as a derecho moved east-southeast at 60 miles per hour (mph) from Indiana in the early afternoon to the Mid-Atlantic region around midnight. Winds were commonly above 60 mph with numerous reports of winds exceeding 80 mph. Some areas reported isolated pockets of winds greater than 100 mph. Nearly every county impacted by this convective system suffered damages and power outages. To make matters worse, the area affected was in the midst of a prolonged heat wave. Unlike many major tornado outbreaks in the recent past, this event was not forecast well in advance. Warm-season derechos, in particular, are often difficult to forecast and frequently result from subtle, small-scale forcing mechanisms that are difficult to resolve more than 12-24 hours in advance. (Source: http://www.nws.noaa.gov/os/assessments/pdfs/derecho12.pdf)
October 26, 2012	Hurricane Sandy made landfall along the southern New Jersey shore on October 29, 2012, causing historic devastation and substantial loss of life. The National Hurricane Center (NHC) Tropical Cyclone Report estimated the death count from Sandy at 147 direct deaths. In the United States, the storm was associated with 72 direct deaths in eight states: 2 in Virginia. The storm also resulted in at least 75 indirect deaths (i.e., related to unsafe or unhealthy conditions that existed during the evacuation phase, occurrence of the hurricane, or during the post-hurricane/clean-up phase). These numbers make Sandy the deadliest hurricane to hit the U.S. mainland since Hurricane Katrina in 2005, as well as the deadliest hurricane/post-tropical cyclone to hit the U.S. East Coast since Hurricane Agnes in 1972. (Source: http://www.nws.noaa.gov/os/assessments/pdfs/Sandy13.pdf)

*History from 1827-2010 in Appendix B-3

The National Oceanic Atmospheric and Atmospheric Administration's (NOAA) Coastal Services Center maintains historical hurricane, tropical storm, and tropical depression track data dating back to the mid-1880s. Figure 5-7 shows all tropical system and hurricane tracks through and near the region between 1950 and 2015. Most of the tropical systems to pass directly over the region have been at either tropical storm or tropical depression strength, but several hurricanes have directly impacted the area including the Irene and Lee Hurricanes.

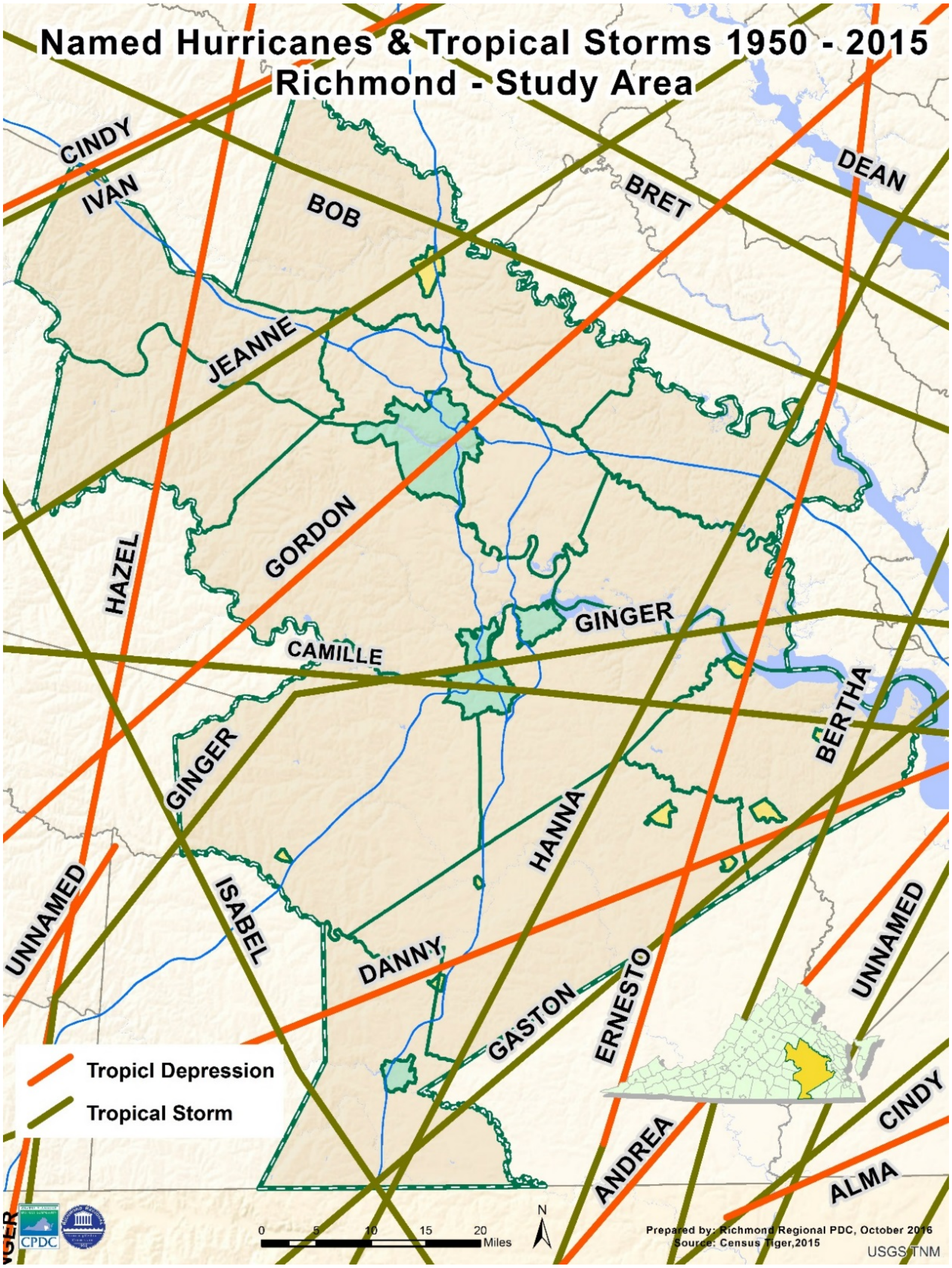

Figure 5-7. Named Hurricane and Tropical Cyclone Tracks, 1950–2015

5.7.4 Vulnerability Analysis

Probability

Hazus has used to complete the wind analysis for vulnerability and loss estimates. The Hazus software has been developed by FEMA and the National Institute of Building Sciences. Level 1, with default parameters, was used for the analysis done in this plan. For analysis purposes, the U.S. Census tracks are the smallest extent in which the model runs. The results of this analysis are captured in the vulnerability analysis and loss estimation.

Hazus uses historical hurricane tracks and computer modeling to identify the probable tracks of a range of hurricane events and then assigns potential wind gusts that result. Figures 5-8 through 5-10 are individual wind speed maps (50-year, 100-year, and 1,000-year events) for the jurisdictions in the region. When a hurricane impacts these areas, these maps can be used to determine what areas are more likely to be impacted than others (at the U.S. Census track level).

Impact and Vulnerability

Results from the model were used to develop the annualized damages. The impacts of these various events are combined to create a total annualized loss or the expected value of loss in any given year. Widespread extreme thunderstorm wind events, such as those associated with well- developed squall lines, may have wind gusts of a similar magnitude to those of the 50- or 100-year hurricane wind event.

In all cases, Hazus estimates the highest wind gusts to occur over the eastern and southeastern portions of the region, nearest the coast.

The type of building construction will have a significant impact on potential damages from high wind events. Basic Building Types in declining order of vulnerability are: manufactured, non-engineered wood, non-engineered masonry, lightly engineered and fully engineered buildings. A summary of basic building types – listed in order of decreasing vulnerability (from most to least vulnerable) is provided below.

The region includes a variety of building types. The primary residential construction type is wood framed, varying from single story to multiple stories, although some masonry and steel properties are present as well. As mentioned in the previous list, non-engineered wood-framed structures are among the most susceptible to potential damage. With the prevalence of this type of construction throughout the Richmond-Crater region, a majority of structures in the area could be classified to have a high level of vulnerability to damages due to a high wind event. Table 5-15 illustrates the building stock exposure broken down by the type of occupancy, for a total exposure of more than $79.3 billion. As seen in the table, almost 72% of the building stock for the region is considered residential, 18% of the building stock is commercial, and almost 6% is industrial. The majority of the region's building stock is wood. The building stock type is a main parameter used by HAZUS to determine potential damages; building stock characteristics are important in determining the strength of the structure and how it withstands wind speeds produced by storm events. Specific details on Hazus loss estimation and building stock can be found online at http://www.fema.gov/plan/prevent/hazus/hz_manuals.shtm.

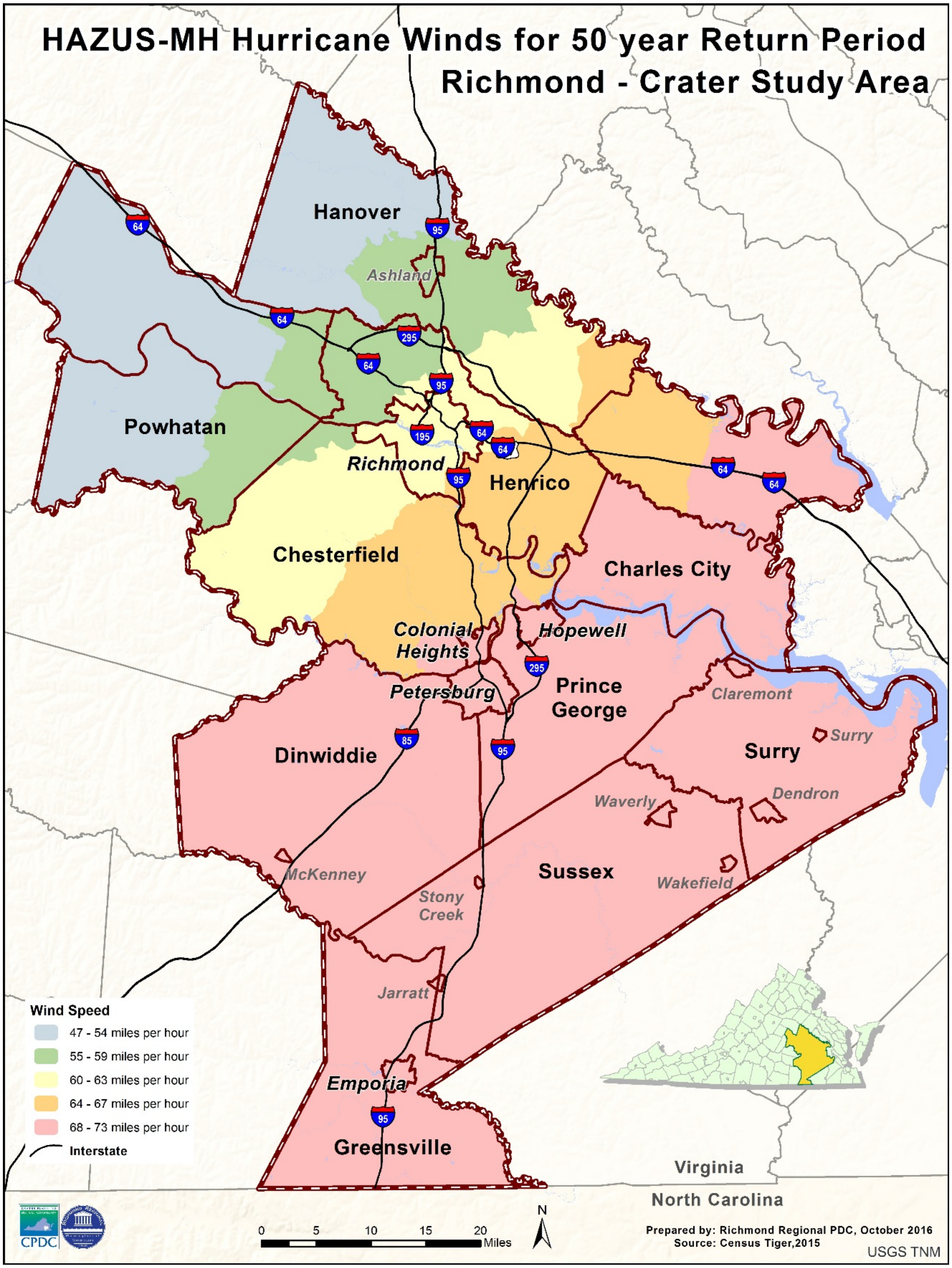

Figure 5-8. Hazus Hurricane Winds for 50-year Return Period

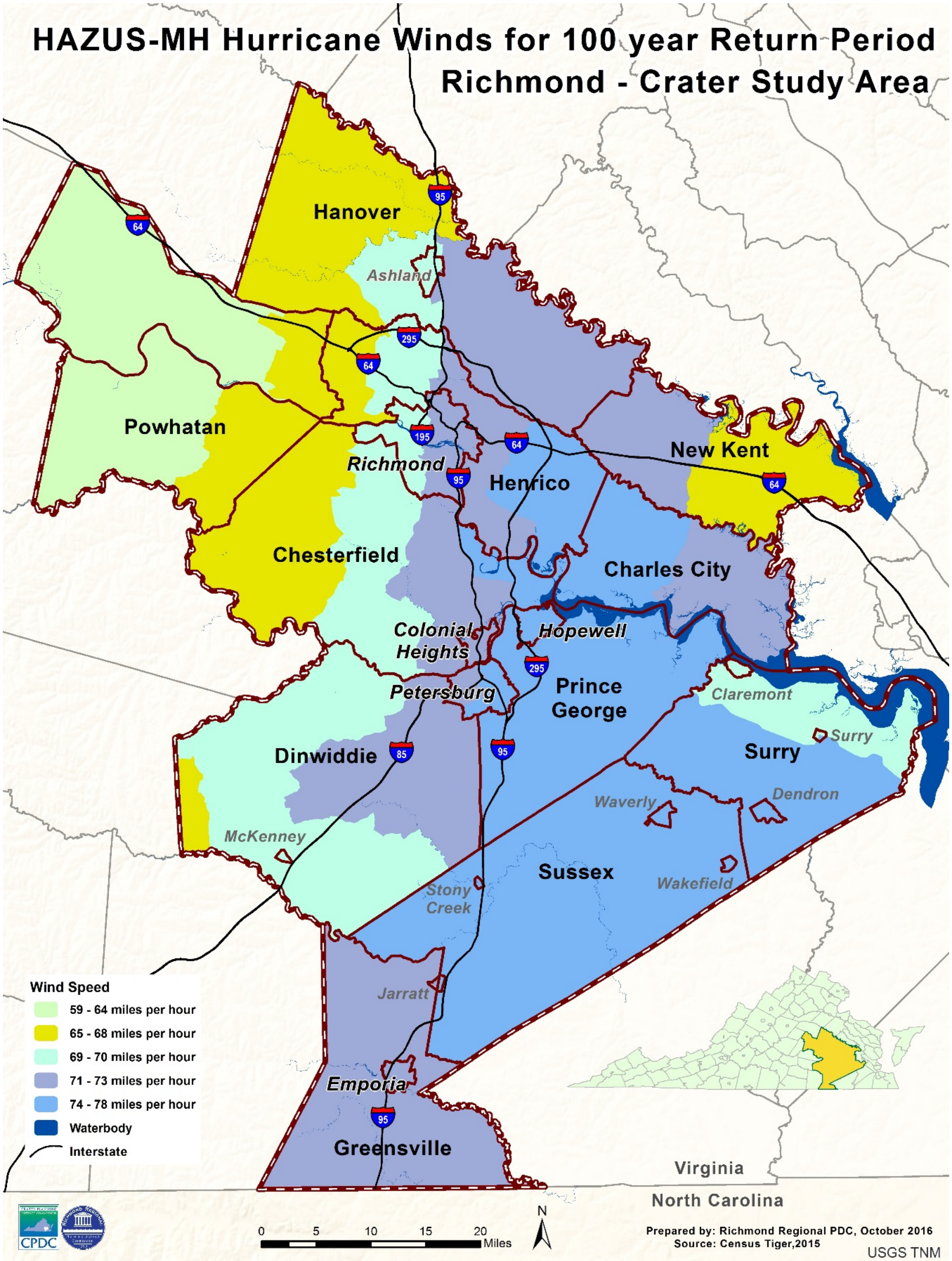

Figure 5-9. Hazus-MH Hurricane Winds for 100-year Return Period

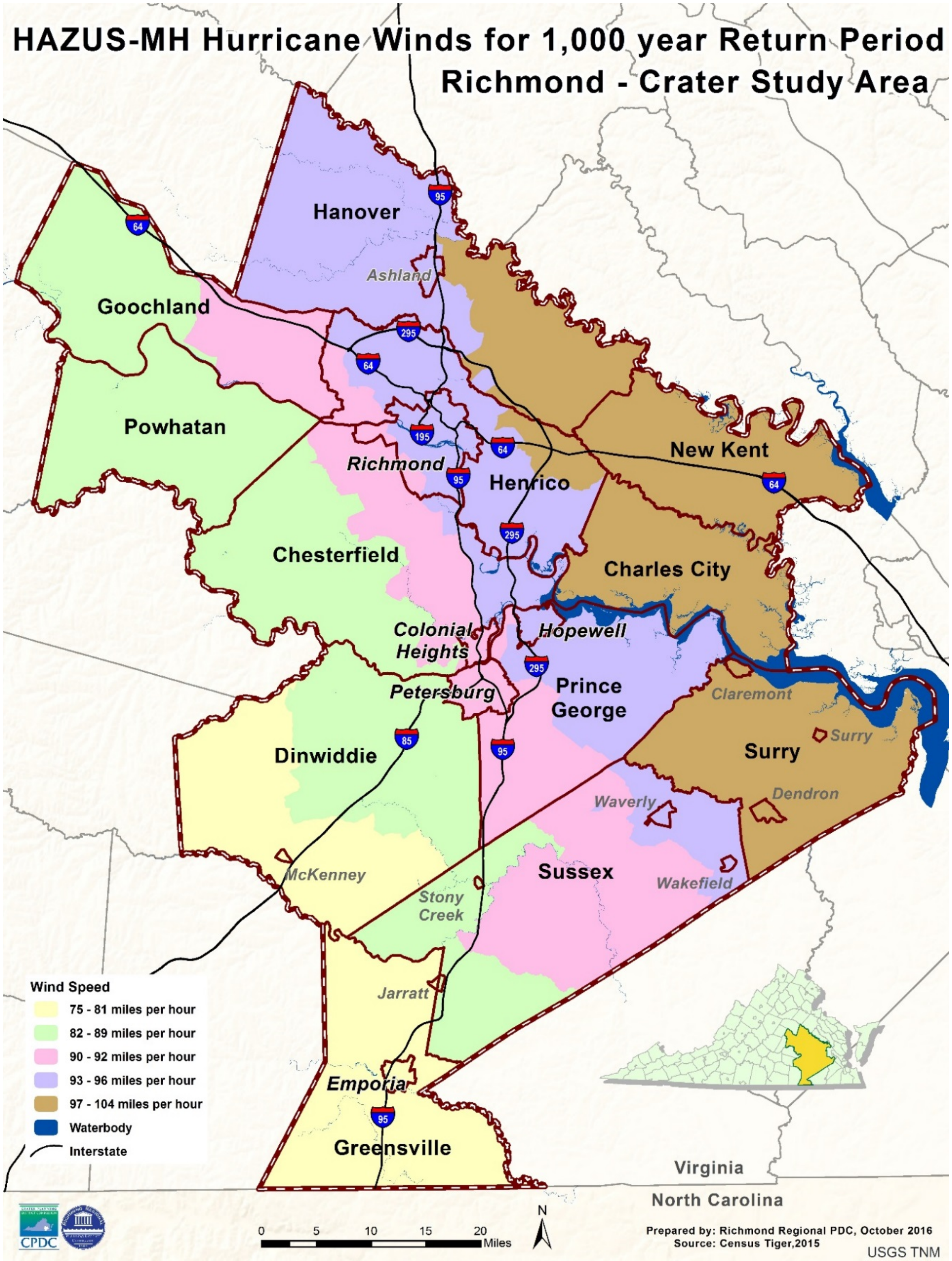

Figure 5-10. HAZUS-MH Hurricane Winds for 1,000-year Return Period

Table 5-15. HAZUS Wind Analysis Damages for 100-year event

Jurisdiction	Residential	Commercial	Industrial	Agricultural	Religious	Government	Education	Total
Charles City County	$108,877.70	$1,661.01	$429.04	$268.30	$381.95	$239.87	$159.05	$112,016.92
Chesterfield County	$1,953,673.59	$45,387.75	$17,667.64	$1,344.37	$4,587.23	$2,646.18	$2,728.99	$2,028,035.75
Colonial Heights city	$149,680.36	$14,770.46	$873.95	$109.62	$771.20	$357.23	$343.15	$166,905.97
Dinwiddie County	$196,098.64	$3,267.09	$867.86	$332.85	$585.07	$566.84	$509.17	$202,227.52
Emporia city	$73,579.69	$7,118.41	$3,815.26	$67.38	$913.11	$274.19	$519.59	$86,287.63
Goochland County	$172,917.13	$2,409.33	$615.39	$252.85	$338.71	$153.23	$87.89	$176,774.53
Greensville County	$66,553.53	$1,141.82	$879.23	$185.52	$422.54	$14.88	$37.67	$69,235.19
Hanover County	$1,148,479.33	$22,145.97	$7,866.53	$1,120.84	$2,203.72	$649.93	$3,304.26	$1,185,770.58
Henrico County	$1,718,625.62	$76,972.87	$37,897.11	$2,022.37	$6,102.87	$2,582.52	$5,221.15	$1,849,424.51
Hopewell city	$197,915.84	$8,737.86	$3,397.54	$121.23	$1,803.42	$482.45	$673.90	$213,132.24

Table 5-15. HAZUS Wind Analysis Damages for 100-year event

Jurisdiction	Residential	Commercial	Industrial	Agricultural	Religious	Government	Education	Total
Jarratt town*	-	-	-	-	-	-	-	-
McKenney town*	-	-	-	-	-	-	-	-
New Kent County	$381,016.11	$2,699.79	$1,759.29	$187.16	$483.96	$314.71	$336.08	$386,797.10
Petersburg city	$272,210.70	$20,962.86	$16,551.25	$122.48	$2,499.92	$809.91	$751.52	$313,908.64
Powhatan County	$228,147.84	$1,220.43	$466.11	$127.98	$241.38	$65.80	$457.79	$230,727.33
Prince George County	$377,787.09	$6,921.27	$2,460.96	$394.47	$958.33	$1,411.10	$1,193.27	$391,126.49
Richmond city	$989,837.11	$89,028.83	$24,746.34	$772.80	$15,082.47	$8,120.71	$7,014.40	$1,134,602.66
Surry town*	-	-	-	-	-	-	-	-
Sussex County	$76,234.87	$1,698.86	$1,459.69	$277.80	$580.82	$462.84	$228.08	$80,942.96
Wakefield town*	-	-	-	-	-	-	-	-
Grand Total	$8,111,635.15	$306,144.61	$121,753.19	$7,708.02	$37,956.70	$19,152.39	$23,565.96	$8,627,916.02

Risk and Loss Estimation

As shown in Figures 5-8 through 5-10, there is a slight variation (around 10%) from the eastern to western portions of the region of wind speed in the 50-, 100-, and 1,000-year storm events. In general, critical facilities located in the eastern portion of the region will have slightly higher vulnerability than those in the western portion of the region due to a greater likelihood of higher winds associated with tropical storms and hurricanes. Building construction type will largely determine the vulnerability of a particular facility. As described previously in the section on Building Types, wood-framed structures are more vulnerable to wind than those constructed of masonry or steel.

The Hazus hurricane model only allows for analysis at the U.S. Census track level, which is smaller than most of the towns in the region.

In addition to widespread wind events associated with tropical storms and hurricanes, NCDC records show that the region experiences a significant number of other types of wind events that produce damaging wind gusts. These range from wide-scale events associated with fronts, storm systems, squall lines, or large thunderstorm complexes to smaller scale phenomena such as single-cell thunderstorm events. For example, thunderstorm winds downed numerous trees causing power outages throughout central Virginia in June and July, 2016. Numerous traffic intersections lost power to traffic signals, in one instance causing a fatal accident in Henrico County. Table 5-16 illustrates the historical annual hurricane occurrence in the region with Prince George, Chesterfield, and Henrico counties most affected by potential annual damages.

Table 5-16. Annualized Hurricane Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.08	$3,937	$28,352	$32,289
Chesterfield County	0.17	$1,951,015	$10,695	$1,961,710
City of Colonial Heights	-	-	-	-
City of Emporia	-	-	-	-
City of Hopewell	-	-	-	-
City of Petersburg	-	-	-	-
City of Richmond	-	-	-	-
Dinwiddie County	0.08	$304,949	$118,207	$423,155

Table 5-16. Annualized Hurricane Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Goochland County	0.04	-	$15,302	$15,302
Greensville County	0.17	$19,373	$4,423	$23,796
Hanover County	0.08	$4,423	$17,692	$22,115
Henrico County	0.17	$982,142	$43,258	$1,025,400
New Kent County	0.08	$1,106	$5,396	$6,502
Powhatan County	0.04	$216,288	$19,412	$235,700
Prince George County	0.25	$1,305,028	$931,931	$2,236,959
Surry County	0.17	$367,252	$115,894	$483,146
Sussex County	0.13	$4,733	$44,231	$48,964
Total	**1.46**	**$5,160,245**	**$1,354,793**	**$6,515,038**

Source: National Climatic Data Center.

5.8 Tornadoes

5.8.1 Hazard Profile

A tornado is classified as a rotating column of wind that extends between a thunderstorm cloud and the earth’s surface. Winds are typically less than 100 mph, with the most violent tornado wind speeds exceeding 250 mph. The rotating column of air often resembles a funnel-shaped cloud. The widths of tornadoes are usually several yards across, and in rare events can be more than a mile wide. Tornadoes and their resultant damage can be classified into six categories using the Fujita Scale. This scale assigns numerical values for wind speeds inside the tornado according to the type of damage and degree of the tornado. Most tornadoes are F0 and F1, resulting in little widespread damage. Tornado activity normally spans from April through July but tornadoes can occur at any time throughout the year. In Virginia, peak tornado activity is in July. Hot, humid conditions stimulate tornado growth.

5.8.2 Magnitude or Severity

Strong tornadoes may be produced by thunderstorms and are often associated with the passage of hurricanes. On average, about seven tornadoes are reported in Virginia each year. The total number may be higher as incidents may occur over areas with sparse populations, or may not cause any property damage.

Tornado damage is computed using the Fujita Scale, as seen in Table 5-17. Classification is based on the amount of damage caused by the tornado, where the measure of magnitude is based on the impact. Tornadoes and their resultant damage can be classified into the six categories using the scale. The scale assigns numerical values for wind speeds inside the tornado according to the type of damage and degree of the tornado. Most tornadoes are F0and F1, resulting in little widespread damage. A tornado's intense power can destroy buildings, especially manufactured homes, downed power lines and can cause significant tree and crop damage.

Table 5-17. Fujita Tornado Intensity Scale

Classification	Max. Winds (mph)	Path Length (miles)	Path Width (miles)	Damage
F0	less than 73	less than 1.0	less than 0.01	Chimneys damaged, trees broken
F1	73–112	1.0–3.1	0.01–0.03	Mobile homes moved off foundations or overturned
F2	113–157	3.2–9.9	0.03–0.09	Considerable damage, mobile homes demolished, trees uprooted
F3	158–206	10–31	0.10–0.29	Roofs and walls torn down, trains overturned, cars thrown
F4	207–260	32–99	0.30–0.90	Well-constructed walls leveled
F5	261–318	100–315	1.0–3.1	Homes lifted off foundations and carried some distance, cars thrown as far as 300 feet

Source: National Weather Service.

The classification of a tornado gives an approximate depiction of what the corresponding damage will be. Hazus analysis for hurricane wind shows that wind speeds with a 1,000-year hurricane event are roughly the same as a weak to mid-range EF1 (defined below) tornado. These usually result in minimal extensive damage. The majority of tornadoes occurring in the Richmond Regional – Crater PDC are F0 and F1 on the Fujita Scale. The winds associated with Hazus hurricane wind show wind speeds at a 1,000 year hurricane event are somewhat equivalent to a weak to mid-range EF-1 tornado. These events typically result in minimal damage which can occur over an extensive area such as damage to trees, shrubbery, signs, antennas, and some damage to roofs and unanchored trailers and manufactured homes. Low-intensity tornadoes can also cause localized transportation route disruption due to debris from trees and impacted buildings, signs, etc. Utilities can also be out of service for several days due to downed power and phone lines. An Enhanced Fujita Scale (EF Scale) was developed and implemented operationally in 2007. The EF Scale was developed to better align tornado wind speeds with associated damages. Table 5-18 provides a side-by-side comparison of the F Scale and the EF Scale.

Table 5-18. Fujita Scale Vs. Enhanced Fujita Scale

Fujita Scale			Enhanced Fujita Scale	
F Number	Fastest 1/4-mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)
0	40–72	45–78	0	65–85
1	73–112	79–117	1	86–110
2	113–157	118–161	2	111–135
3	158–207	162–209	3	136–165
4	208–260	210–261	4	166–200
5	261–318	262–317	5	Over 200

5.8.3 Hazard History

Table 5-19 includes descriptions of major tornado events that have touched down in the region since 2011. Other events are included in Appendix B. Events have been broken down by the date of occurrence and, when available, by individual community descriptions. When no community description is available, the general description applies to the entire region. Although not comprehensive in terms of tornado fatalities and injuries, the NCDC database indicates that since 1950 there have been ten deaths and 347 injuries in the region due to tornadoes.

Table 5-19. History of Tornado Events and Damages, 2011–2016

Date	Damages
April 16, 2011	**Dinwiddie County:** A high-end EF1 tornado touched down near Doyle Road west of Glebe Road and tracked to the Five Forks area, some 8 miles east/northeast. The twister injured at least four people, downed hundreds of trees, knocked down power lines, and damaged (minor to moderate) several homes.
October 14, 2011	**New Kent County:** Preliminary information showed the tornado had 95 mph winds and was 200 yards wide. A school and a dozen homes suffered damage. One injury was reported. (Source: The Virginian-Pilot)

Table 5-19. History of Tornado Events and Damages, 2011–2016

Date	Damages
June 30, 2012	**Hanover County:** An EF-0 tornado traveled 4.5 miles in Mechanicsville. It reached wind speeds up to 80 mph. It was only on the ground periodically. Several roads were closed due to downed trees and power lines. (Source: http://www.nbc12.com/story/18927663/national-weather-service-confirms-tornado-in-hanover-county)
May 22, 2014	**Prince George County:** _ The tornado was confirmed near the city of Prince George. The storm intensified northwest of Richmond, then produced wind damage in the City of Richmond, with trained storm spotters periodically reporting a funnel cloud in the Metro as it raced southeast. At 5:45 p.m., a tornado touched down on Kurnas Lane, destroying a shed, snapping trees and causing minor damage to a home. The tornado was rated an EF-0, with winds of 70 mph. It was 25 yards wide, and was on the ground for 75 yards. No injuries were reported. **Sussex County:** The tornado was confirmed near Waverly in Sussex county at 6:20 p.m. The tornado developed just north of Highway 460 and south of Petersburg Road, about mile northwest of Waverly. It moved south and crossed Highway 460 just north of Waverly. It struck an auto parts store, causing minor damage. Many large trees were uprooted along Highway 460, and the highway was closed due to trees on the road. The tornado tracked southward to North Church Street, causing minor damage to the First Baptist Church. Many large trees fell into the nearby cemetery, causing damage. The tornado moved across New Street, snapping trees and damaging homes. The tornado lifted shortly after crossing Highway 460 on the west side of Waverly. This tornado was classified as an EF-0 tornado, with winds of 75 mph. It was 100 yards wide, and was on the ground for 1.5 miles. No injuries were reported. (Source: http://wtvr.com/2014/05/23/two-tornadoes-confirmed-from-may-22-storm/)
Feb 25, 2016	Virginia State Police confirmed three deaths and eight with minor injuries after a confirmed tornado hit the Town of Waverly in in Sussex County. Emergency management officials spotted the twister moving along Route 460 and into Waverly. Crews spotted a church and trailer in the storm. Snapped trees and signs were also spotted. Troopers began responding to the damage along Route 40 in Waverly around 2:40 p.m. That's where officials said a 50-year-old man, 26-year-old man and 2-year-old boy were killed when their mobile home was destroyed. The victims, whose bodies were transported to the Office of the Medical Examiner in Norfolk for positive identification, were found about 300 yards from the mobile home. Officials said four other structures suffered damage in the town." (Source: http://wtvr.com/2017/02/24/2-killed-in-wavery-tornado/)

Table 5-19. History of Tornado Events and Damages, 2011–2016

Date	Damages
	This was the first deadly tornado in Virginia since 1950. (Source: http://www.vaemergency.gov/news-local/tornado-history/)

*History from 1790-2010 in Appendix B-3

Figure 5-11. A deadly EF-1 Tornado in Waverly killed three on 25 February 2016

Source: NewsRadio WINA

Figure 5-12 presents the results of a tornado frequency analysis performed as part of the 2013 Virginia State Hazard Mitigation Plan update. The analysis suggests that relative to the entire Commonwealth of Virginia, the region is considered to be "Medium-High" to "High" in terms of tornado frequency. Even so, annualized tornado frequency is quite low and calculated as being between 0.0000101 and 0.000316 for any particular point in the region, with no one specific jurisdiction more likely to experience tornadoes than another.

Table 5-20 presents a calculation of annualized tornado occurrence by jurisdiction based on NCDC tornado data. The annual tornado frequency, a reasonable predictor of future tornado probability, ranges from 0.27 to 0.02 which roughly correlates to a tornado occurring every 4 to 50 years.

Table 5-21 and Figure 5-13 show tornado occurrences in the region since 1950.

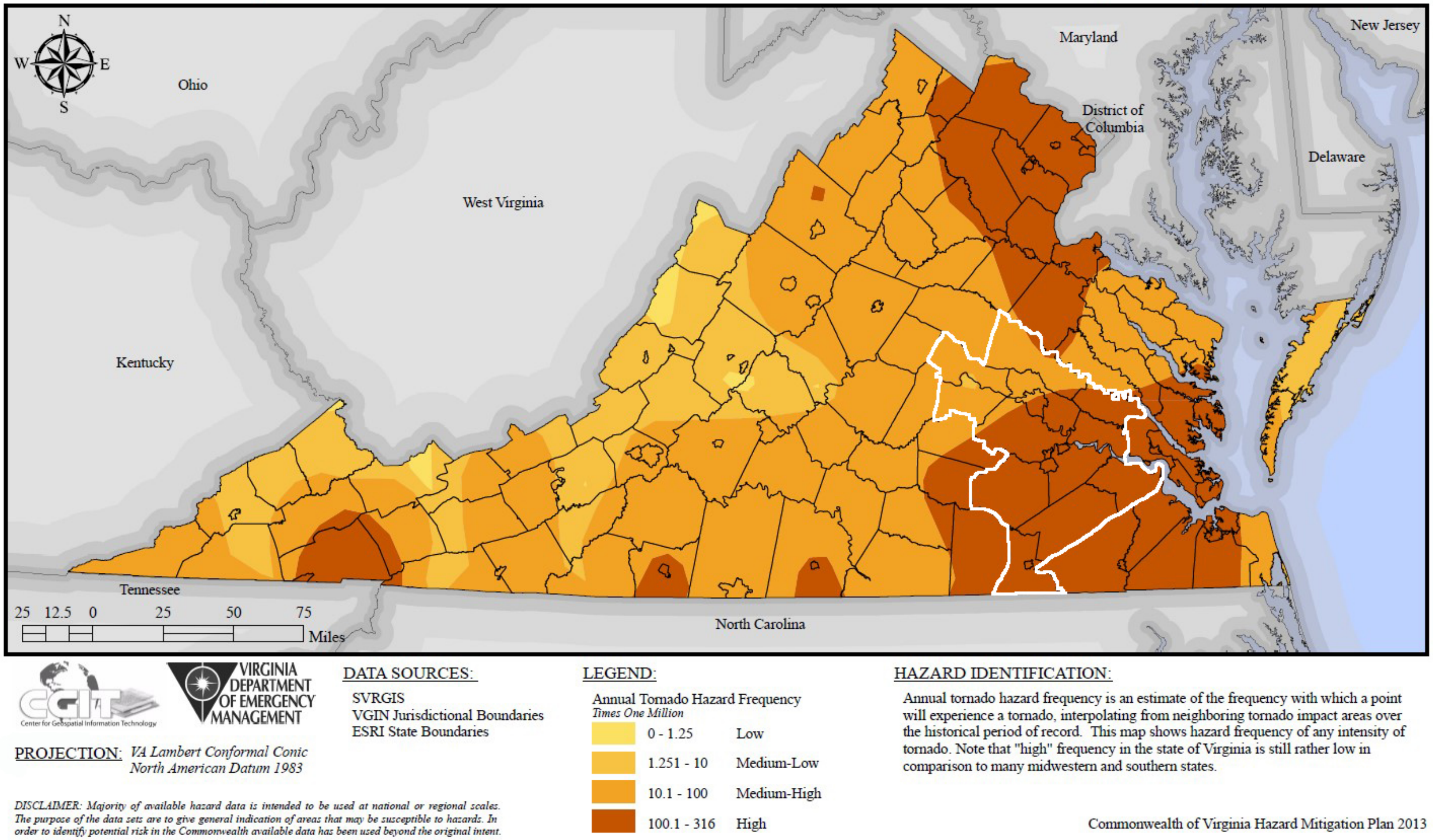

Figure 5-12. Historical Tornado Hazard Frequency Analysis

Source: 2013 Virginia State Hazard Mitigation Plan

Table 5-20. Annualized Tornado Events and Losses, 1950 - 2016

Jurisdiction	Annualized Number of Tornado Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.03	$13,988	-	$13,988
Chesterfield County	0.26	$201,639	-	$201,639
City of Colonial Heights	0.02	$33,106	-	$33,106
City of Emporia	0.03	$3,337	-	$3,337
City of Hopewell	0.06	$85,942	-	$85,942
City of Petersburg	0.08	$891,490	-	$891,490
City of Richmond	0.14	$73,980	-	$73,980
Dinwiddie County	0.14	$1,272,733	-	$1,272,733
Goochland County	0.14	$24,560	-	$24,560
Greensville County	0.09	$18,033	-	$18,033
Hanover County	0.29	$27,280	-	$27,280
Henrico County	0.18	$114,430	-	$114,430
New Kent County	0.08	$16,581	-	$16,581
Powhatan County	0.05	-	-	-
Prince George County	0.15	$20,546	-	$20,546
Surry County	0.12	$21,636	-	$21,636
Sussex County	0.14	$75,448	-	$75,448
Total	**2**	**$2,894,729**	**$0**	**$2,894,729**

*Particularly damaging tornado events in 1984 and 1993 play a significant role in this loss estimate.

Source: National Climatic Data Center.

Table 5-21. Tornado Touchdowns by Fujita Rating, 1950 - 2017

County	EF0	EF1	EF3	F0	F1	F2	F3	F4	Total
Charles City County					2				**2**
Chesterfield County	1			3	8	3			**15**

Table 5-21. Tornado Touchdowns by Fujita Rating, 1950 - 2017

County	EF0	EF1	EF3	F0	F1	F2	F3	F4	Total
City of Colonial Heights		1							**1**
Dinwiddie County (incl. Town of McKenney)				1		1			**2**
City of Emporia				1			1		**2**
Goochland County	1	1				1	1		**4**
Greensville County (incl. Town of Jarratt)		1		3	1	2			**7**
Hanover County (incl. Town of Ashland)		1		1	4		1	1	**8**
Henrico County	1	1		1	3	1			**7**
City of Hopewell		2		1	1				**4**
New Kent County	5	1		5	1		1		**13**
City of Petersburg		1		4	6				**11**
Powhatan County	1	1		2	1				**5**
Prince George County				1					**1**
City of Richmond	1	1		3		3			**8**
Surry County (incl. Towns of Claremont, Dendron, Surry)		2	1	2	2		1		**8**
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	2	1		1	2	1	1		**8**

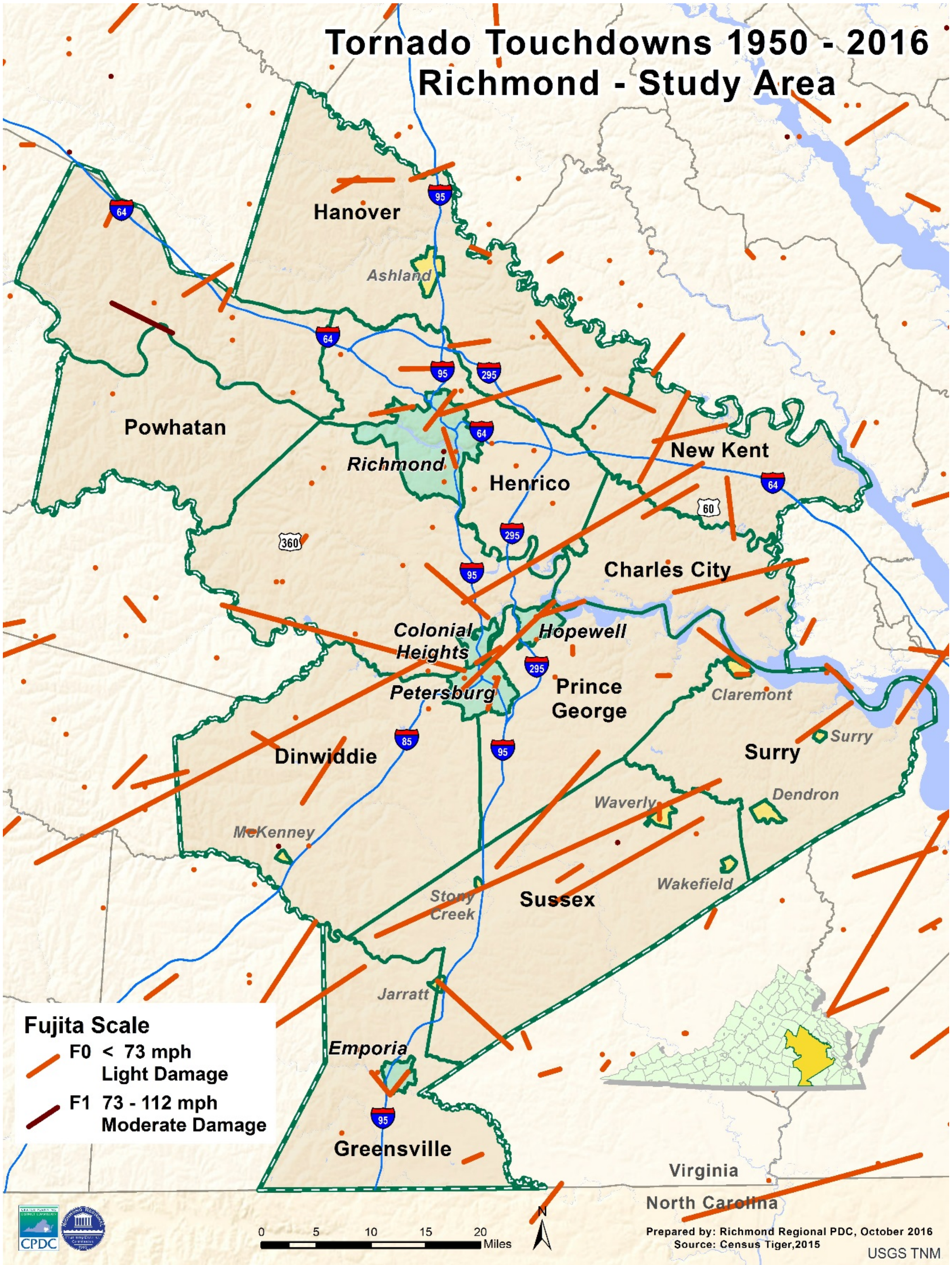

Figure 5-13 Tornado Touchdowns, 1950-2016

5.8.4 Vulnerability Analysis

Probability

Tornadoes are considered to be low-frequency, high-impact events. Electrical utilities and communications infrastructure are vulnerable to tornadoes. Damage to power lines or communication towers has the potential to cause power and communication outages for residents, businesses, and critical facilities. In addition to lost revenues, downed power lines present a threat to personal safety. Further, downed wires and lightning strikes have been known to spark fires.

Impact and Vulnerability

A structure's tornado vulnerability is the same as that for other types of extreme wind events and is based in large part on building construction and standards as discussed previously in greater detail in the section on building types (within the Wind Hazard section). Other factors such as location, condition, and maintenance of trees also play a significant role in determining vulnerability. A tornado will bring about severe damage or destruction to any structure in its path. Clusters of mobile homes may be more vulnerable to tornadoes. Proper anchoring can reduce damage exposure, but not entirely as these structures are extremely vulnerable to damage from downed trees and a tornado's effect on the structure of the manufactured home itself.

Human vulnerability is based on the availability, reception, and understanding of early warnings of tornadoes (e.g., tornado warnings issued by the NWS) and access to safe, substantial indoor shelter. While one might generalize that areas of high population are more vulnerable due to exposure of more people, property and infrastructure, Table 5-21 Tornado Touchdowns by Jurisdiction demonstrates the historical occurrence dominated in both rural and more urban jurisdictions of the Plan area. In some cases, despite having access to technology (computers, radio, television, cell phones, outdoor sirens, etc.) that allow for receiving warnings, language differences may prevent some individuals from understanding them. Once warned of an impending tornado hazard, to seek shelter indoors on the lowest floor of a substantial building away from windows is recommended as the best protection against bodily harm.

Risk and Loss Estimation

Although historical data indicates that there has been some small variation in the distribution of tornadoes across the region, the probability of experiencing a tornado is roughly equal for all of the jurisdictions. With this being the case, the vulnerability of critical facilities across the area is largely determined by construction type of each particular facility. Wood-framed structures are generally considered to be more vulnerable to tornado damage than steel, brick, or concrete structures.

Table 5-20 illustrates that based on the historical record, two tornado events occur annually in the region resulting in about $2.9 million in damages. This loss figure is skewed by two particularly damaging tornado events that occurred on August 6, 1993 (which impacted multiple jurisdictions) and May 8, 1984. The City of Petersburg was hit hard in both instances and has a very high annualized tornado loss estimate as a result.

Each county (to include the town(s) located within the counties) and city has a jurisdictional executive summary that highlights the hazards and vulnerability within their community.

5.9 Thunderstorms (including Hail and Lightning)

5.9.1 Hazard Profile

Thunderstorms are caused when air masses of varying temperatures and moisture content meet. All thunderstorms produce lightning. Droplets of water in a thunderstorm may get picked up in the storm's updraft, a column of rising air. The updraft can carry the droplets to levels of the atmosphere where temperatures are below freezing. The frozen droplets, now hail, may then fall due to gravity injuring people, property and animals.

5.9.2 Magnitude or Severity

A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning can remain in-cloud or can contact the ground or other surfaces. A cloud-to-ground bolt of lightning can sometimes strike locations 10 or more miles away from the parent thunderstorm, producing the effect that the lightning came from 'out of the blue' or without warning. In the past 30 years, lightning has killed an average of 58 people per year in the United States.[10]

Hail can be smaller than a pea, or as large as a softball, and can be very destructive to automobiles, glass surfaces (e.g., skylights and windows), roofs, siding, plants, and crops.[11]

5.9.3 Hazard History

Virginia averages 40 to 50 thunderstorm days per year.[12] Thunderstorms can occur at any time during any season, but are most common in the late afternoon and evening hours during the summer months. In addition to flooding rainfall, damaging winds, and sometimes tornadoes thunderstorms might also produce large hail and deadly lightning.

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[10] http://www.weather.gov/os/lightning/overview.htm; NWS; retrieved April 11, 2011.

[11] *Talking About Disaster*.

[12] Sammler, William. Personal interview, September 15, 2005. (National Weather Service, Warning Coordination Meteorologist, Wakefield, Virginia office.)

Past occurrences of thunderstorm events that produced damage, injuries, or fatalities as a result of hail or lightning are listed in Table 5-22. The NCDC database shows that at least two people in the region have been killed and three others injured as a result of lightning since 1993. The database did not indicate any deaths or injuries in the region during this period as a result of hail.

Table 5-22. History of Hail/Lightning Events and Damages, 2010–2016

Date	Damages
August 12, 2010	**Hanover County:** Hail, two inches in diameter, damaged vehicles in the county east of Old Cold Harbor.
June 29, 2012	The June 2012 Mid-Atlantic and Midwest derecho was one of the most destructive and deadly fast-moving severe thunderstorm complexes in North American history. The progressive derecho tracked across a large section of the Midwestern United States and across the central Appalachians into the mid-Atlantic states on the afternoon and evening of June 29, 2012, and into the early morning of June 30, 2012. It resulted in 20 deaths, widespread damage and millions of power outages across the study region. (Source: https://en.wikipedia.org/wiki/June_2012_North_American_derecho)
June 13, 2013	On the morning of the 13, another linear complex of severe storms developed along a line near the southern border of Ohio. The storms eventually strengthened into a powerful derecho and raced to the south and east. Fatalities and injuries occurred as a result of falling trees and power lines as the storms ripped through Virginia, along with numerous reports of damaging winds and power outages. The derecho downed numerous tress and damaged structures winds up to 80 mph (130 km/h) in some areas. (Source: https://en.wikipedia.org/wiki/June_12%E2%80%9313,_2013_derecho_series)
May 22, 2014	A large Hail and Thunderstorm event came through the region. Some hail was reported to be as large as ping pong balls. Several areas were affected from fallen electric lines. The NCDC data reports that 12 direct deaths in the study region resulted from this event. (Source: NCDC data & http://www.nbcwashington.com/news/local/Severe-Thunderstorms-DC-Area-May-22-260300391.html)
February 24, 2016	This storm started in the north eastern states and traveled down through Virginia and south. During the thunderstorm, hail in some parts of the region were as large as 3 inches in diameter. (Source: http://www.weather.gov/akq/Feb24-2017TOR)

5.9.4 Risk Assessment

Probability

Although most frequent in the Southeast and parts of the Midwest, thunderstorms are a relatively common occurrence across the region and have been known to occur in all calendar months. No one portion of the central Virginia region is deemed more likely to experience thunderstorms than another. Table 5-23 indicates the annualized number of hail and damaging lightning events by jurisdiction based on NCDC data.

Impact and Vulnerability

Electrical utilities and communications infrastructure are vulnerable to lightning. Damage to power lines or communication towers due to direct lightning strikes have the potential to cause power and communication outages for residents, businesses, and critical facilities. In addition to lost revenues, downed power lines present a threat to personal safety. Further, downed wires and lightning strikes have been known to spark fires.

A structure's thunderstorm vulnerability is based in large part on building construction and standards. Other factors, such as location, condition, and maintenance of trees also plays a significant role in determining vulnerability. Windows, roofs, and siding are most vulnerable to the impacts of large hail.

Human vulnerability is based on the availability and reception of early warnings of significant thunderstorm events (i.e., Severe Thunderstorm Warning issued by the NWS) and access to substantial indoor shelter. Seeking shelter indoors on the lowest floor of a substantial building away from windows is recommended as the best protection against thunderstorm-related hazards.

Risk and Loss Estimation

A quantitative assessment of critical facilities at risk for hail and lightning damage was not feasible for this plan update. It is important to note, however, that not all critical facilities have redundant power sources and may not even be wired to accept a generator for auxiliary power. Future plan updates should consider including a more comprehensive examination of critical facilities that are vulnerable to these hazards.

Table 5-23 is based on NCDC historical data; on average, the region experiences approximately six to seven hail storms annually and one damaging lightning event every two years. In terms of damages, roughly $1,600 in losses is attributed to hail and about $23,900 to lightning annually. Jurisdictional executive summaries highlight hazards and vulnerability within the community.

Table 5-23. Annualized Thunderstorm (with Hail and Lightning) Events and Losses, 1956 - 2016

Jurisdiction	Annualized Thunderstorm Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.95	$1,535	-	$1,535
Chesterfield County	3.98	$15,640	-	$15,640
City of Colonial Heights	0.59	$4,370	-	$4,370
City of Emporia	0.54	$1,408	-	$1,408
City of Hopewell	0.70	$1,199	-	$1,199
City of Petersburg	0.82	$3,764	-	$3,764
City of Richmond	1.41	$3,673	-	$3,673
Dinwiddie County	2.03	$10,713	$1	$10,714
Goochland County	2.03	$2,972	-	$2,972
Greensville County	1.13	$2,513	-	$2,513
Hanover County	3.16	$15,037	-	$15,037
Henrico County	4.26	$36,087	-	$36,087
New Kent County	1.54	$5,979	-	$5,979
Powhatan County	1.80	$4,538	-	$4,538
Prince George County	2.74	$6,247	-	$6,247
Surry County	1.38	$2,224	-	$2,224
Sussex County	1.80	$3,418	-	$3,418
Total	**30.86**	**$121,316**	**$1**	**$121,317**

Source: National Climatic Data Center.

5.10 Winter Weather

5.10.1 Hazard Profile

Winter weather comes in many forms ranging from sub-freezing temperatures and dangerously low wind chills to an assortment of precipitation including freezing rain, sleet and snow. Winter storms can vary in size and strength throughout the region and can even include embedded thunderstorms. Snow typically maintains its crystalline structure from the clouds in which it forms until it reaches the surface. Freezing rain, on the other hand, may have started in the clouds as either rain or snow, but reaches the surface as liquid that freezes on contact with surfaces (power lines, tree limbs, the ground) with temperatures below freezing. Freezing rain can accrete on these surfaces resulting in an ice coating. Sleet reaches the surface in the form of clear pellets of ice that bounce upon contact. Extremely cold temperatures accompanied by strong winds can result in wind chills that cause harm and injury such as frostbite and rarely in the region death. There are a variety of winter weather phenomena and conditions as detailed by the National Weather Service:

1. Ice Storm Warning is issues when a period of freezing rain is expected to produce ice accumulation of ¼" or greater or can cause significant disruptions to travel or utility function.
2. Heavy Sleet Warning is issued when a period of sleet is expected to produce ice accumulation of 1" or greater, or causes significant disruption to travel or utilities.
3. Heavy Snow Warning is issued when snow is expected to accumulate four inches or more in a 12 hour period or six inches in more than 24 hours.
4. A Winter Storm Warning is issued for a winter weather event in which there is more than one hazard present, and one of the warning criteria listed above is expected to be met.
5. A Blizzard Warning is issued for sustained wind or frequent wind gusts greater than or equal to 35 mph accompanied by falling and/or blowing snow, frequently reducing visibility to less than ¼ mile for three hours or more. Watches are issued when conditions may be met 12 to 48 hours in the future.

5.10.2 Magnitude or Severity

The impacts of winter storms are usually minimal in terms of property damage and long-term effects. The most notable impact from winter storms is damage to power distribution networks and utilities. Severe winter storms have the potential to inhibit normal functions of the community. Government costs for these events include overtime personnel wages and equipment or contractors for road clearing. Private-sector losses are attributed to time lost when employees are unable to travel. Homes and businesses suffer damage when electric service is interrupted for long periods of time. Several utility companies and cooperatives provide service to the region, which can make power restoration complicated.

Health threats can become severe when frozen precipitation makes roadways and walkways very slippery, when prolonged power outages occur, and when 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 water content of snow can vary significantly from one storm to another and can drastically impact the degree to which damage might occur. In snow events that occur at temperatures at or even above freezing, the water content of the snowfall is generally higher. Higher water content translates into a heavier, "wet" snowfall that more readily adheres to power lines and trees, increasing the risk of their failure. Roof collapse is also more of a concern with wetter, heavier snowfall. Clearing of roadways and sidewalks is usually easier with a drier, more powdery snow which is also less likely to accumulate on power lines and trees. This type of snow generally occurs in temperatures below freezing, as water content decreases with temperature. The primary impact of excessive cold is increased risk for frostbite, and potentially death as a result of over-exposure to extreme cold.

Secondary effects of extreme/excessive cold include danger to livestock and pets as well as frozen water pipes in homes and businesses.

Primary Impacts

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 have the potential to inhibit normal functions of the community. 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 of time (see Table V-34. Estimated Losses due to Electricity Outage for Residential Structures). Six utility companies provide service to the region, which can make power restoration complicated.

Health threats can become severe when frozen precipitation makes roadways and walkways very slippery and also 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 water content of snow can vary significantly from one storm to another and can significantly impact the degree to which damage might occur. In snow events that occur at temperatures at or even above freezing, the water content of the snowfall is generally higher. Higher water content translates into a heavier, 'wet' snowfall that more readily adheres to power lines and trees, increasing the risk for their failure. Roof collapse is also more of a concern with wetter, heavier snowfall. On the other hand, clearing roadways and sidewalks is considerably easier for a drier, more powdery snow. A dry, fluffy snow is less likely to accumulate on power lines and trees. This type of snow generally occurs in temperatures below freezing with water content decreasing with temperature. The primary impact of excessive cold is increased potential for frostbite, and potentially death as a result of over-exposure to extreme cold.

Secondary Effects

Some of the secondary effects presented by extreme/excessive cold are threats to the health of livestock and pets, and frozen water pipes in homes and businesses.

Predictability and Frequency

A winter storm is a weather event that can include a combination of heavy snowfall, high winds, freezing rain, ice and extreme cold. Winter weather typically impacts the state of

Virginia between the months of November and April, with varied intensities. Analysis from the previous plan(s) was reviewed and determined to still represent relative winter storm risk for the region.

To determine the geographic distribution and frequency with which major snow or ice events impact the region, issued National Weather Service warnings and advisories were examined (see Table 5-25).

Specifically, the number and types of warnings and advisories issued was analyzed for each county and city and a weighting system was applied that factored the 'severity' of an event implied by a particular warning or advisory type. *Note: National Weather Service warnings/advisories for winter weather are issued at a county level. The warnings/advisories apply to all towns and cities located within a particular county.* In the case of snowfall for example, issuance of a Blizzard Warning implies a more significant event than that of a Snow Advisory. A higher weight was thereby applied to the Blizzard Warning.

5.10.3 Hazard History

Table 5-24 includes descriptions of major winter storm events in the region. Events have been broken down by the date of occurrence and, when available, by individual community descriptions. When no community description is available, the general description applies to the entire region. All descriptions are based on NCDC and VDEM data unless otherwise noted. Although very limited in terms of winter weather-related fatalities and injuries, the NCDC database indicates that since 1993 there has been one death and five injuries in the region due to winter storm events.

Table 5-24. History of Winter Storm Events and Damages, 2010–2016

Date	Damages
December 25, 2010	A 4- to 10-inch snowfall blanketed the region with the heaviest amounts falling over the south and eastern sections. Amounts ranged from 4 inches northwest of the City of Richmond, 6 to 7 inches in the Cities of Petersburg and Emporia, and around a foot near the Town of Wakefield.
February 10, 2014	This was a major ice and snow storm that affected the entire region and elsewhere in the Eastern United States. This event produced devastating amounts of freezing rain and snow along and east of Interstate 95 all the way down to the coast. Overall temperatures throughout the winter were much colder in 2014. This was rated as 3 (Major) on the NESIS scale. A Presidential Disaster event was declared in Chesterfield. (Source: http://www.weather.gov/phi/02132014)
January 22, 2016	What transpired was reasonably close to what was forecast, with a major snowstorm for our entire region, which also included a mix of some sleet across portions of the area as well as small amounts of freezing rain. NOAA ranks Northeast U.S. storms according to overall impact, part of which is dependent on societal and economic factors, thus population density is a key

Table 5-24. History of Winter Storm Events and Damages, 2010–2016

Date	Damages
	component. This particular storm was ranked as a 4 on the "NESIS" scale of 1-5, or "crippling". It is now 4th on the list of historic storms that have been ranked on the NESIS scale, with only two storms ever ranked as a 5 ("extreme). Presidential Disasters for this study region were declared for Sussex and Henrico Counties. (Source: http://www.weather.gov/media/rnk/past_events/2017_01_2223_Winter.pdf)
*History from 1940-2010 in Appendix B-3	

As part of the 2006 analysis, gridded climate data was obtained from the Climate Source and through the Virginia View program. This data was developed by the Oregon State University Spatial Climate Analysis Service using PRISM (Parameter-elevation Regressions on Independent Slopes Model). This climate mapping system is an analytical tool that uses point weather station observation data, a digital elevation model, and other spatial datasets to generate gridded estimates of monthly, yearly, and event-based climatic parameters.

The mean annual days map reveals the 30-year average of the number of days that a location will receive greater than 1 inch of snowfall in a 24-hour period in a given year.

A criterion of greater than 1 inch was selected for winter snowfall severity assessment because this depth will result in complete road coverage that can create extremely dangerous driving conditions and will require removal by the local community. This amount of snowfall in a 24-hour period can also lead to business closures and school delays or cancellation.

Error! Reference source not found. shows the average number of days with snowfall greater than 1 inch for the state. The analysis shows that the highest frequency of days with greater than 1 inch of snow is found in the higher elevations of western portions of the commonwealth. On the flip side, southern and southeastern portions of the commonwealth typically only experience one day or fewer where snowfall accumulates to more than an inch. Availability of new data through PRISM is now somewhat restricted due to that program's limited remaining funding. This circumstance prevented a similar or updated analysis for this plan's update. Even so, the previous analysis is based on long-term records and is still considered valid.

The Virginia Tech Center for Geospatial Information and Technology performed analyses of weather station daily snowfall data for the Commonwealth of Virginia's 2013 Hazard Mitigation Plan Update. Station-specific statistics were used as the basis for a seamless statewide estimate based on multiple linear regressions between the weather statistics (dependent variable) and elevation and latitude (independent variables). **Error! Reference source not found.** shows that the average number of days with at least 3 inches of snowfall ranges from 1.51 to 2 days over northwestern portions of the region, including portions of Hanover, Goochland, Powhatan, and Henrico Counties to 1.5 days or fewer over the remainder of the area.

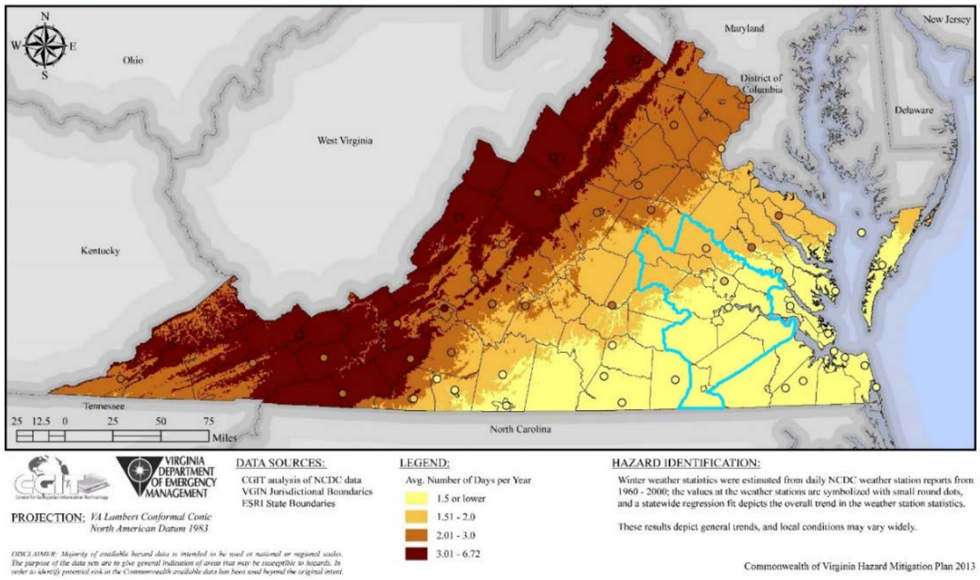

Figure 5-14 Virginia Average Number of Days with Snowfall > 3 Inches
Source: 2010 Virginia State Hazard Mitigation Plan

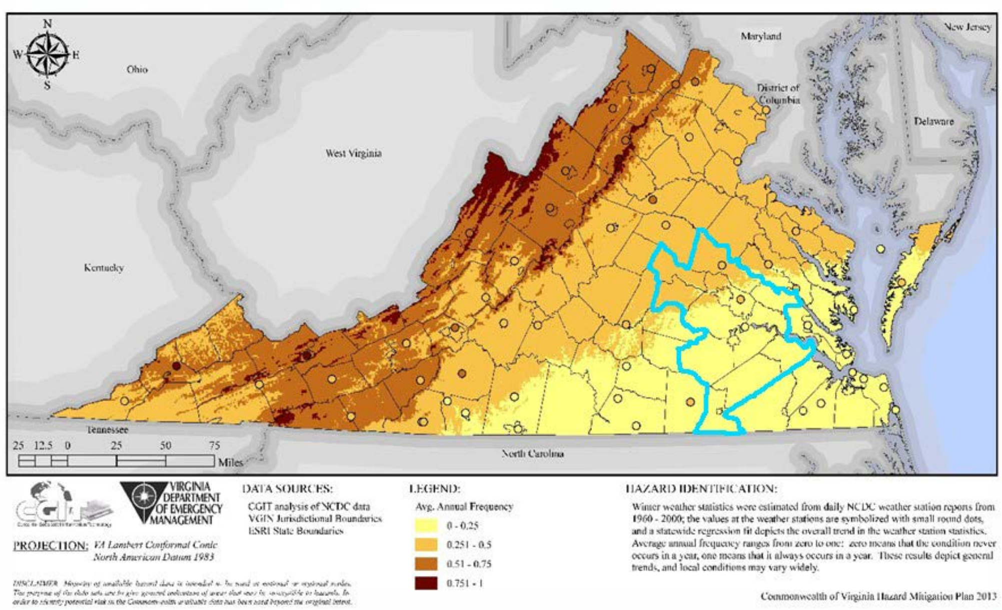

Figure 5-15 Average Number of Days with at Least 3 Inches of Snowfall
Source: 2010 Virginia State Hazard Mitigation Plan

5.10.4 Ice Potential

Another challenge with winter weather in the region is the amount of ice that often accompanies the winter season. Ice in winter storms takes two primary forms:

Sleet is rain that freezes into ice pellets before it reaches the ground. Sleet usually bounces when hitting a surface and does not stick to objects; however, it can accumulate like snow and cause roads and walkways to become hazardous.

Freezing rain (also known as an ice storm) is rain that falls onto a surface that has a temperature below freezing. The cold surface causes the rain to freeze, so surfaces such as tree branches, utility wires, vehicles, and roads become glazed with ice. Even small accumulations of ice can cause significant hazards to people, especially to pedestrians and motorists, as well as to property.[13]

Ice from freezing rain can accumulate on trees, power lines, and communication towers causing damage and leading to power and communication outages that can last for days, and in the most severe cases, for weeks. Even small accumulations of ice can be severely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

The debris created by the trees can also blocks roadways and impact emergency services. Clean-up of the debris is often complicated because responsibility is shared by the Virginia Department of Transportation (VDOT) and private utility companies.

5.10.5 Vulnerability Analysis

Probability

Winter storms can be a combination of heavy snowfall, high winds, ice, and extreme cold. Winter weather typically impacts the state of Virginia between the months of October and April, with varied intensities.

To determine the geographic distribution and frequency with which major snow or ice events impact the region, the Iowa Environmental Mesonet (IEM) obtains data from cooperating members that have observing networks. Watch, Warning, and Advisory events were collected and examined between 1986 and 2017 (see Table 5-25 and Table 5-26). The events were sorted into the following categories: Freeze, Freezing Fog, Freezing Rain, Frost, Heavy Snow, Snow, Winter Storm, and Winter Weather. (Data was collected from: http://mesonet.agron.iastate.edu/vtec/search.php)

The most alerts between 1986 and 2016 were for Goochland County, followed next by Hanover and Powhatan Counties. The fewest alerts were issued for Charles City, Sussex,

[13] *Talking About Disaster.*

and Prince George Counties. The most common type of events for all counties were the Winter Weather, Winter Storm, Freeze, and Frost type events.

It should be noted that the number of reported events from the IEM and NCDC collections were slightly different. With the number of annual IEM events being 49.3 and the NCDC annual winter events being around 45.9. Because of the difference in collection criteria, agencies, and time frames of the reported events, the 7% difference between the two annualized events reported was not significant.

Table 5-25. National Weather Service Winter Alerts, 1986 - 2016

Jurisdiction	Watch Events	Warning Events	Advisory Events	Total Events	Annualized Events
Charles City County	20	36	59	**115**	**3.71**
Chesterfield County	21	38	63	**122**	**3.94**
City of Colonial Heights	-	-	-	-	-
Dinwiddie County	22	39	66	**127**	**4.10**
City of Emporia	-	-	-	-	-
Goochland County	33	45	73	**151**	**4.87**
Greensville County	21	37	62	**120**	**3.87**
Hanover County	26	41	77	**144**	**4.65**
Henrico County	22	38	64	**124**	**4.00**
City of Hopewell	-	-	-	-	-
New Kent County	22	34	65	**121**	**3.90**
City of Petersburg	-	-	-	-	-
Powhatan County	32	46	65	**143**	**4.61**
Prince George County	19	38	62	**119**	**3.84**
City of Richmond	-	-	-	-	-
Surry County (Incl. Towns of Claremont, Dendron, Surry)	22	34	62	**118**	**3.81**
Sussex County (Incl. Towns of Stony Creek, Wakefield, Waverly)	22	37	65	**124**	**4.00**
Totals	**282**	**463**	**783**	**1528**	**49.3**

Table 5-26. Annualized Winter Alert Types, 1986 - 2016

Jurisdiction	Freeze	Freezing Fog	Freezing Rain	Frost	Heavy Snow	Snow	Winter Storm	Winter Weather	Total Annualized Events
Charles City County	0.87	0.03	-	0.48	-	0.06	0.94	1.32	**3.7**
Chesterfield County	0.77	0.03	0.03	0.48	0.03	0.03	1.1	1.45	**3.92**
City of Colonial Heights	-	-	-	-	-	-	-	-	
Dinwiddie County	0.97	0.03	0.03	0.48	-	0.06	1	1.52	**4.09**
City of Emporia	-	-	-	-	-	-	-	-	
Goochland County	0.94	0.03	0.19	0.35	0.03	0.03	1.55	1.74	**4.86**
Greensville County	0.97	0.03	-	0.48	-	0.06	0.9	1.42	**3.86**
Hanover County	0.81	0.03	0.13	0.45	0.03	0.06	1.32	1.81	**4.64**
Henrico County	0.77	0.03	0.03	0.52	0.03	0.03	1.13	1.45	**3.99**
City of Hopewell	-	-	-	-	-	-	-	-	
New Kent County	0.84	0.03	-	0.48	-	0.06	0.97	1.52	**3.9**
City of Petersburg	-	-	-	-	-	-	-	-	
Powhatan County	0.94	0.03	0.16	0.39	0.03	0.03	1.55	1.48	**4.61**
Prince George County	0.94	0.03	-	0.52	-	0.06	0.9	1.39	**3.84**
City of Richmond	-	-	-	-	-	-	-	-	
Surry County (Incl. Towns of Claremont, Dendron, Surry)	0.94	0.03	-	0.52	-	0.1	0.87	1.35	**3.81**
Sussex County (Incl. Towns of Stony Creek, Wakefield, Waverly)	0.97	0.03	-	0.52	-	0.06	0.94	1.48	**4**
Totals	**10.73**	**0.36**	**0.57**	**5.67**	**0.15**	**0.64**	**13.17**	**17.93**	**49.22**

Impact and Vulnerability

Winter storm vulnerability can be expressed by impacts to people, property, and societal function. For example, exposure of individuals to extreme cold, falls on ice-covered walkways, carbon monoxide poisoning from generators and automobile accidents is heightened during winter weather events. According to NCDC records dating back to 1993, at least one fatality was officially recorded resulting from a winter storm event in the area. NCDC storm event records typically do not contain traffic fatalities blamed on wintry weather, and although details were not provided, the fatality took place during a severe snow storm on January 25, 2000.

Property damage due to winter storms includes damage done by and to trees, water pipe breakage, structural failure due to snow loads, and injury to livestock and other animals. The average amount of total damages due to winter events is $40,000 per year (1993-2017) for the region (adjusted for inflation to 2017 dollars). The counties most affected from winter events are Prince George ($9,089/yr.), Henrico ($8,948/yr.), and Chesterfield ($7,962/yr.). Disruption of utilities and transportation systems, as well as lost business and decreased productivity represent societal vulnerability.

Vulnerability to winter storm damages varies due to specific factors; for example, proactive measures such as regular tree maintenance and utility system winterization can minimize property vulnerability. Localities accustomed to winter weather events or with resources to take proactive preventive measures are typically more prepared to deal with them and therefore less vulnerable than localities that rarely experience winter weather.

Risk and Loss Estimation

A quantitative assessment of critical facilities for winter storm risk was not feasible for this plan update. Even so, it is apparent that transportation structures are at great risk from winter storms. In addition, building construction variables – particularly roof span and construction method, are factors that determine the ability of a building to perform under severe stress weights from snow. Finally, not all critical facilities have redundant power sources and many are not wired to accept a generator for auxiliary power. Future plan updates should consider including a more comprehensive examination of critical facility vulnerability to winter storms.

Table 5-27 summarizes NCDC historical data for winter weather events since 1993. Based on this information, on average, the region experiences approximately two winter weather events annually, of which some rare winter storms have historically included significant accumulations of ice (due to freezing rain). In terms of annualized damages, roughly $40,411 per year in losses is attributed to winter weather events, 57% of which is attributed to ice storms.

Table 5-27. NCDC Annualized Winter Weather Events, 1993 - 2016

Jurisdiction	Number of Winter Weather Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	2.38	$1,444	-	$1,444
Chesterfield County	6	$7,962	-	$7,962
City of Colonial Heights	-	-	-	-
City of Emporia	-	-	-	-
City of Hopewell	-	-	-	-
City of Petersburg	-	-	-	-
City of Richmond	-	-	-	-
Dinwiddie County	2.42	$2,600	-	$2,600
Goochland County	3.5	$3,004	-	$3,004
Greensville County	4.17	-	-	-
Hanover County	3.54	$3,030	-	$3,030
Henrico County	6.08	$8,948	-	$8,948
New Kent County	2.5	$1,444	-	$1,444
Powhatan County	3.04	$2,889	-	$2,889
Prince George County	7.88	$9,089	-	$9,089
Surry County	2.08	-	-	-
Sussex County	2.29	-	-	-
Total	**45.88**	**$40,411**	**$0**	**$40,411**

Source: National Climatic Data Center.

5.11 Droughts and Extreme Heat

5.11.1 Hazard Profile

A drought can be characterized in several different ways depending on the impact. The most common form of drought is agricultural. Agricultural droughts are characterized by unusually dry conditions during the growing season. Meteorological drought is an extended period of time (six or more months) with precipitation of less than 75% of normal precipitation. Severity of droughts often depends on the community's reliance on a specific water source. The probability of a drought is difficult to predict given the number of variables involved. As seen in Table 5-29, drought conditions appear to make an appearance at least once a decade.

5.11.2 Magnitude or Severity

Many problems can arise at the onset of a drought, some of which include diminished water supplies and quality, undernourishment of livestock and wildlife, crop damage, and possible wildfires. Secondary impacts from droughts pose problems to farmers with reductions in income, while food prices and lumber prices could drastically increase.

High summer temperatures can exacerbate the severity of a drought. When soils are wet, a significant portion of the sun's energy goes toward evaporation of the ground moisture. However, when drought conditions eliminate soil moisture, the sun's energy heats the ground surface and temperatures can soar, further drying the soil. The impact of excessive heat is most prevalent in urban areas, where urban heat-island effects prevent inner-city buildings from releasing heat built up during the daylight hours. Secondary impacts of excessive heat are severe strain on the electrical power system and potential brownouts or blackouts.

Extreme heat combined with high relative humidity slows evaporation, limiting the body's ability to efficiently cool itself. Overexposure may result in heat exhaustion or stroke, which could lead to death. The Centers for Disease Control and Prevention state that excessive heat exposure caused 8,015 deaths in the United States between 1979 and 1999.[14] The Virginia Department of Health reports that between 1999 and 2004 there were three deaths from extreme heat in the Richmond region. All three deaths occurred in Hanover County. Newer data is not available while central Virginia record high seasonal and annual temperatures have been set during the past five years quantitative impacts have not been recorded.

Table 5-28 provides a summary of drought categories and impacts produced by the U.S. Drought Monitor. The U.S. Drought Monitor classification used both science and subjectivity, the result of which is a drought severity classification table for each dryness level. Notice that water restrictions are usually initiated as "voluntary" and can evolve to "mandatory."

Table 5-28. Drought Severity Classification and Possible Impacts

Category	Description	Possible Impacts
D0	Abnormally dry	Going into a drought: short-term dryness slows planting, growth of crops or pastures; fire risk above average. Coming out of a 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 develop or are 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.

Source: U.S. Drought Monitor.

For excessive heat, the NWS uses heat index thresholds as criteria for the issuance of heat advisories and excessive heat warnings. NWS heat advisory bulletins inform citizens of

[14] National Center for Environmental Health, Centers for Disease Control. *About Extreme Heat*. Retrieved from http://www.cdc.gov/nceh/hsb/extremeheat/

forecasted extreme heat conditions. The bulletins are based on projected or observed heat index values and include:

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

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

5.11.3 Hazard History

There have been a number of significant droughts recorded in Virginia since 1900. An extended period of abnormally dry weather occurred during a period of four years, from 1998 to 2002. This period saw rainfall levels well below normal and caused many communities throughout the state to institute water restrictions. In the most recent planning cycle, periods of dry weather have mostly had superficial landscaping impacts rather than impacts to crops and water supplies.

Table 5-29 includes descriptions of major droughts that have occurred in the Crater region. Drought conditions generally occur over a region or larger area rather than in a single jurisdiction.

Table 5-29. History of Drought Events and Damages, 1976–2016

Date	Damages
November 1976 – September 1977	The region experienced ten months of below average precipitation. The drought began in November 1976 when rainfall totaled only 50% to 75% of normal. During the rest of the winter, storms tracked across the Gulf. During the spring and summer storms tracked across the Great Lakes. These weather patterns created significant droughts throughout most of Virginia.
June – November 1998	A heat wave over the Southeast produced warm and dry conditions over much of Virginia. Unusually dry conditions persisted through much of the fall. The drought produced approximately $38.8 million in crop damages over portions of central and south-central Virginia.
December 2001 – November 2004	Beginning in the winter of 2001, the Mid-Atlantic began to show long-term drought conditions. The NWS issued reports of moisture-starved cold fronts that would continue throughout the winter. Stream levels were below normal with record lows observed at

Table 5-29. History of Drought Events and Damages, 1976–2016

Date	Damages
	gauges for the York, James, and Roanoke River basins. By November 2002, the U.S. Secretary of Agriculture had approved 45 counties for primary disaster designation, while 36 requests remained pending.
2007	Unusually dry conditions persisted through a significant portion of the year through much of southern and central Virginia. Virginia as a whole experienced its tenth driest year on record.
July 21, 2011	This was one of the hottest July's in the last 75 years, breaking records for multiple. According to the NCDC data, all counties were recorded as having excessive heat waves and drought throughout the entire month. (Source: https://www.ncdc.noaa.gov/sotc/national/201107)
July 5, 2012	Another year of record setting highs and ties throughout the states. These high were accompanied with droughts and heat waves. (Source: https://en.wikipedia.org/wiki/Summer_2012_North_American_heat_wave)

5.11.4 Vulnerability Analysis

Probability

Based on historical frequency of occurrence using NCDC, an annual determination of probability of future drought events can be made. Table 5-30 indicates that drought events of some significance affect any jurisdiction in the region from the NCDC database. The annualized event occurrence and damages are shown for the study area.

Table 5-30. Annualized Drought Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Charles City County	0.17	-	$131,417	$131,417
Chesterfield County	0.25	-	-	-
City of Colonial Heights	-	-	-	-
Dinwiddie County (incl. Town of McKenney)	-	-	$402,556	$402,556
City of Emporia	-	-	-	-
Goochland County	-	-	$122,077	$122,077
Greensville County (incl. Town of Jarratt)	-	-	-	-

Table 5-30. Annualized Drought Events and Losses, 1993 - 2016

Jurisdiction	Annualized Number of Events	Annualized Property Losses	Annualized Crop Losses	Annualized Total Losses
Hanover County (incl. Town of Ashland)	0.25	-	$500,830	$500,830
Henrico County	0.21	-	$244,153	$244,153
City of Hopewell	0.25	-	-	-
New Kent County	0.25	-	$69,428	$69,428
City of Petersburg	0.5	-	-	-
Powhatan County	0.13	-	$378,381	$378,381
Prince George County	0.25	-	$223,161	$223,161
City of Richmond	0.5	-	-	-
Surry County (incl. Towns of Claremont, Dendron, Surry)	0.13	-	-	-
Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	0.13	-	-	-
Total	**3.02**	**$0**	**$2,072,003**	**$2,072,003**

Source: National Climatic Data Center.

Impact and Vulnerability

If a significant drought event were to occur, it could bring economic, social, and environmental impacts to the study area. The elderly, small children, the chronically ill, livestock and pets are most vulnerable to extreme heat. Commonly, one of the most significant economic effects to a community is agricultural impact. Other economic effects could be felt by businesses that rely on adequate water levels for their day-to-day business, such as carwashes and Laundromats.

Droughts can also create conditions that enable the occurrence of other natural hazard events such as wildfires or wind erosion. The likelihood of flash flooding is increased if a period of severe drought is followed by a period of extreme precipitation. Low-flow conditions also decrease the quantity and pressure of water available to fight fires, while the dry conditions increase the likelihood that fires will occur.

Environmental drought impacts include those on both human and animal habitats and hydrologic units. During periods of drought, the amount of available water decreases in lakes, streams, aquifers, soil, wetlands, springs, and other surface and subsurface water sources. This decrease in water availability can affect water quality such as oxygen levels, bacteria, turbidity, temperature increase, and pH changes. Changes in any of these levels can have a significant effect on the aquatic habitat of numerous plants and animals found throughout the study area.

Low water flow can result in decreased sewage flows and subsequent increases in contaminants in the water supply. Decrease in the availability of water also decreases drinking water supply and the food supply as food sources become scarcer. This disruption can work its way up the food chain within a habitat. Loss of biodiversity and increases in mortality can lead to increases in disease and endangered species.

Table 5-31 provides an overview of the agricultural products that could be affected by a drought. These numbers are based on the 2007 Census of Agriculture conducted by the U.S. Department of Agriculture. The numbers show all of the counties with significant agricultural sectors that could be impacted by droughts. Hanover County, in particular, had more than $55 million in products sold, most of which were crops.

Table 5-31. Value of Agricultural Products Potentially Affected by Drought

Jurisdiction	Number of Farms 2012 (% change from 2007)	Total Value of Agricultural Products Sold
Charles City County	79 (-1.3%)	$23,680,000
Chesterfield County	197 (-11.7%)	$6,400,000
Dinwiddie County	383 (2.3%)	$24,798,000
Goochland County	315 (-20.3%)	$16,562,000
Greensville County	151 (5.3%)	$9,884,000
Hanover County	600 (-4.2%)	$55,272,000
Henrico County	117 (-52.1%)	$9,371,000
New Kent County	137 (11.7%)	$7,003,000
Powhatan County	250 (8.8%)	$10,009,000
Prince George County	167 (-11.4%)	$10,763,000
Surry County	127 (4.7%)	$27,723,000
Sussex County	123 (-22.8%)	$37,277,000
Total	2646 (-6%)	$238,742,000

Source: United States Department of Agriculture, Virginia Agricultural Statistics Service. 2007 Census of Agriculture. County Profiles.

Risk and Loss Estimation

Except for potential water supply issues associated with a prolonged drought, droughts have little impact on critical facilities.

The data shows recurrence of drought conditions, of varying magnitude, on a relatively regular basis. With records dating back to 1993, the NCDC database indicates that drought events of some significance occur roughly three times annually in the region (Table 5-30). Based on historical data, it is reasonable to assume that drought events will continue to impact the region with some regularity and may even increase with climate change into the future. Annual regional crop losses associated with drought events are more than $2.7M.

5.12 Mass Evacuation

5.12.1 Hazard Profile

Mass evacuations from urban areas can strain a community's resources and cause gridlock on major transportation routes, overcrowding of hospitals and shelters, and increased load on local utilities' infrastructures leading to potential failure.

VDOT has worked with the localities to develop incident plans that include evacuation routes. When an event occurs, the Emergency Alert System (EAS) provides the latest information on evacuation. The majority of the Richmond and Crater regions are within the Richmond Extended EAS area. Surry County is an exception and is part of the Eastern Virginia EAS area.

Many of the region's community emergency operations plans outline the concerns surrounding mass evacuation, in terms of jurisdictional evacuation, evacuation of other areas in which the locality acts as a "host," or as a transit route locale.

5.12.2 Hazard History

A mass evacuation of significant proportions has not impacted the area in the past decade. In anticipation of Hurricane Floyd in September 1999, more than three million people were evacuated from Florida to the North Carolina coastline, and to a lesser extent from the Virginia coast. Although the majority of these evacuations were from North and South Carolina coasts to inland areas of those states, some limited impact was likely experienced in the planning region.

5.12.3 Vulnerability Analysis

Probability

The probability of a mass evacuation impacting the planning region includes factors such as the probability and location of the hazard (e.g., terrorist incident, hurricane, etc.) that would make such an evacuation necessary, as well as sociological considerations. Determining the probability of a mass evacuation was not quantified for this plan update. Future plan updates should consider potential methods and data that might allow such an analysis.

Impact and Vulnerability

An influx of evacuees as a result of a mass evacuation has the potential to overload infrastructure and support systems. Impacted segments might include transportation, public safety, medical facilities and shelters, utilities, and depending on the duration of the evacuation, potentially the education sector. Although vulnerability is difficult to quantify, jurisdictions located along major evacuation routes (interstates and major highways) are more likely to be impacted than those away from such routes.

Risk and Loss Estimation

Mass evacuations do not necessarily pose a structural risk to critical facilities, but rather have the potential to strain critical services and resources by overwhelming response systems. Such risks were not quantified in terms of dollar losses for this plan update.

A major concern for the region is the possibility of a mass evacuation of the coastal areas of Virginia and North Carolina due to a hurricane threat, or from the Northern Virginia/Washington, D.C. metro area due to a potential or actual terrorist attack.

A project termed the U.S. Route 460 Corridor Improvements Project is proposed to create a four-lane divided limited access highway between the Cities of Petersburg and Suffolk in Virginia. The highway could potentially serve as a route for those evacuating the coast due to a hurricane threat.

Researchers at the Institute for Infrastructure and Information Assurance, which is part of James Madison University, have conducted preliminary studies to determine the possible number of displaced residents that may need to be temporarily housed in the region, and the impact resulting from the increased traffic flow on Interstates 64, 66, and 81. The Institute has developed a Rural Citizen's Guide for Emergency Preparedness that provides citizens with information on threats facing rural areas and ways to prepare for emergencies (natural and human-made). Terrorism-related issues for Northern Virginia and adjacent regions will require extensive intra-regional planning and cooperation in the future.

Some localities have detailed evacuation routes in the Warning, Evacuation, and Emergency Transportation Annex of their emergency operations plans. These jurisdictions have established traffic control measures and routes to enhance the rate of evacuation and to provide security for evacuated areas, critical facilities, and resources. The emergency operations plans address evacuation from the locality, and touch on the potential impacts caused by a mass evacuation. The type and scale of event that warrants evacuation will drive the type of response the localities will implement. To assist and mitigate against mass evacuation, jurisdictions should include additional detail in their plans regarding secondary evacuation routes, coordination between and among neighboring jurisdictions, the number and location of potential shelters, and what needs the communities foresee in their capacity as "host" communities.

5.13 Wildfires

5.13.1 Hazard Profile

Wildfires can be classified as either wildland fires or urban-wildland interface (UWI) fires. The former involves situations where a wildfire occurs in an area that is relatively undeveloped except for the possible existence of basic infrastructure such as roads and power lines. An urban-wildland interface fire includes situations in which a wildfire enters an area that is developed with structures and other human developments. In UWI fires, the fire is fueled by both naturally occurring vegetation and the urban structural elements themselves. According to the National Fire Plan issued by the U.S. Departments of Agriculture and Interior, the urban-wildland interface is defined as "…the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildlands or vegetative fuels."

A wildfire hazard profile is necessary to assess the probability of risk for specific areas. Certain conditions must be present for a wildfire hazard to occur. A large source of fuel must be present; the weather must be conducive (generally hot, dry, and windy); and fire suppression sources must not be able to easily suppress and control the fire. After a fire starts, topography, fuel, and weather are the principal factors that influence wildfire behavior. According to the Virginia Department of Forestry (VDOF), there are several factors that influence an area's risk to the occurrence of wildfires. These include, but are not limited to:

- Historical wildfire data
- Land cover
- Percent slope of topography
- Slope orientation
- Population density
- Distance to roads
- Railroad buffer
- Road density and developed areas

5.13.2 Severity or Magnitude

A wildfire can range from a very localized and containable burn to an out-of-control blaze that can spread quickly and is capable of scorching thousands of acres of land over many days. The Virginia wildfire season is normally in the spring (March and April) and then again in the fall (October and November). During these months, the relative humidity is usually lower and the winds tend to be higher. In addition, the hardwood leaves are on the ground, providing more fuel and allowing the sunlight to directly reach the forest floor, warming and drying the surface fuels.

As fire activity fluctuates during the year from month to month, it also varies from year to year. Historically, extended periods of drought and hot weather can increase the risk of wildfires. Some years with adequate rain and snowfall amounts keep fire occurrences low; while other years with extended periods of warm, dry, and windy days exhibit increased fire activity.

Long-term climate trends as well as short-term weather patterns play a major role in the risk of wildfires occurring. For instance, short-term heat waves along with periods of low humidity can increase the risk of fire, while high winds directed toward a fire can cause it to spread rapidly.

There are numerous secondary effects that could impact the study area due to wildfires. Areas that have been burned due to wildfires have an increased risk of flooding and landslides in the event of heavy rains. Additional secondary impacts due to wildfires include a degradation of air and water quality, as well as a threat to wildlife habitat including endangered species.

5.13.3 Hazard History

Most of Virginia's wildfires were caused by humans either intentionally or unintentionally. Due to the growth of the population of the commonwealth, there has been an increase in people living in the urban-wildland interface, as well as an increase in use of the forest for recreational purposes. Historical records of wildfire events specific to the study area are limited, and not all wildfires are reported.

The VDOF website provided fire incidence data for the years between 2002 and 2016. The fire incidence data provided from 1995 to 2001 came from the 2011 Hazard Mitigation study that used VDOF data for those years. The data provided by VDOF was summarized into Table 5-32 that shows the number of wildfires per jurisdiction per year. In the Vulnerability Analysis section, Table 5-35 summarizes the number of acres burned and total damages associated with wildfires in the region. According to VDOF records from 1995 to 2008, there were 1,849 wildfires that burned approximately 24,800 acres and caused nearly $3.9 million in damages in the region during the period. Another 435 fires occurred in the region from 2010 to 2016, averaging to 62 fires per year. Dinwiddie County experienced the most occurrences and acres burned. The City of Richmond has the highest dollar amount of damages due to the hazard.

Table 5-32. Number of Wildfires by Fire Year, 1995–2016

Jurisdiction Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010-2016	Total
Charles City County	12	2	17	8	10	7	20	24	5	6	15	9	11	18	7	71	**242**
Chesterfield County	33	18	28	22	29	11	22	3			1	2		3	11	37	**220**
City of Colonial Heights							1										**1**
Dinwiddie County	14	11	6	11	12	10	31	33	3	16	15	26	25	23	2	56	**294**
Town of McKenney																	
City of Emporia					1		1									3	**5**
Goochland County	21	15	15	14	11	8	18	6	2	6	5	10	7	7	2	42	**189**
Greensville County	6	4	11	3	6	4	16								3	42	**95**
Town of Jarratt						1											**1**
Hanover County	19	6	4	11	16	8	11	7	2	7	6	17	15	21	10	43	**203**
Town of Ashland																	
Henrico County	13	4	13	4	5	8	8	8	2	5	6	2	3	5		11	**97**
City of Hopewell							1										**1**
New Kent County	14	8	13	5	7	4	15								8	65	**139**
City of Petersburg							1	39	5	26	28	35	26	33			**193**
Powhatan County	26	16	24	14	19	5	27									13	**144**
Prince George County	12	4	9	7	8	6	17								11	11	**85**
City of Richmond			1			1		28	11	20	19	27	29	19			**155**
Surry County	11	3	6	5	7	2	4	9	1	3	4	4	5	7	3	14	**88**
Town of Claremont																	
Town of Dendron																	
Town of Surry																	
Sussex County	22	9	11	13	12	2	21	9	4	8	13	10	13	12	3	27	**189**
Town of Jarratt						1											**1**
Town of Stony Creek																	
Town of Wakefield																	
Town of Waverly					1		1										**2**
Total	**203**	**100**	**158**	**117**	**144**	**78**	**215**	**166**	**35**	**97**	**112**	**142**	**134**	**148**	**60**	**435**	**2344**

5.13.4 Vulnerability Analysis

Probability

The probability of wildfires is difficult to predict and is dependent on many things, including the types of vegetative cover in a particular area, and weather conditions, including humidity, wind, and temperature. Analysis of VDOF data indicates that on an annual basis, roughly 132 wildfires impact the region.

Impact and Vulnerability

VDOF used a Geographic Information System (GIS) to develop a statewide spatial Wildfire Risk Assessment model to identify areas where conditions are more conducive and favorable for wildfires to occur and advance. This model incorporated the factors listed in the Hazard Profile section and weighted them on a scale of 0 to 10, with 10 representing the characteristic of each factor that has the highest wildfire risk. With this model VDOF identified areas of the study area as having a wildfire risk level of High, Medium, or Low. The results are shown on the maps included at the end of this section (Figure 5-16). New Kent and Charles City Counties have the largest proportion of high risk commercial timber areas while Chesterfield and Henrico Counties and the City of Richmond have the greatest amount of residential property at risk in wooded areas as shown on Figure 5-16.

Hurricanes Isabel and Irene downed thousands of trees in both New Kent and Charles City Counties in 2003 and 2011, respectively. While the counties removed the most hazardous trees from public facilities and many homeowners have removed trees from their property, thousands still remain. These trees provide an easy source of fuel for wildfires and create a high risk across these counties.

Goochland County has been working with VDOF to promote best management practices among landowners in the county. The department and the county have offered joint courses on forestry management and wetlands protection. In addition, the county has thinned more than 160 acres as part of instituting best management practices on county-owned property.

Risk and Loss Estimation

There is a table (redacted Appendix G) that shows the percentages of critical facilities in fire risk zones, with 44.33% in the high-risk category. This was based on the VDOF Burn Probability analysis for the Richmond and Crater Regions. The burn probability data has categories 1-10, with 1 being the lowest risk and 10 being the highest. Because all critical facilities were only within the 1-3 range, 1 was set as low, 2 as medium, and 3 as high risk. Facilities not in a burn probability zone were assumed to be zero, or have no risk. The structures that had the highest risk were 8 cell towers (Dinwiddie, Goochland, Henrico, and

Powhatan Counties), 2 combined Fire/EMS facilities (Town of McKenney and Hanover County), and 1 Fire Facility (Prince George County).

Jurisdictional Risk

VDOF defines woodland home communities as clusters of homes located along forested areas at the wildland-urban interface that could possibly be damaged during a nearby wildfire incident. Table 5-33 illustrates the number of woodland communities while Table 5-34 illustrates the number of homes in woodland communities, as designated by the Virginia Department of Forestry. The data indicates that approximately 46% of woodland home communities in the region are located in a high-fire-risk area. Of the 132,218 homes in woodland home communities, approximately 33% are located in a high-fire-risk area.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

Table 5-33. Number of Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Charles City County	0	6	36	42	86%
Chesterfield County	82	140	189	411	46%
City of Colonial Heights	0	0	1	1	100%
Dinwiddie County	1	5	4	10	40%
Town of McKenney	1	0	0	1	0%
City of Emporia	5	0	0	5	0%
Goochland County	4	93	79	176	45%
Greensville County	1	5	0	6	0%
Town of Jarratt	0	0	2	2	100%
Hanover County	10	184	79	273	29%
Town of Ashland	2	3	1	6	17%
Henrico County	54	67	74	195	38%
City of Hopewell	1	0	0	1	0%
New Kent County	0	8	47	55	85%
City of Petersburg	5	2	4	11	36%
Powhatan County	0	31	73	104	70%
Prince George County	2	7	24	33	73%
City of Richmond	23	2	4	29	14%

Table 5-33. Number of Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Surry County	0	0	1	1	100%
Town of Claremont	0	0	1	1	100%
Town of Dendron	0	0	0	0	0%
Town of Surry	0	0	0	0	0%
Sussex County	0	0	1	1	100%
Town of Jarratt	0	0	2	2	100%
Town of Stony Creek	0	0	0	0	0%
Town of Wakefield	0	0	0	0	0%
Town of Waverly	0	0	0	0	0%
Totals	**191**	**553**	**622**	**1,366**	**46%**

Source: Virginia Department of Forestry 2010 dataset.

Table 5-34. Number of Homes in Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Charles City County	0	136	855	991	86%
Chesterfield County	20,697	27,146	25,142	72,985	34%
City of Colonial Heights	0	0	75	75	100%
Dinwiddie County	135	144	253	532	48%
Town of McKenney	31	0	0	31	0%
City of Emporia	240	0	0	240	0%
Goochland County	138	3,099	2,720	5,957	46%
Greensville County	85	149	0	234	0%
Town of Jarratt	0	0	76	76	100%
Hanover County	981	7,278	3,342	11,601	29%
Town of Ashland	255	312	14	581	2%
Henrico County	13,700	4,409	3,761	21,870	17%
City of Hopewell	65	0	0	65	0%
New Kent County	0	293	1,829	2,122	86%
City of Petersburg	555	104	271	930	29%

Table 5-34. Number of Homes in Woodland Communities by Fire Risk

Jurisdiction Name	Low	Moderate	High	Total	% High Risk
Powhatan County	0	713	3,204	3,917	82%
Prince George County	415	199	1,397	2,011	69%
City of Richmond	7,595	65	185	7,845	2%
Surry County	0	0	15	15	100%
Town of Claremont	0	0	21	21	100%
Town of Dendron	0	0	0	0	0%
Town of Surry	0	0	0	0	0%
Sussex County	0	0	43	43	100%
Town of Jarratt	0	0	76	76	100%
Town of Stony Creek	0	0	0	0	0%
Town of Wakefield	0	0	0	0	0%
Town of Waverly	0	0	0	0	0%
Totals	**44,892**	**44,047**	**43,279**	**132,218**	**33%**

Virginia Department of Forestry 2010 dataset.

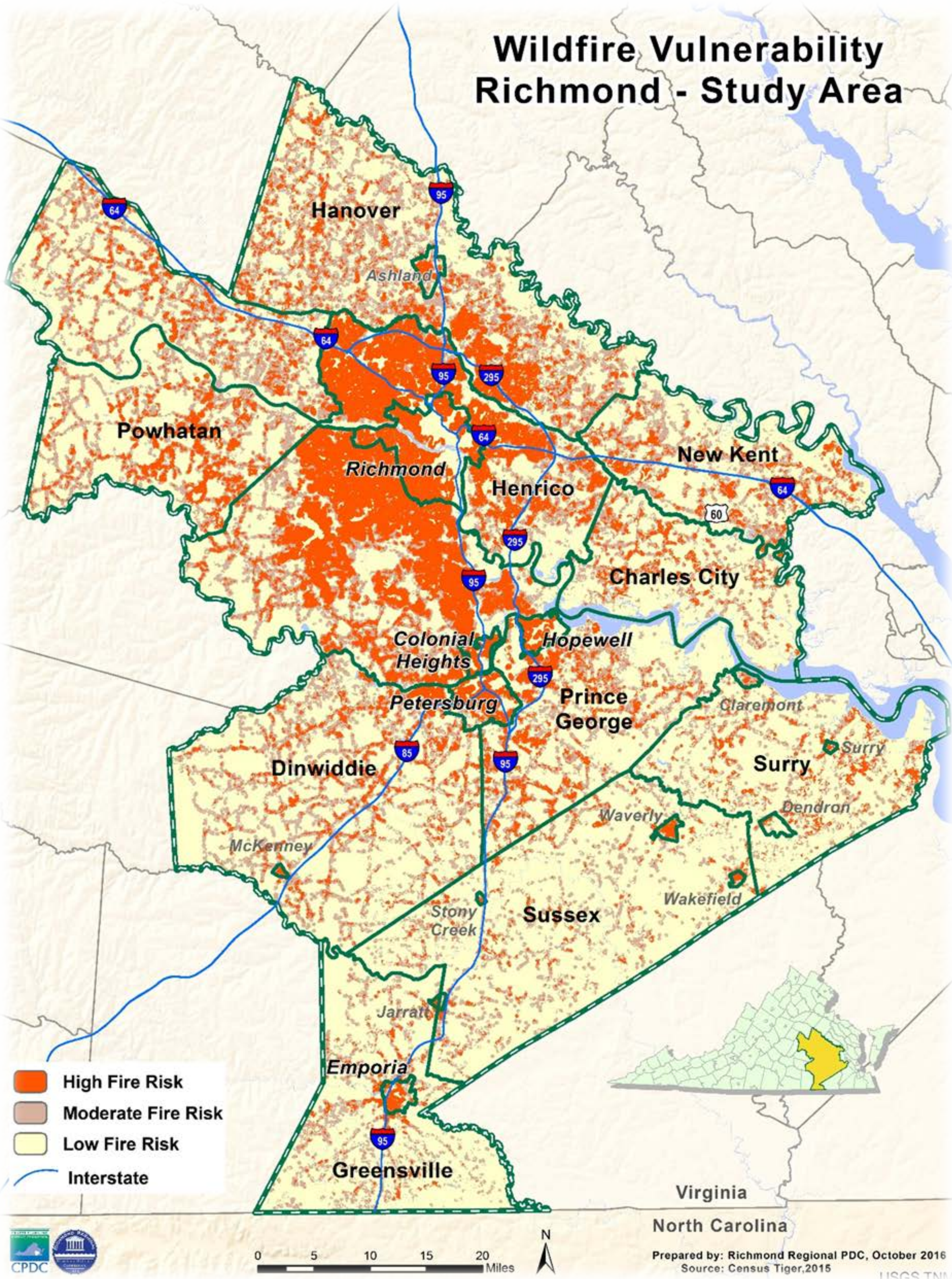

Figure 5-16. Wildfire Vulnerability

Source: Virginia Department of Forestry

In summary, based on the VDOF historical record (1995–2008; refer to Table 5-35), the region experiences approximately 132 fires per year that result in approximately $152,941 in damages. The past is a reasonable predictor of the future. It should be expected that the region will continue to battle wildfires from time to time, particularly during extended periods of dry and windy weather.

Table 5-35. Wildfire Events and Losses, 1995–2008

Jurisdiction Name	Total		Annualized	
	Total Acres	Total Losses	Number of Events	Losses
Charles City County	392.5	$71,100	10.31	$5,469
Chesterfield County	631.2	$53,675	18.92	$4,129
City of Colonial Heights	3	$500	0.08	$38
Dinwiddie County	13,227.05	$868,350	17.38	$66,796
Town of McKenney	0		0.00	$0
City of Emporia	2.25	$100	0.23	$8
Goochland County	232.1	$120,100	10.15	$9,238
Greensville County	1,758.3	$359,175	6.54	$27,629
Town of Jarratt	0.5		0.08	$0
Hanover County	432.8	$133,840	10.92	$10,295
Town of Ashland	7.5	$1,200	0.31	$92
Henrico County	328.5	$28,040	6.46	$2,157
City of Hopewell	0.1		0.08	$0
New Kent County	199.1	$11,150	11.69	$858
City of Petersburg	26.4		0.31	$0
Powhatan County	167.4	$167,100	11.92	$12,854
Prince George County	533.6	$22,990	9.62	$1,768
City of Richmond	6	$100	0.15	$8
Surry County	656.7	$45,700	5.15	$3,515
Town of Claremont	0		0.00	$0
Town of Dendron	0		0.00	$0
Town of Surry	0		0.00	$0
Sussex County	1,175.1	$104,040	11.85	$8,003
Town of Jarratt	0.5		0.08	$0
Town of Stony Creek	0		0.00	$0
Town of Wakefield	1.5	$1,000	0.08	$77
Town of Waverly	0.2	$75	0.15	$6

Table 5-35. Wildfire Events and Losses, 1995–2008

Jurisdiction Name	Total		Annualized	
	Total Acres	Total Losses	Number of Events	Losses
Total	**19,781**	**$1,988,235**	**132.46**	**$152,941**

Source: Virginia Department of Forestry.

5.14 Landslide and Shoreline/Coastal Erosion

5.14.1 Hazard Profile

Landslides

The term "landslide" describes many types of downhill earth movements ranging from rapidly moving catastrophic rock avalanches and debris flows in mountainous regions to more slowly moving earth slides.[15]

Shoreline/Coastal Erosion

NOAA describes shoreline/coastal erosion as a process whereby large storms, flooding, strong wave action, sea level rise, and human activities, such as inappropriate land use, alterations, and shore protection structures, wear away beaches and bluffs. Erosion undermines and often destroys homes, businesses, and public infrastructure.[16]

5.14.2 Magnitude or Severity

The severity of a landslide is dependent on many factors including the slope and width of the area involved and any structures or infrastructure directly in the path of the slide. Impacts of a landslide can range from a minor inconvenience to a life-threatening situation when automobiles and buildings are involved. The extent or severity of erosion is related to a number of factors: composition of the shoreline (rock, sand, clay, marsh, or human-made structures), fetch, orientation to prevailing wind direction, and relative sea level rise.[17]

5.14.3 Hazard History

Landslides

The greatest landslide hazards are found in the higher elevations of western and southwestern Virginia. Analysis of the hazards here is limited by the availability of data.

[15] National Disaster Education Coalition. Talking About Disaster: Guide for Standard Messages. Washington, D.C., 2004.
16 NOAA. (2011) http://coastalmanagement.noaa.gov/hazards.html#erosion
17 Virginia Department of Mine Minerals and Energy. (2011) http://www.dmme.virginia.gov/DMR3/coastalerosion.shtml

There is no comprehensive database documenting all landslide occurrences within the commonwealth. Landslides have the potential to cause serious damage to buildings and infrastructure and may result in injuries or even fatalities. The expansion of urban development can increase the damages caused by a landslide. Damages sustained by roads and highways during a landslide can result in long-term loss of use of certain transportation routes, and contribute to increased traffic and emergency response times in the affected region. The soil movement that occurs during a landslide can destabilize structural supports for pipelines potentially resulting in pipeline ruptures and decreased or loss of service in a region.

Local officials from the City of Richmond reported that a number of areas in the city were affected by landslides triggered by the rains of Tropical Storm Gaston in August 2004. The Church Hill and Riverside Drive sections of Richmond experienced 14 inches of rain in eight hours. Church Hill features numerous caves and unstable geologic formations which were stressed by saturation effects of the storm. One home in Church Hill was severely impacted by the landslide and was ultimately condemned and purchased by the City. Nearly tennis courts were also impacted. The Riverside Drive area features steep embankments along the south shore of the James River and abandoned granite quarries. During Gaston localized landslides occurred near Forest Hill Park.

Although no significant landslide occurrences have been reported for the rest of the region, the following map from the 2013 Virginia State Hazard Mitigation Plan (

Figure 5-17) shows landslide susceptibility and incidence for the region based on U.S. Geological Survey (USGS) analysis and data. A strip of High Susceptibility and Moderate Incidence runs through portions of Henrico County and the City of Richmond and touches portions of Chesterfield and Prince George Counties and the Cities of Hopewell, Petersburg, and Colonial Heights (Figure 5-18).

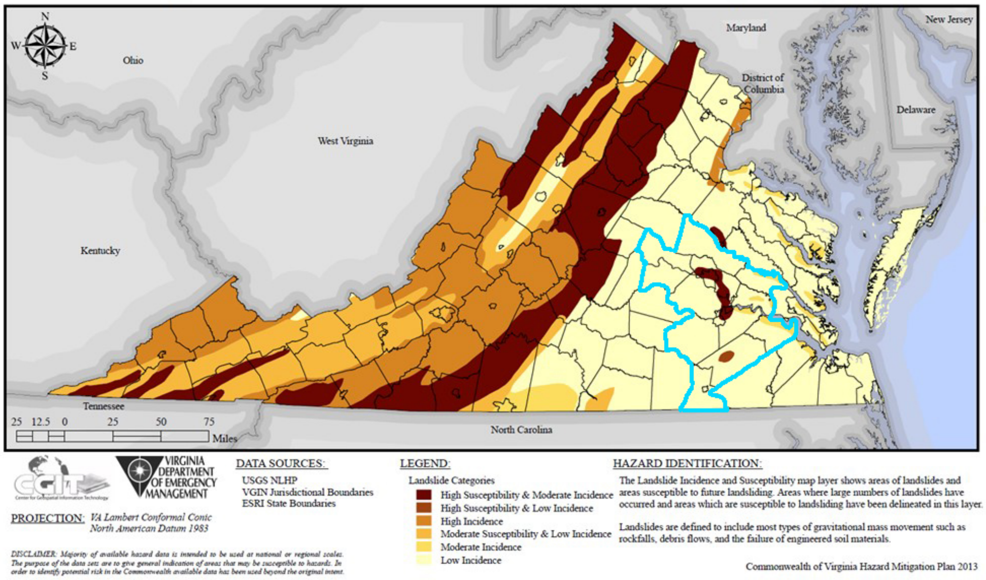

Figure 5-17. U.S. Geological Survey Landslide Susceptibility and Incidence

Source: 2013 Virginia State Hazard Mitigation Plan

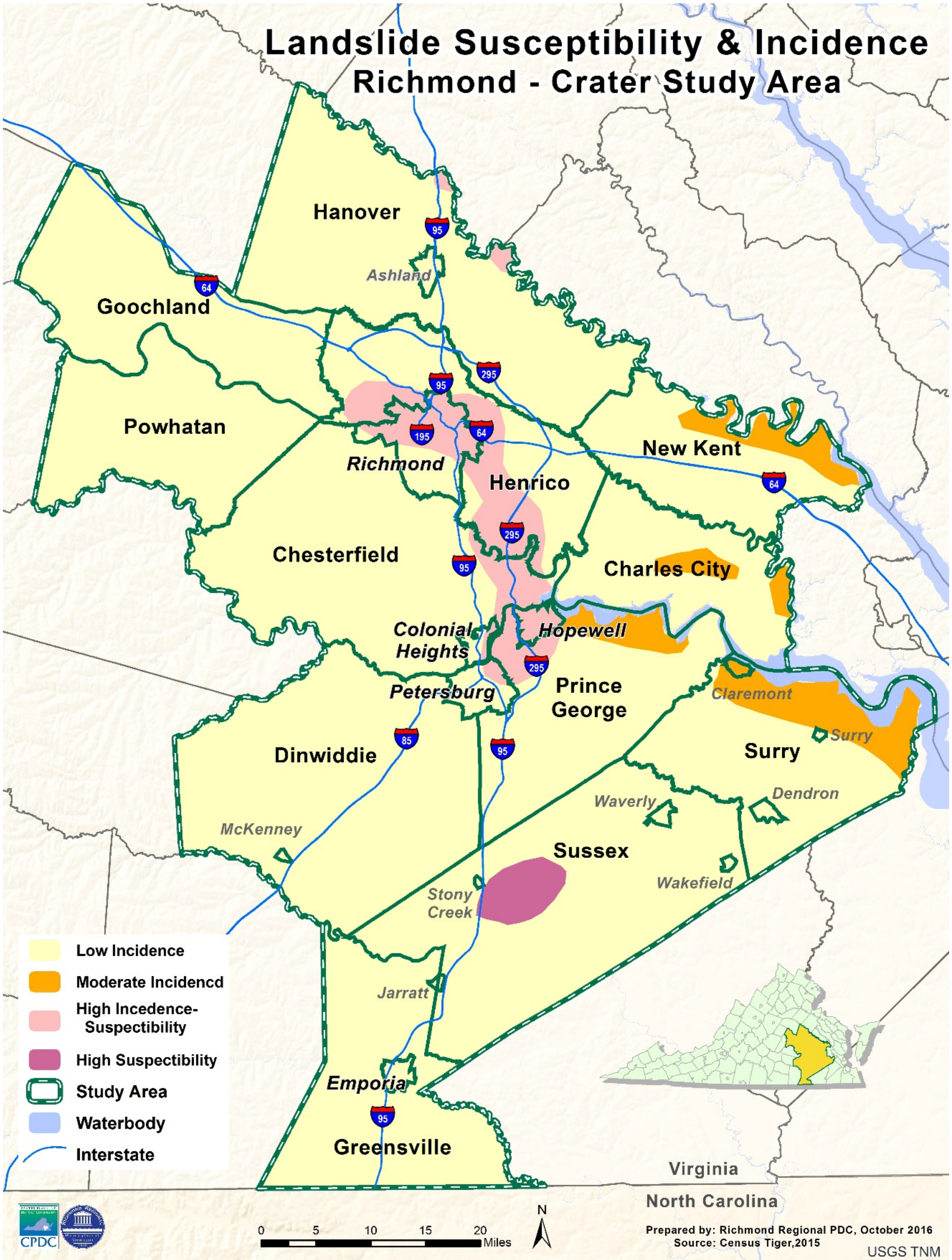

Figure 5-18. U.S. Geological Survey Landslide Susceptibility and Incidence for Region

Shoreline/Coastal Erosion

The shoreline areas of the region are consistently undergoing coastal erosion. However, severe storms that increase wave activity, such as hurricanes, tropical storms, and nor'easters, sea level rise, and shoreline development can increase occurrences of erosion. The banks of the James River have historically experienced substantial erosion (varying rates) from storm events. However, data regarding specific events that resulted in substantial erosion is lacking.

5.14.4 Vulnerability Analysis

Landslides

The probability of a landslide is difficult to ascertain given the lack of data available to perform such an analysis. Even so, landslide events in the region are considered to be a low-probability event, but with the potential to have a significant impact when and where they do occur.

The USGS first developed a national landslide incidence map in 1982. This national map was used as a basis for the maps in this analysis. The map shows areas where large numbers of landslides have been recorded (incidence) and areas that may be susceptible to landslides because of their geologic composition (susceptibility). According to the report that accompanies the incidence map, "susceptibility is not shown where it is comparable to incidence – for example, where areas of the highest category of incidence are assumed to have high susceptibility and where areas of the lowest category are assumed to have low susceptibility."[18]

The report goes on to state, "The map was prepared by evaluating formations or groups of formations shown on the geologic map of the United States and classifying them as having high, medium, or low landslide incidence (number of landslides) and being of high, medium, or low susceptibility to landslides. Those map units or parts of units with more than 15 percent of their area involved in landslides were classified as having high incidence; those with 1.5 to 15 percent of their area involved in landslides, as having medium incidence; and those with less than 1.5 percent of their area involved, as having low incidence. This classification scheme was modified where particular lithofacies are known to have variable landslide incidence or susceptibility."

The susceptibility categories are largely subjective because insufficient data was available for precise determinations. Because the map is highly generalized, was created at a national scale, and is based on relatively old and imprecise data, it should not be taken as an absolute guide to landslide incidence and susceptibility and should not be used for site selection purposes.

[18] Radbruch-Hall, Dorothy H. et al. United States Geologic Survey. *Landslide Overview Map of the Conterminous United States.* U.S. Geological Survey Professional Paper 1183. 1982.

While the majority of the region has low landslide incidence, high susceptibility and moderate incidence is located in portions of Prince George County, City of Hopewell, City of Colonial Heights, City of Petersburg, Chesterfield County, City of Richmond, Henrico County, and Hanover County. High susceptibility and low incidence is located in Sussex County. Moderate incidence is located in New Kent County, Charles City County, Prince George County, and Surry County.

As noted in the previous section, landslides have occurred in the City of Richmond following high rainfall but have generally been limited in scope and/or extent. The primary area of concern noted by city officials is Government Road. At the time of this report, this is the best available data; no other historical data is available.

The impact of landslides on jurisdictions in the region has historically been that of inconvenience resulting from partially blocked roadways. Data regarding landslide risk in the region is limited. Depending on the scale of a landslide event and the damage it inflicts, losses could potentially range into the thousands or perhaps millions of dollars in an extreme event. The jurisdictional executive summaries highlight hazards and vulnerability within the community.

Shoreline/Coastal Erosion

The probability of shoreline erosion is difficult to quantify, but is a near-certainty along the region's shorelines. The Harrison Point subdivision, along the James River, experiences recurrent flooding. In addition, the river banks experience substantial erosion from storm events and are considered to be vulnerable for ongoing erosion.

The coastal portion of the region is protected by the Virginia Coastal Zone Management Program. Surry, Prince George, Chesterfield, Henrico, New Kent, Hanover, and Charles City Counties, and the Cities of Richmond, Colonial Heights, Hopewell, and Petersburg are all part of Virginia's Coastal Management Program. The program aims to reduce the likelihood of erosion and the effects of erosion on Virginia's shoreline by emphasizing land use best practices. Figure 5-19 shows the boundary of Virginia's Coastal Zone.[19]

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

[1919] Virginia Department of Environmental Quality. (2011) http://www.deq.virginia.gov/coastal/coastmap.html

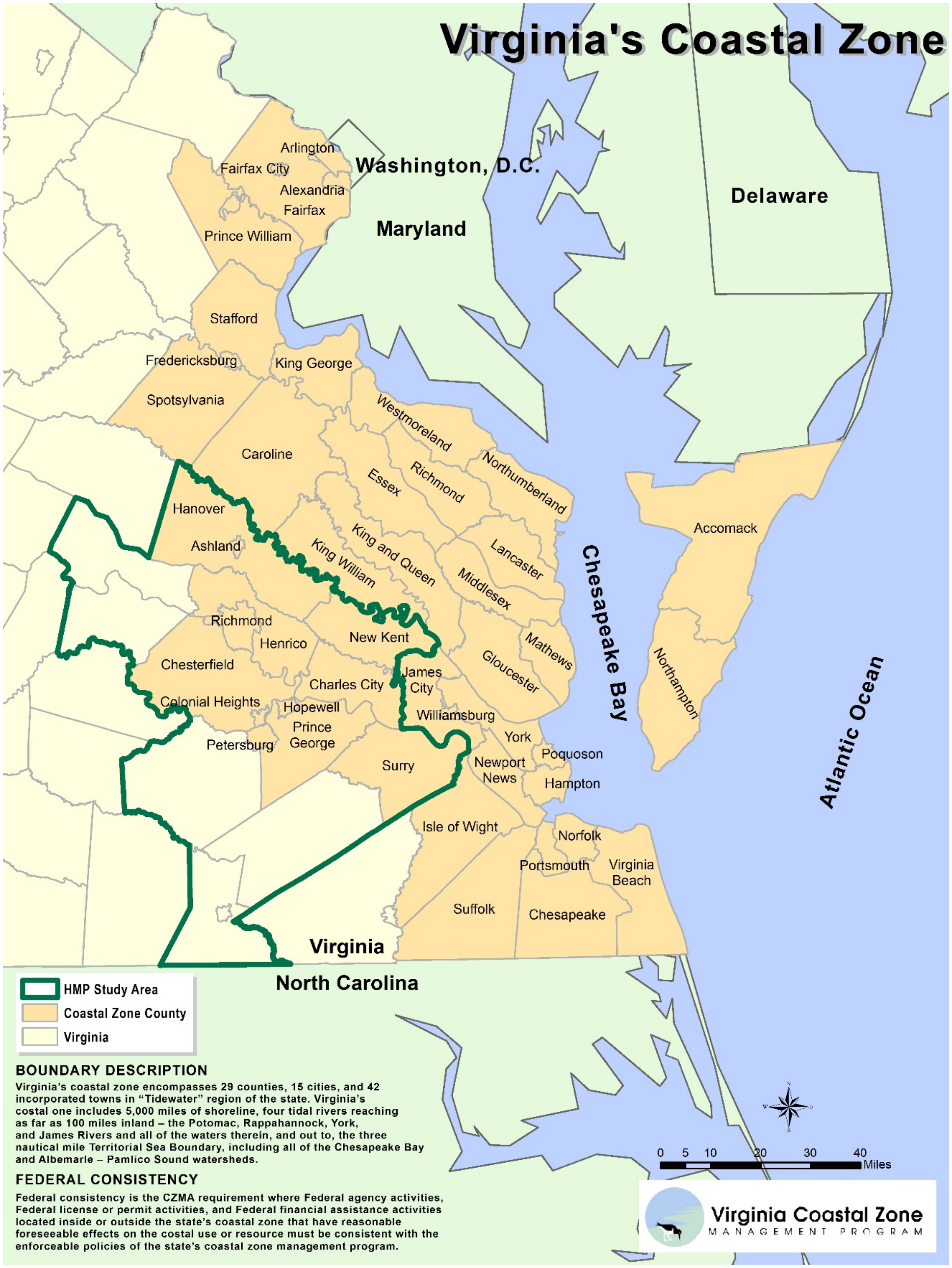

Figure 5-19. Jurisdictions included in the Virginia Coastal Zone Management Program

5.15 Land Subsidence/Karst/Sinkholes

5.15.1 Hazard Profile

Karst topography can be described as a landscape formed over limestone, dolomite, or gypsum, and is characterized by sinkholes, caves, and underground drainage. The collapse of land in the karst topography creates sinkholes.

Sinkholes are classified as natural depressions of the land surface and are caused when the acidic groundwater dissolves the surrounding geology. Most of these events are triggered by human activity in the karst environment. Excessive pumping of groundwater from karst aquifers may rapidly lower the water table and cause a sudden loss of buoyant forces that stabilize the roofs of cavernous openings. Human-induced changes in surface water flow and infiltration also may cause collapse. Most sinkholes that form suddenly occur where soil that overlies bedrock collapses into the pre-existing void.

5.15.2 Magnitude or Severity

Depending on its size, sinkholes can cause damage to bridges, roads, railroads, storm drains, sanitary sewers, canals, levees, and private and public buildings. Another problem associated with karst topography is its impact on aquifers and potential for groundwater contamination. The greatest impact occurs when polluted surface waters enter karst aquifers. This problem is universal among all populated areas located in areas of karst. The groundwater problems associated with karst are accelerated with the advent of (1) expanding urbanization, (2) misuse and improper disposal of environmentally hazardous chemicals, (3) shortage of suitable repositories for toxic waste (both household and industrial), and (4) ineffective public education on waste disposal and the sensitivity of the karstic groundwater system.

Areas over underground mine workings are also susceptible to subsidence. Mine collapses have resulted in losses of homes, roadways, utilities, and other infrastructure. Subsidence is often exacerbated by the extensive pumping of groundwater associated with underground mining. Abandoned coal mines occur in Henrico, Chesterfield, and Goochland Counties in the Richmond coal basin and Buchanan, Dickenson, Lee, Scott, Russell, Tazewell, Wise, Montgomery, and Pulaski Counties in southwest Virginia.

In addition to areas of karst and underground or abandoned mine sites, aging or crumbling infrastructure is another potential source of sudden sinkholes. This can occur anywhere and is difficult to predict.

5.15.3 Hazard History

Dramatic collapses of land that swallow homes or persons have happened in Virginia, but generally are rare. Although there have been a few in the region, the most notable incidents occurred in western Virginia in the City of Staunton. On August 11, 1911, parts of several homes and the firehouse were lost in a series of sinkholes on Baldwin Street and

Central Avenue, and on October 28, 2001, a 45-foot-deep chasm opened up on Lewis Street.[20]

According to the 2013 Virginia State Hazard Mitigation Plan, there have been no Federal Declared Disasters or NCDC recorded events for karst-related events in the commonwealth. Land subsidence is very site-specific. There is no comprehensive long-term record of past events in Virginia. Several documented occurrences have been included in Table 5-36 but there have been no occurrences since the 2011 plan update. Future plan updates and/or mitigation strategies might include working with VDOT to determine those roadways and areas most susceptible to sinkholes.

Table 5-36. History of Sinkhole Damages, January 2010 – March 2011

Date	Damages
January 4, 2010	**City of Richmond:** The ramp from I-95 North to Broad Street in downtown Richmond was closed because of a sinkhole. Reports say that what started as a pothole quickly became a gaping hole in which the ground collapsed, with about 5 feet of earth underneath it washed away. (Source: WWBT-TV NBC 12 Richmond, VA; http://www.nbc12.com/story/11763653/update-sinkhole-closes-i-95-downtown-exit?redirected=true)
August 2010	**Chesterfield County:** Sinkholes in the Scottingham neighborhood were reported around storm drain infrastructure. (Source: WWBT-TV NBC 12 Richmond, VA)
March 2011	**City of Richmond:** A sinkhole closed the intersection of Grove and Stafford Avenues in Richmond. (Source: Richmond Times-Dispatch)

5.15.4 Risk Assessment

In Virginia, the principal area affected by sinkholes is the Valley and Ridge province, an extensive karst terrain underlain by limestone and dolomite, but the narrow marble belts in the Piedmont and some shelly beds in the Coastal Plain are also pocked with sinkholes. A majority of the karst regions in Virginia follow I-81, as seen in Figure 5-20. These areas are broadly defined and mapped with a general understanding of karst hazard risks.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

[20] Virginia Department of Mines Minerals and Energy; http://www.dmme.virginia.gov/DMR3/sinkholes.shtml.

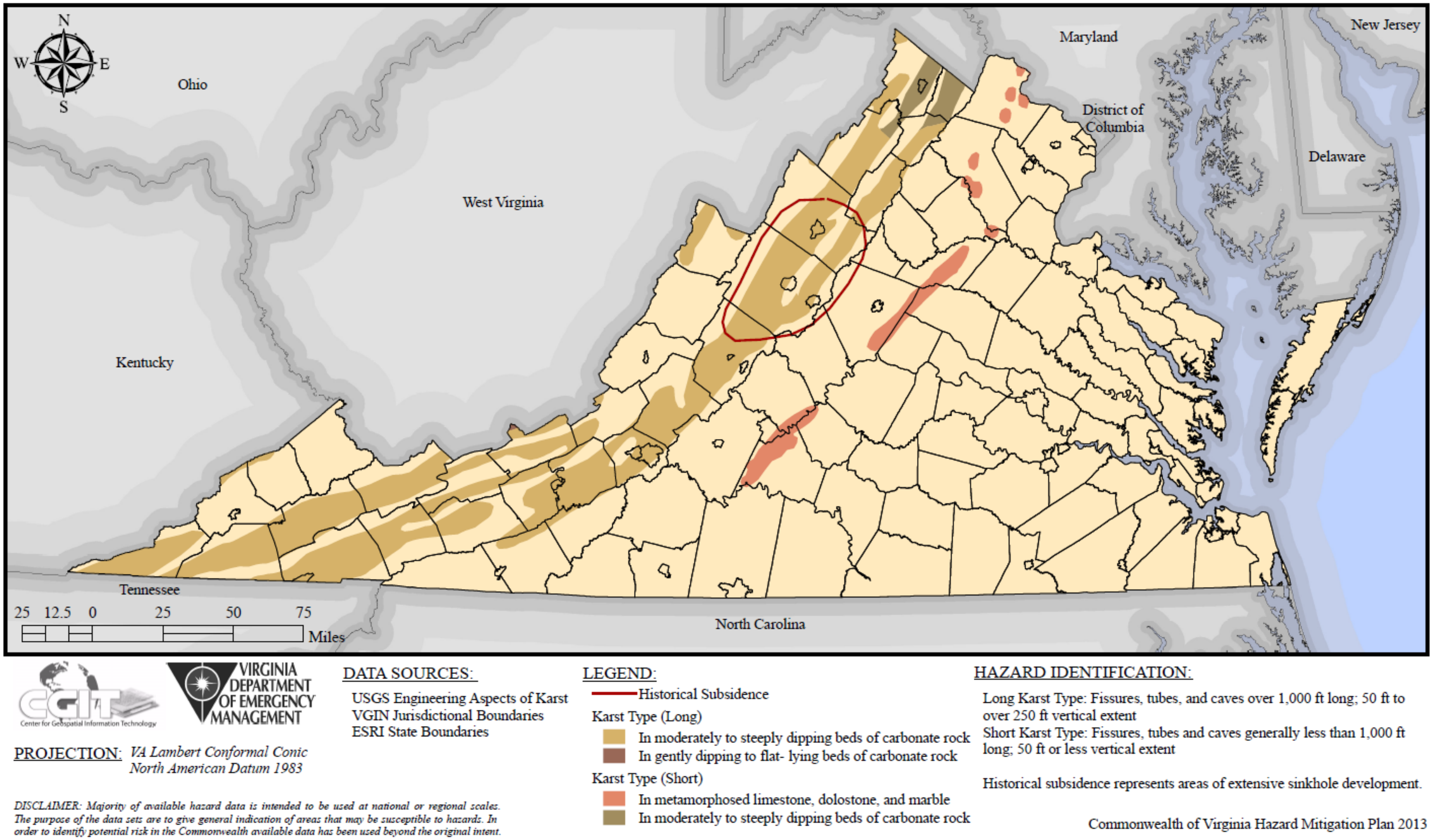

Figure 5-20. Karst Areas in the Commonwealth of Virginia

Source: 2013 Virginia State Hazard Mitigation Plan

Based on the previous maps, the Richmond Regional – Crater Planning District Commissions region does not have a karst-like environment. However, abandoned coal mines do exist in the region and, as stated previously, areas over underground mine workings are also susceptible to subsidence. Maps of historic mining activities are available for a majority of the region, including Powhatan, Goochland, Hanover, New Kent, Charles City, Chesterfield, and Henrico Counties, as well as the Cities of Richmond and Hopewell. The maps can be found at the following website:

http://www.dmme.virginia.gov/DMR3/abandonedmines.shtml.

http://www.srh.noaa.gov/MLB/hwofiles/tc_deaths.html

As discussed previously, sinkholes are relatively uncommon events in the region. The existing soil types are not conducive to creating natural sinkholes. There are no known sources of data for determining sinkhole probability for the region. Based on previous instances, likely the result of aging infrastructure, and the fact that abandoned mines exist, there is at least a low probability of future sinkhole occurrences in the region.

Limited data prevents a detailed vulnerability analysis at the jurisdictional level. Those jurisdictions with underground infrastructure in need of replacement or repair and those sitting on top of abandon mine locations are at an elevated risk from sinkholes as compared to those without such risk factors.

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

Potential impacts from land subsidence could include damage to residential, commercial, and industrial structures; damage to underground and above-ground utilities; damage to transportation infrastructure, including roads, bridges, and railroad tracks; as well as damage to or loss of crops. Potential damage and loss due to sinkholes or land subsidence is nearly impossible to assess because the nature of the damage is site- and event-specific.

5.16 Earthquakes

5.16.1 Hazard Profile

The earth's outer surface is broken into pieces called tectonic plates, which move away from, toward, or past each other. Because the continents are part of these plates, they also move. An earthquake occurs when the stresses caused by plate movements are released. The abrupt release of stored energy in the rocks beneath the earth's surface results in a sudden motion or trembling of the earth. The epicenter is the point on the Earth's surface directly above the source of the earthquake.

5.16.2 Magnitude or Severity

Smaller earthquakes occur much more frequently than larger earthquakes. These smaller earthquakes generally cause little or no damage. However, very large earthquakes can cause tremendous damage and are often followed by a series of smaller aftershocks lasting for weeks after the event. This phenomenon, referred to as "minor faulting," occurs during an adjustment period that may last for several months.

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale (Table 5-37). The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology, as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Table 5-37. The Richter Scale

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

The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally, total destruction. Although numerous intensity scales have been developed in the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli Intensity Scale. It was developed in 1931 by American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals as shown in Table 5-38. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects.

The Modified Mercalli Intensity value assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than the magnitude because intensity refers to the effects actually experienced at a particular place.

The lower numbers of the intensity scale deal with the manner in which people feel the earthquake. The higher numbers of the scale are based on observed structural damage. Structural engineers usually contribute information for assigning intensity values of VIII or above.

Table 5-38. Modified Mercalli Intensity Scale for Earthquakes

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

5.16.3 Hazard History

Significant earthquakes were first recorded in Virginia in 1774. Virginia has had more than 160 earthquakes since 1977, of which 16% were felt. This averages to approximately one earthquake every month, with two felt each year.[21] Figure 5-21 shows the significant earthquakes that have impacted Virginia from 1568 to 2009. There have been four significant earthquakes centered in the region. There is quaternary faulting in the Central Virginia Seismic Zone, running through Powhatan, Goochland, Fluvanna, and Cumberland Counties. Quaternary faults and folds are believed to be sources of earthquakes greater than magnitude 6 in the past 1,600,000 years; however, the USGS reports that only liquefaction features are evidence of strong shaking and that individual faults in the Central Virginia Seismic Zone remain unidentified.[22]

Of the four significant earthquakes that have been recorded in the region, one was centered near the City of Petersburg, two near Goochland County, and one near Powhatan County. Historical earthquake occurrences, which have affected the region and are summarized in the following paragraphs, are based on available records from the Virginia Tech Seismological Observatory, Seismicity of the United States (USGS Paper 1527), and Earthquakes in Virginia and Vicinity 1774 – 2004 (USGS Paper 2006 1017).

The first earthquake (4.5 on the Richter Scale) occurred on February 21, 1774, near the City of Petersburg and Prince George County. The earthquake was felt in much of Virginia and southward into North Carolina. Many houses were moved considerably off their foundations in the cities of Petersburg and Blandford. The shock was described as "severe" in Richmond and terrified residents about 50 miles north in the City of Fredericksburg, but caused no damage in those areas. The total felt area covered about 57,900 square miles.

On August 27, 1833, an earthquake near Goochland County (4.5 on the Richter Scale) was felt from Norfolk to Lexington and from Baltimore, Maryland, to Raleigh, North Carolina – about 52,110 square miles. In Charlottesville, Fredericksburg, Lynchburg, and Norfolk, windows rattled violently, loose objects shook, and walls of buildings were visibly agitated.

Although it did not occur within the region, an earthquake (4.3 on the Richter Scale) was observed on November 2, 1852, with the epicenter in Buckingham County, Virginia. Chimney damage was reported in Buckingham and the earthquake was reported to be the strongest in Fredericksburg and Richmond, and the Town of Scottsville.

Centered near Goochland County, a series of shocks (4.8 on the Richter Scale) in quick succession were felt throughout the eastern two-thirds of Virginia and a portion of North Carolina on December 23, 1875. The highest intensities from this earthquake occurred mainly in towns near the James River shoreline in Goochland and Powhatan Counties, and in Louisa County. In Richmond and Henrico Counties, the most severe damage was sustained in the downtown business and residential areas adjacent to the James River. Damage included bricks knocked from chimneys, fallen plaster, an overturned stove, and several broken windows. Waves "suddenly rose several feet" at the James River dock in Richmond, causing boats to "part their cables" and drift below the wharf. At Manakin,

[21] Virginia Tech Seismological Observatory. (2010) http://www.geol.vt.edu/outreach/vtso/quake.html
[22]USGS. (2011) http://geohazards.usgs.gov/cfusion/qfault/qf_web_disp.cfm?qfault_or=1235&qfault_id=2653

about 20 kilometers west of Richmond, shingles were shaken from a roof and many lamps and chimneys were broken. The total felt area was about 50,180 square miles.

On February 11, 1907, an earthquake reaching 4 on the Richter Scale affected the community of Arvonia in Buckingham County. The earthquake was also felt strongly from Powhatan to Albemarle Counties.

The December 9, 2003, Powhatan County earthquake (4.5 on the Richter Scale) was a complex event consisting of two sub-events occurring 12 seconds apart and causing slight damage nearest the epicenter. The quakes were felt in much of Maryland and Virginia; in north-central North Carolina; and in a few areas of Delaware, New Jersey, New York, Pennsylvania, and West Virginia.

A 5.8 magnitude quake centered near Mineral, VA occurred at 1:51 pm EDT on August 23, 2011. The earthquake was reportedly felt as far north as Boston, as far south as Georgia and as far west as Chicago. Effects of the earthquake were reported to the USGS through its online survey from over 8,434 zip codes, and ranged from weak intensity to very strong. In terms of damage, particularly hard-hit were brick and unreinforced structures and infrastructure near the quake's epicenter. In addition to cracks and buckling, some buildings were knocked off of their foundations. Minor injuries were reported as a result of the damage and debris. The earthquake forced the North Anna Power Station nuclear power plant offline pending an all-clear from a Nuclear Regulatory Commission review. Aftershocks of a lesser magnitude continued to plague the area for several weeks after the event. The strongest aftershock measured 4.5 and occurred on August 25 at 1:08 am EDT.

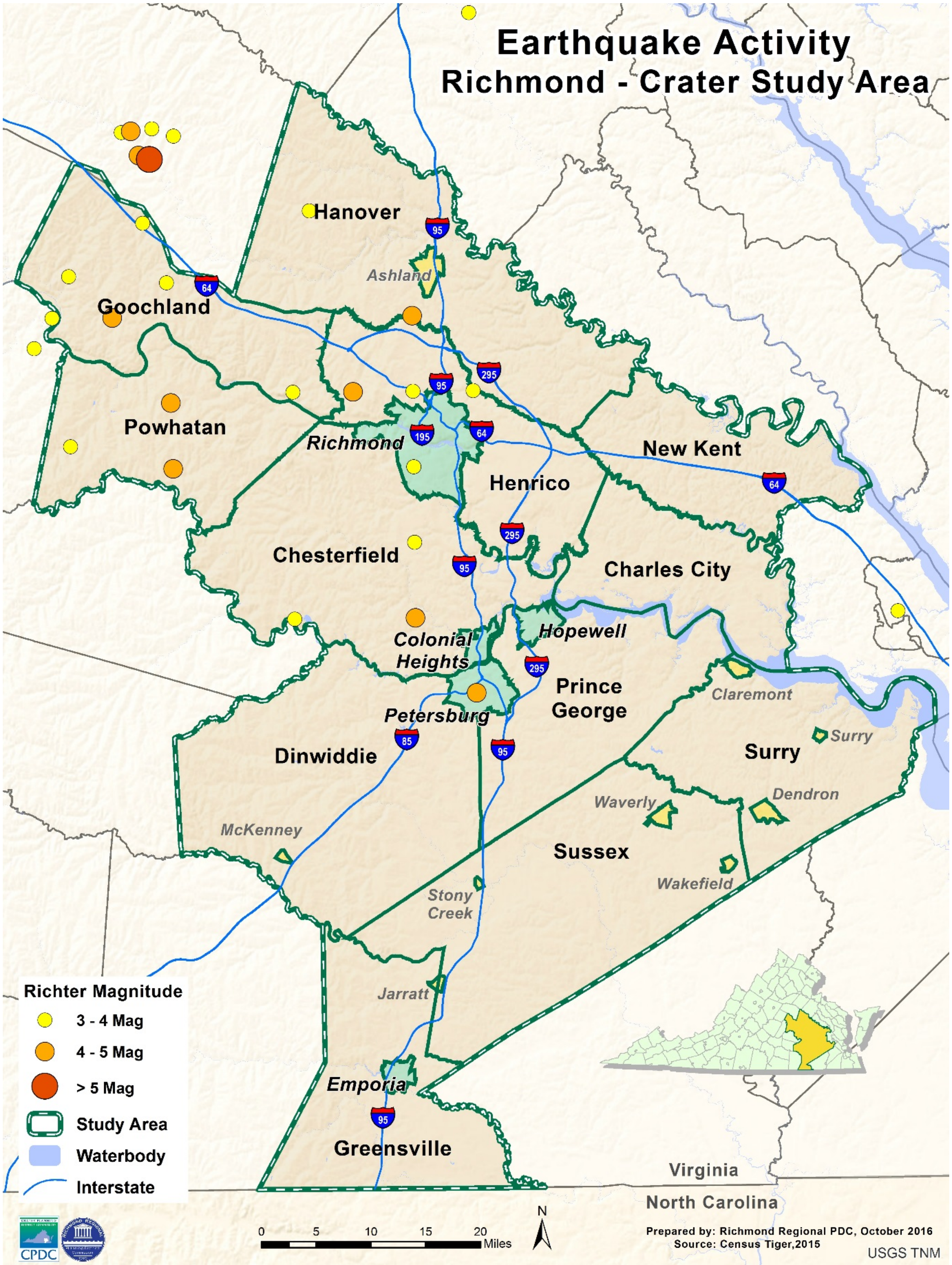

Figure 5-21. Earthquake Activity and Seismic Hazard Map

5.16.4 Vulnerability Analysis

Probability

Because earthquakes have a limited ranking for the region, calculation of probability was not performed for this analysis. Earthquakes are high-impact, low-probability events. With the few historical incidents throughout the region and limited data, the probability is low.

Impact and Vulnerability

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

Risk and Loss Estimation

Because earthquakes have a limited ranking for the region, analysis for critical facilities was not performed. The HAZUS-MH earthquake model estimates damages and loss to buildings, lifelines, and essential facilities from scenario and probabilistic earthquakes.

For the 2013 Virginia State Hazard Mitigation Plan, probabilistic earthquake events were modeled using HAZUS-MH MR3. HAZUS-MH was used to generate damage and loss estimates for the probabilistic ground motions associated with each of eight return periods (100-, 250-, 500-, 750-, 1,000-, 2,000-, and 2,500-year return periods). The building damage estimates were then used as the basis for computing direct economic losses. These include building repair costs, contents and business inventories losses, costs of relocation, and capital-related wage and rental losses.

Annualized loss was computed in the 2011 update in HAZUS, by multiplying losses from eight potential ground motions by their respective annual frequencies of occurrence, and then summing the values. Table 5-39 shows the HAZUS results for the jurisdictions in the region. These results were extracted directly from the 2013 Virginia State Hazard Mitigation Plan. Based on this analysis, Henrico County would be expected to see the greatest losses on an annual basis in the region, followed closely by the City of Richmond and Chesterfield County.

The jurisdictional executive summaries highlight hazards and vulnerability within the community.

Table 5-39. Annualized Earthquake Losses (Hazus 2011)

Jurisdiction	Annualized Losses
15 Charles City County	$7,849
2 Chesterfield County	$596,915
8 City of Colonial Heights	$42,257
11 Dinwiddie County (incl. Town of McKenney)	$35,223
14 City of Emporia	$11,286
6 Goochland County	$58,031
Greensville County (incl. Town of Jarratt)	$10,862
4 Hanover County (incl. Town of Ashland)	$215,922
1 Henrico County	$726,316
10 City of Hopewell	$35,637
12 New Kent County	$16,193
5 City of Petersburg	$78,970
7 Powhatan County	$55,723
9 Prince George County	$42,008
3 City of Richmond	$591,619
Surry County (incl. Towns of Claremont, Dendron, Surry)	$5,523
13 Sussex County (incl. Towns of Stony Creek, Wakefield, Waverly)	$11,465
Total	**$2,541,799**

Source: Commonwealth of Virginia Hazard Mitigation Plan, Chapter 3-HIRA: Section 3.9, Winter Weather

5.17 Hazard Identification and Risk Assessment Summary

A variety of hazards, both natural and human caused, have the potential to impact the region. Data analysis presented in the preceding sections and input from the TAC indicate that flooding has the most significant and frequent impacts on the region and its citizens.

In addition to the potential for injury or loss of life and damage to property and crops, hazards have the potential to cause disruption of utilities, communication and transportation systems, which can contribute to lost business and decreased productivity. Table 5-40 provides a summary of potential annualized losses by hazard for which losses could be determined. Table 5-41 and Table 5-42 are summarized annual total damages and events for each county. Table 5-43, Table 5-44, and Table 5-45 show the individual scores and ranks of each of the hazards analyzed for each of the Jurisdictions. The scores were based on a similar analysis shown in Section 5.4.3, except for being compared as totals for the study area, hazards were compared within each jurisdiction to determine the ranks for each hazard.

It is important to point out that data limitations prevent a full accounting of past or potential future losses. This is particularly true in the case of the wildfire, earthquake, landslides, and karst hazards, as there was no applicable data found from the NCDC and historical data may have been supplemented. Also, the NCDC database recognizes that it may not contain every event or damages and should only be considered as estimates.

The jurisdictional executive summaries in Appendix G highlight hazards and vulnerability within each community.

NOTES: *Data for some hazards is only available at the city and/or county level.

**Loss data for the Towns are incorporated into their larger counties for consistency with the NCDC dataset.

Table 5-40 Potential Annualized Losses

Jurisdiction	Total Annualized Losses	Largest Event Property Losses	Event Type with Largest Property Losses	Largest Event Crop Losses	Event Type with Largest Crop Losses
Charles City County	$180,743.34	$13,987.96	Tornado	$131,416.88	Drought
Chesterfield County	$2,479,939.80	$1,951,015.48	Hurricanes	$10,694.79	Hurricanes
City of Colonial Heights	$109,139.03	$71,663.27	Flood	-	N/A
City of Emporia	$20,252.60	$12,223.05	Flood	$3,284.57	Flood
City of Hopewell	$87,141.27	$85,942.05	Tornado	-	N/A
City of Petersburg	$946,015.13	$891,490.10	Tornado	$11,943.88	Flood
City of Richmond	$1,142,827.00	$1,065,174.56	Flood	-	N/A
Dinwiddie County	$2,295,987.73	$1,272,732.68	Tornado	$402,556.43	Drought
Goochland County	$167,949.85	$24,560.15	Tornado	$122,076.69	Drought
Greensville County	$163,994.86	$71,663.27	Flood	$47,775.51	Flood
Hanover County	$677,733.31	$109,340.00	Flood	$500,830.07	Drought
Henrico County	$1,571,013.91	$982,142.37	Hurricanes	$244,153.37	Drought
New Kent County	$139,018.00	$38,965.66	Flood	$69,427.79	Drought
Powhatan County	$621,507.27	$216,288.04	Hurricanes	$378,380.68	Drought
Prince George County	$2,654,799.45	$1,305,027.80	Hurricanes	$931,930.92	Hurricanes
Surry County	$608,554.11	$367,251.73	Hurricanes	$115,894.15	Hurricanes
Sussex County	$455,933.42	$265,726.39	Flood	$62,186.96	Flood

Table 5-41. Summary of Annualized Total Damages for each HIRA Category

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Wildfires*	Earthquake*
Charles City County	$0	$1,535	$70	$1,444	$13,988	$131,417	$32,289	$5,469	$7,849
Chesterfield County	$290,444	$15,640	$2,545	$7,962	$201,639	$0	$1,961,710	$4,129	$596,915
City of Colonial Heights	$71,663	$4,370	$0	$0	$33,106	$0	$0	$38	$42,257
City of Emporia	$15,508	$1,408	$0	$0	$3,337	$0	$0	$8	$11,286
City of Hopewell	$0	$1,199	$0	$0	$85,942	$0	$0	$0	$35,637
City of Petersburg	$50,761	$3,764	$0	$0	$891,490	$0	$0	$0	$78,970
City of Richmond	$1,065,175	$3,673	$0	$0	$73,980	$0	$0	$8	$591,619
Dinwiddie County	$184,075	$10,714	$154	$2,600	$1,272,733	$402,556	$423,155	$66,796	$35,223
Goochland County	$0	$2,972	$34	$3,004	$24,560	$122,077	$15,302	$9,238	$58,031
Greensville County	$119,439	$2,513	$214	$0	$18,033	$0	$23,796	$27,629	$10,862
Hanover County	$109,340	$15,037	$102	$3,030	$27,280	$500,830	$22,115	$10,387	$215,922
Henrico County	$141,487	$36,087	$508	$8,948	$114,430	$244,153	$1,025,400	$2,157	$726,316
New Kent County	$38,966	$5,979	$117	$1,444	$16,581	$69,428	$6,502	$858	$16,193
Powhatan County	$0	$4,538	$0	$2,889	$0	$378,381	$235,700	$12,854	$55,723
Prince George County	$158,329	$6,247	$469	$9,089	$20,546	$223,161	$2,236,959	$1,768	$42,008
Surry County	$101,548	$2,224	$0	$0	$21,636	$0	$483,146	$3,515	$5,523
Sussex County	$327,913	$3,418	$190	$0	$75,448	$0	$48,964	$8,086	$11,465
Totals	$2,674,649	$121,317	$4,403	$40,411	$2,894,729	$2,072,003	$6,515,038	$6,515,038	$6,515,038

*Data used from 2011 Plan Update and were not from NCDC dataset due to lack of updated information.

Table 5-42. Summary of Annualized Events for each HIRA Category

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires*	Earthquake	Landslide	Karst
Charles City County	0.29	0.95	0.02	2.38	0.03	0.17	0.08	-	10.31	-	-	-
Chesterfield County	0.92	3.98	0.10	6.00	0.25	0.25	0.17	-	18.92	-	-	-
City of Colonial Heights	0.21	0.59	0.00	0.00	0.01	0.00	0.00	-	0.08	-	-	-
City of Emporia	0.33	0.54	0.00	0.00	0.03	0.00	0.00	-	0.23	-	-	-
City of Hopewell	0.13	0.70	0.00	0.00	0.06	0.00	0.00	-	0.08	-	-	-
City of Petersburg	0.21	0.82	0.00	0.00	0.07	0.00	0.00	-	0.31	-	-	-
City of Richmond	0.54	1.41	0.00	0.00	0.13	0.00	0.00	-	0.15	-	-	-
Dinwiddie County	0.38	2.03	0.05	2.42	0.13	0.25	0.08	-	17.38	-	-	-
Goochland County	0.13	2.03	0.02	3.50	0.13	0.21	0.04	-	10.15	-	-	-
Greensville County	0.25	1.13	0.07	4.17	0.09	0.25	0.17	-	6.62	-	-	-
Hanover County	0.58	3.16	0.07	3.54	0.28	0.25	0.08	-	11.23	-	-	-
Henrico County	0.58	4.26	0.26	6.08	0.18	0.50	0.17	-	6.46	-	-	-
New Kent County	0.42	1.54	0.02	2.50	0.07	0.13	0.08	-	11.69	-	-	-
Powhatan County	0.42	1.80	0.00	3.04	0.04	0.25	0.04	-	11.92	-	-	-
Prince George County	0.58	2.74	0.20	7.88	0.15	0.50	0.25	-	9.62	-	-	-
Surry County	0.67	1.38	0.00	2.08	0.12	0.13	0.17	-	5.15	-	-	-
Sussex County	0.63	1.80	0.07	2.29	0.13	0.13	0.13	-	12.16	-	-	-
Totals	7.27	30.86	0.88	45.88	1.90	3.02	1.46	-	0.00	-	-	-

*Data used from 2011 Plan Update and were not from NCDC dataset

Table 5-43. HIRA Analysis Scores for Ranking

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires	Earthquake	Landslide	Karst
Charles City County	0.75	1.08	0.88	1.58	1.08	1.88	1.20	0.19	1.45	0.33	0.31	0.31
Chesterfield County	1.13	1.64	0.88	1.57	1.07	0.57	2.19	0.19	1.44	0.41	0.31	0.31
City of Colonial Heights	2.06	1.14	0.69	0.63	1.36	0.38	0.69	0.19	0.69	0.51	0.31	0.31
City of Emporia	2.06	1.18	0.69	0.63	1.22	0.38	0.69	0.19	0.69	0.55	0.31	0.31
City of Hopewell	0.75	1.08	0.69	0.63	2.25	0.38	0.69	0.19	0.69	0.45	0.31	0.31
City of Petersburg	0.82	1.07	0.69	0.63	2.25	0.38	0.69	0.19	0.69	0.34	0.31	0.31
City of Richmond	2.25	1.63	0.69	0.63	1.03	0.38	0.69	0.19	0.69	0.49	0.31	0.31
Dinwiddie County	0.94	1.64	0.88	1.57	2.25	0.98	1.31	0.19	1.45	0.32	0.31	0.31
Goochland County	0.75	1.66	0.88	1.59	1.20	1.88	1.04	0.19	1.46	0.47	0.31	0.31
Greensville County	2.06	1.65	0.88	1.57	1.14	0.57	1.14	0.19	1.51	0.34	0.31	0.31
Hanover County	1.22	1.66	0.88	1.57	1.01	1.88	0.93	0.19	1.44	0.45	0.31	0.31
Henrico County	1.12	1.67	0.88	1.57	1.08	0.88	2.19	0.19	1.44	0.54	0.31	0.31
New Kent County	1.49	1.74	0.88	1.59	1.25	1.88	1.00	0.19	1.44	0.39	0.31	0.31
Powhatan County	0.75	1.64	0.69	1.57	0.94	1.88	1.69	0.19	1.45	0.36	0.31	0.31
Prince George County	1.03	1.63	0.88	1.57	0.95	0.69	2.19	0.19	1.44	0.32	0.31	0.31
Surry County	1.21	1.63	0.69	1.57	1.00	0.57	2.19	0.19	1.44	0.32	0.31	0.31
Sussex County	2.25	1.64	0.88	1.57	1.24	0.57	1.07	0.19	1.45	0.32	0.31	0.31

Table 5-44. Individual County HIRA Analysis Ranking (High, Moderate, or Low)

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires	Earthquake	Landslide	Karst
Charles City County	Low	Moderate	Low	High	Moderate	High	Moderate	Low	High	Low	Low	Low
Chesterfield County	Moderate	High	Low	Moderate	Moderate	Low	High	Low	Moderate	Low	Low	Low
City of Colonial Heights	High	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
City of Emporia	High	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
City of Hopewell	Moderate	Moderate	Low	Low	High	Low	Low	Low	Low	Low	Low	Low
City of Petersburg	Moderate	Moderate	Low	Low	High	Low	Low	Low	Low	Low	Low	Low
City of Richmond	High	Moderate	Low	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
Dinwiddie County	Low	High	Low	Moderate	High	Low	Moderate	Low	Moderate	Low	Low	Low
Goochland County	Low	High	Low	High	Moderate	High	Moderate	Low	High	Low	Low	Low
Greensville County	High	High	Low	High	Moderate	Low	Moderate	Low	High	Low	Low	Low
Hanover County	Moderate	High	Low	High	Moderate	High	Low	Low	High	Low	Low	Low
Henrico County	Moderate	High	Low	Moderate	Moderate	Low	High	Low	Moderate	Low	Low	Low
New Kent County	High	High	Low	High	Moderate	High	Low	Low	High	Low	Low	Low
Powhatan County	Low	High	Low	High	Low	High	High	Low	High	Low	Low	Low
Prince George County	Moderate	High	Low	Moderate	Low	Low	High	Low	Moderate	Low	Low	Low
Surry County	Moderate	High	Low	High	Moderate	Low	High	Low	Moderate	Low	Low	Low
Sussex County	High	High	Low	Moderate	Moderate	Low	Moderate	Low	Moderate	Low	Low	Low

Table 5-45. Individual County HIRA Analysis Ranking (1 Highest - 12 Lowest)

Jurisdiction	Flood	Thunderstorm	Wind	Winter	Tornado	Drought	Hurricanes	Mass Evacuation	Wildfires	Earthquake	Landslide	Karst
Charles City County	8	5	7	2	6	1	4	12	3	9	10	10
Chesterfield County	5	2	7	3	6	8	1	12	4	9	10	10
City of Colonial Heights	1	3	4	7	2	9	4	12	6	8	10	10
City of Emporia	1	3	4	7	2	9	4	12	6	8	10	10
City of Hopewell	3	2	4	7	1	9	4	12	6	8	10	10
City of Petersburg	3	2	4	7	1	8	4	12	6	9	10	10
City of Richmond	1	2	4	7	3	9	4	12	6	8	10	10
Dinwiddie County	7	2	8	3	1	6	5	12	4	9	10	10
Goochland County	8	2	7	3	5	1	6	12	4	9	10	10
Greensville County	1	2	7	3	6	8	5	12	4	9	10	10
Hanover County	5	2	8	3	6	1	7	12	4	9	10	10
Henrico County	5	2	7	3	6	8	1	12	4	9	10	10
New Kent County	4	2	8	3	6	1	7	12	5	9	10	10
Powhatan County	7	3	8	4	6	1	2	12	5	9	10	10
Prince George County	5	2	7	3	6	8	1	12	4	9	10	10
Surry County	5	2	7	3	6	8	1	12	4	9	10	10
Sussex County	1	2	7	3	5	8	6	12	4	9	10	10

6 Capability Assessment

6.1 Introduction

A "capability assessment" qualitatively summarizes the current and anticipated future capacity of the communities within the Richmond Regional Planning District Commission (PDC) and the Crater PDC to mitigate the effects of the natural hazards identified in Section 5.0 of this plan. The capability assessment includes a comprehensive examination of the following local government capabilities:

- *Administrative Capability* – describes the forms of government in the region, including the departments that may be involved in hazard mitigation.
- *Technical Capability* – addresses the technical expertise of local government staff.
- *Fiscal Capability* – examines budgets and currently used funding mechanisms.
- *Policy and Program Capability* – describes past, present, and future mitigation projects in the region and examines existing plans (e.g., emergency operations plan, comprehensive plan).
- *Legal Authority* – describes how jurisdictions in the region use the four broad government powers (i.e., regulation, acquisition, taxation, and spending) to influence hazard mitigation activities.

The purpose of a capability assessment is to identify resources which will support implementation of potential hazard mitigation opportunities available to the Richmond Regional Planning District's local governments, specifically the Town of Ashland; the Counties of Charles City, Goochland, Hanover, Henrico, New Kent, and Powhatan; and the City of Richmond; and also to the local governments of the Crater Planning District including the Counties of Chesterfield, Dinwiddie, Greensville, Prince George, Surry, and Sussex; the Cities of Colonial Heights, Emporia, Hopewell, and Petersburg; and the Towns of Claremont, Dendron, Jarratt, McKenney, Stony Creek, Surry, Wakefield, and Waverly. For the most part, the towns in the Richmond Regional - Crater PDC region with the exception of Ashland are extremely small with many functions like building inspections or public safety supported or performed by their corresponding county. To the extent information regarding towns was available, it is included in the capability assessment.

Careful analysis should detect any existing gaps, shortfalls, or weaknesses within existing government activities that could exacerbate a community's vulnerability. The assessment also will highlight positive measures already in place or being taken at the local level, which should continue to be supported and enhanced, if possible, through future mitigation efforts.

The capability assessment serves as a foundation for designing an effective hazard mitigation strategy. It not only helps establish the goals and mitigation actions for the Richmond-Crater region communities to pursue, but assures that those goals and actions are realistically achievable by communities.

A master Capability Assessment matrix table which summarizes each jurisdiction's programs may be found in Appendix I. Elements of the master table and a capability assessment survey may be found later in this section. This analysis and the Appendix I summary table were informed by a local, detailed survey and follow-up obtained through face-to-face meetings with locality staff, and in some instances phone interviews or emails.

6.2 Staff and Organizational Capability

As described previously, the Richmond Regional Planning District region is comprised of six counties, one city and one town. The counties operate under a Board of Supervisors – County Administrator/Manager system. In this form of government, the elected board of supervisors hires a county administrator/manager who oversees daily operations of the county. Charles City County has the smallest board with three members. Goochland, Henrico, New Kent, and Powhatan Counties each have five board members. Hanover County's board is the largest in the region with seven members.

The City of Richmond operates under the Mayor-Council system of government. The nine members of the council and the mayor are elected. The mayor appoints, with council approval, a chief administrative officer who oversees daily business operations of the city.

The Crater region is comprised of seven counties (which include eight towns) and four cities. Charles City and Chesterfield Counties are duel members of both regional planning district commissions. Within the Crater region, the size of the Board of Supervisors also varies from jurisdiction to jurisdiction. Greensville has the smallest board with four members, Dinwiddie has a five-member board, and the remaining counties have six-member boards. The cities in the Crater region operate under the City Council -City Manager system. The city council is an elected body. Emporia has an eight-member council and the other cities have seven-member councils. The council, in turn, appoints a city manager who acts as the city's chief executive officer.

Incorporated towns in the Commonwealth of Virginia also have an elected governing body. Towns have zoning and planning authority though most choose to use the county planning commission as their town planning commission. Towns have the ability to issue general obligation and revenue bonds. In addition, towns of more than 5,000 residents may appoint an emergency services director and exercise emergency powers separate from the county. Ashland is the only town in the Richmond-Crater region to exercise that power.

Under the county administrator/manager, city mayor/manager, or town manager/mayor, each jurisdiction has numerous departments and boards that are responsible for the various functions of local government. Table 6-1 highlights the departments in each jurisdiction that could facilitate the implementation of the hazard mitigation plan update. The departments that have been assigned responsibilities to carry out mitigation activities or hazard control tasks for a specific jurisdiction are set in bold. Representatives of these departments have been involved in the development of this mitigation plan in order to identify gaps, weaknesses, or opportunities for enhancement with existing mitigation programs.

Table 6-1. Key Departments Responsible for the Implementation of the Hazard Mitigation Plan

Jurisdiction	Departments
Charles City County	• **County Administrator's Office** • Fire • Public Safety and Code Compliance • **Planning** • Public Works/Utilities • Recreation • Sheriff
Chesterfield County	• Fire and EMS • Planning • Police • **Emergency Management**
City of Colonial Heights	• Building Inspections • **Fire and EMS** • Planning and Community Development • Public Works • Police
Town of Dendron	• Town Administration • **Surry County Emergency Management** • Volunteer Fire • Sheriff's Office
Dinwiddie County	• Building Permits • Code Enforcement • Economic Development • Parks and Recreation • Planning and Zoning • **Public Safety/EMS/Emergency Services**
Town of McKenney	• Town Administration • **Dinwiddie Fire and EMS** • Town Fire • Sheriff's Office
City of Emporia	• Building Official • Code Enforcement • **Emergency Services** • City Manager • Facilities Management • Fire Chief • Public Utilities • Public Works • Zoning Administrator

Table 6-1. Key Departments Responsible for the Implementation of the Hazard Mitigation Plan

Jurisdiction	Departments
Goochland County	• Building Inspections • Economic Development • Public Utilities • **Fire and Rescue** • Parks and Recreation • Planning • Public Works
Greensville County	• County Administration • Building • **Emergency Services** • Planning
Town of Jarratt	• Town Administration • **Sussex County Emergency Management** • Fire • Sheriff's Office • VA Department of Corrections Police
Hanover County	• Building Inspections • Economic Development • **Fire/EMS** • Parks and Recreation • Planning • Public Utilities • Public Works • Sheriff
Town of Ashland	• Fire • **Planning and Community Development** • Public Works • **Police**
Henrico County	• Community Revitalization • Economic Development Authority • **Fire and Emergency Management** • Planning • Police • Public Utilities • Public Works
City of Hopewell	• City Administration • **Emergency Management** • Development • Fire • Public Works
New Kent County	• Economic Development • Parks and Recreation • Planning • **Public Safety** • Public Utilities • Public Works

Table 6-1. Key Departments Responsible for the Implementation of the Hazard Mitigation Plan

Jurisdiction	Departments
City of Petersburg	• Economic Development • **Fire, Rescue, and Emergency Services** • Planning • Public Works
Powhatan County	• Building • Economic Development • **Emergency Management** • Fire • Planning and Community Development
Prince George County	• County Administration • **Fire, EMS, and Emergency Management** • Building Officials Office • Economic Development • Parks and Recreation • Planning Office
City of Richmond	• Community Development • Economic Development • **Emergency Management** • Fire • Parks and Recreation • Public Utilities • Police • Public Works
Surry County	• County Administration • Building Inspections • **Emergency Management** • Parks and Recreation • Planning and Community Development • Social Services
Town of Claremont	• Town Administration • **Surry County Emergency Management** • Town Volunteer Fire
Town of Dendron	• Town Administration • **Surry County Emergency Management** • Town Volunteer Fire
Town of Surry	• Town Administration • **Surry County Emergency Management** • Town Volunteer Fire
Sussex County	• **County Administration** • Building Inspections • Planning
Town of Stony Creek	• Town Administration • **Sussex County Emergency Management** • Fire • Sheriff's Office

Table 6-1. Key Departments Responsible for the Implementation of the Hazard Mitigation Plan

Jurisdiction	Departments
Town of Wakefield	• Town Administration • **Sussex County Emergency Management** • Fire • Town Police
Town of Waverly	• Town Administration • **Sussex County Emergency Management** • Fire • Town Police

Note: The departments that have been assigned responsibilities to carry out mitigation activities or hazard control tasks for a specific jurisdiction are set in boldface type.
Sources: Community websites; 2016 Capability Assessment Surveys.

While exact responsibilities differ from jurisdiction to jurisdiction, the general duties of the departments highlighted in Table 6-1 are described as follows:

Building Inspections offices enforce the Virginia Uniform Statewide Building Code (VUSBC). This code includes implications for building construction and floodplain management to insure that new construction and construction exceeding 50% substantial improvement in the Special Flood Hazard Area (regulated floodplain) is compliant with the locality's floodplain management ordinance.

Departments of Emergency Management/Fire/EMS/Public Safety are responsible for the mitigation, preparedness, response, and recovery operations that deal with both natural and human-caused disaster events. These departments are typically categorized as first responders and encompass emergency response, emergency management, and fire safety. In addition, Fire/EMS departments provide medical aid and fire suppression at the scene of accidents and emergencies. These departments are often responsible for responding to hazardous materials incidents, water rescues, and entrapments. Members of the Richmond Regional - Crater PDC Hazard Mitigation Technical Advisory Committee were primarily comprised of each participating jurisdiction's emergency manager who made sure to engage local participation from other departments within their jurisdictions. They had the primary role of working with other departments to ensure that their vulnerability analysis and mitigation actions are integrated into appropriate jurisdictional comprehensive plan updates, zoning and floodplain management regulatory or policy changes, emergency operations plan updates, disaster recovery plans and resiliency planning as these plans and policies are updated and renewed.

The Police or Sheriff's department is responsible for public safety and evacuation activities that might occur prior to events and assists in the response and recovery operations that deal with both natural and human-made disaster events. They also work to ensure the safety and security of citizens and businesses as well as personal property during the immediate recovery period.

Parks and Recreation departments may be responsible for open-space programs. If acquisition projects are undertaken, coordination with this department becomes critical.

The Planning Department (or Department of Development/Community Development) addresses land use planning. Planning departments, depending on the jurisdiction, may enforce the National Flood Insurance Program (NFIP) floodplain management ordinance requirements and other applicable local codes. Two communities, the City of Richmond and the Town of Ashland, participate in the FEMA Community Rating System which gives national flood insurance program insurance policy holders within the regulated floodplain a discount on their flood insurance policy premium depending on the participating community's CRS rating. Planning and Community Development departments are typically responsible for managing grant programs funded by the U.S. Department of Housing and Urban Development but some larger jurisdictions may have separate housing departments or authorities who manage some HUD-funded programs. These grant programs provide assistance to low- and moderate-income persons for needed housing improvements. These departments also may develop residential and commercial revitalization plans for older areas, serve as a resource for housing and community development issues, and manage special redevelopment projects.

Economic Development departments concentrate on ensuring the growth and prosperity of existing businesses. These departments often administer small business loan programs, state economic development programs, and workforce training programs. In smaller jurisdictions, such as Charles City County, this function is managed through the County Administrator's office. They are also increasingly involved in recruiting new businesses.

Public utilities departments or cooperatives, in some jurisdictions, oversee community potable water treatment, and natural gas services. More rural areas may be served by rural electric cooperatives which are not for profit, while a large extent of the region is served by Dominion Resources. In some jurisdictions, Public Works Departments oversee maintenance of infrastructure including roadways, stormwater management, sewer, and waste water treatment facilities. These departments may also review new development plans, ensure compliance with stormwater management and erosion and sediment control regulations, and work with VDOT on road issues. Depending on the jurisdiction, departments of Planning, Public Works, Engineering or Zoning may enforce the NFIP requirements.

GIS staff, vital in their support of mitigation with tools such as multiple data sets and mapping capability providing data as requested to various local government departments and citizens. GIS staff may be located in several departments depending on the local government organizational structure or within an independent agency.

For the most part, it was determined that local governments serving more populated counties and the City of Richmond are adequately staffed, trained, and funded to accomplish their missions while more rural counties and small towns along with the City of Petersburg are experiencing resource gaps due in part to lingering budget issues related to the Great Recession.

6.3 Technical Capability

The Richmond-Crater region realizes that mitigation cuts across disciplines. For a successful mitigation program, it is necessary to have a broad range of staff involved with diverse backgrounds. Planners, engineers, building inspectors, emergency managers, floodplain managers, people familiar with Geographic Information Systems (GIS), and grant writers are all integral in supporting successful mitigation actions. Table 6-2 provides information on each jurisdiction's technical capabilities.

All localities have GIS capabilities or receive technical support from their county (in the case of most towns) or their planning district commission. Most local governments have incorporated basic GIS systems into their existing planning and management operations. Several of the larger localities are expanding their GIS capabilities to provide more enhanced assistance to first responders and to improve mitigation techniques. Several counties now track various storm and damage data in GIS. For instance, Chesterfield County used the information to examine power outages to communities dependent on well water to identify where people with private wells during power outages were located. The fire department was then able to prioritize delivery of drinking water to these homes. The county also uses their GIS system to link data to damage assessment photos. Prince George and Dinwiddie Counties also do some limited data tracking of damage assessment. Most localities are interested in working to expand this capacity to help better identify areas of risk before an event occurs and to help in the recovery after an event has occurred. Sussex County has just obtained Arc GIS software and new computer equipment and will begin to integrate GIS into planning and eventually emergency management programs. None of the towns, except Ashland, have their own GIS system and rely on the county for assistance.

Staff members in all the jurisdictions have Internet access. Most local governments use social media; fire, police, and emergency managers leverage Facebook pages and Twitter feeds for messaging. Some localities keep these sites active year-round while others activate them only during emergencies to relay vital information to the public.

Table 6-2. Technical Capability Matrix by Jurisdiction

Jurisdiction	Mitigation Assigned to Specific Department	GIS	Adequate Zoning Staff	Dedicated Floodplain Management Staff	Building Inspectors	Overall Technical Capabilities
Charles City County	Planning	Yes	Yes	No	Yes	Moderate
Chesterfield County	Environmental Engineering Planning Building Inspections	Yes	Yes	Yes	35	Moderate
City of Colonial Heights	Engineering Public Works Fire Department Building Official	Yes	Yes	1	3	Moderate
Dinwiddie County	Public Safety/ Emergency Services	Yes	Yes	Yes	3	Moderate
Town of McKenney	County handles mitigation	Yes	Yes	No	N/A	Limited
City of Emporia	City Manager/Emergency Management	Yes	Yes	Yes	2	Moderate
Goochland County	Fire and Rescue	Yes	Yes	No	3	Moderate
Greensville County	No	Yes	Yes	Yes	2	Moderate
Town of Jarratt	County handles mitigation	Yes	Yes	No	N/A	Limited
Hanover County	Planning Fire/EMS	Yes	Yes	No	4	Moderate

Table 6-2. Technical Capability Matrix by Jurisdiction

Jurisdiction	Mitigation Assigned to Specific Department	GIS	Adequate Zoning Staff	Dedicated Floodplain Management Staff	Building Inspectors	Overall Technical Capabilities
Town of Ashland	Planning Police	Yes	Yes	No	Yes	High
Henrico County	Emergency Management	Yes	Yes	Yes	35	High
City of Hopewell	Emergency Management	Yes	Yes	Yes	2	Moderate
New Kent County	Fire, Sheriff, and Social Services	Yes	Yes	No	Yes	Moderate
City of Petersburg	Fire/Rescue; Public Works	Moderate	No	No	2	Moderate
Powhatan County	Emergency Management	Yes	Yes	No	Yes	Moderate
Prince George County	All Departments	Yes	No	No	6	Limited
City of Richmond	Emergency Management/ Police/Fire	Yes	Yes	Yes	Yes	High
Surry County	Emergency Services Planning and Development	Yes	Yes	Yes	1	High
Town of Claremont	County handles mitigation	Surry County	Surry County	Surry County	Surry County	Limited
Town of Dendron	County handles mitigation	Surry County	Surry County	Surry County	N/A Surry County	Limited
Town of Surry	County handles mitigation	Surry County	Surry County	Surry County	Surry County	Limited

Table 6-2. Technical Capability Matrix by Jurisdiction

Jurisdiction	Mitigation Assigned to Specific Department	GIS	Adequate Zoning Staff	Dedicated Floodplain Management Staff	Building Inspectors	Overall Technical Capabilities
Sussex County	Public Safety Planning and Zoning	Yes	No	No	2	Limited
Town of Stony Creek	County handles mitigation	Sussex County	Sussex County	No	Sussex County	Limited
Town of Wakefield	County handles mitigation	Sussex County	Sussex County	No	Sussex County	Limited
Town of Waverly	County handles mitigation	Sussex County	Sussex County	No	Sussex County	Limited

High: No increase in capability needed.

Moderate: Increased capability desired but not needed.

Limited: Increased capability needed.

6.4 Fiscal Capability

For Fiscal Year 2017, the budgets of the participating jurisdictions which could be determined through on-line documents or community capacity surveys range from $27,600,000 (City of Emporia) to $700,125,553 (city of Richmond). (City of Emporia

The counties and cities receive most of their revenue through local real estate tax, state and local sales tax, local services, and restricted intergovernmental contributions (federal and state pass-through dollars).

Since 1998 Virginia has provided a 20% match on all eligible Hazard Mitigation Grant Program (HMGP) projects, and the allowance of in-kind matches can help to reduce the local requirement to less than 5% cash match. It is unlikely that any of the counties, cities, or towns could easily afford to provide the full 25% non-federal match for the existing non-disaster hazard mitigation grant programs. Considering the current budget deficits at both the state and local government level in Virginia, combined with the apparent increased reliance on local accountability by the federal government, this is a significant and growing concern.

Table 6-3. Fiscal Capability Matrix by Jurisdiction

Jurisdiction	Total FY17 Budget	Public Safety FY17 Budget
Charles City County	$22,400,000	N/A
Chesterfield County	$1,350,000,000	$158,000,000
Colonial Heights	$78,037,047	$8,516,542
Dinwiddie County	$89,101,682	$8,831,340
City of Emporia	$276,000,000	$3,722,716
Goochland County	$72,881,798	$9,258,866
Greensville County	N/A	N/A
Hanover County**	$428,3000,300	$55,250,750
Henrico County	$1,311,569,642	$170,483,485
City of Hopewell	$49,930,358	$4,526,003
New Kent County	$62,123,094	$3,040,100
City of Petersburg**	$101,985,000	$17,452,641
Powhatan County	$56,794,921	$733,000
Prince George County**	$112,000,000	$112,000,000
City of Richmond	$700,125,553	$44,932,033

Table 6-3. Fiscal Capability Matrix by Jurisdiction

Jurisdiction	Total FY17 Budget	Public Safety FY17 Budget
Surry County**	$52,151,000	$3,318,715
Sussex County*	$34,712,259	$1,393,895

Sources: Jurisdictional budget offices; websites. **FY 2017–2018 budget; Public Safety includes fire and police. N/A means information was not available.

Most communities in the Richmond-Crater region use capital improvement plans and general obligation bonds to plan and fund large-scale public expenditures. Most jurisdictions in the study area also use intergovernmental agreements to leverage resources.

Past participation in federal funding programs may mean that jurisdictions have the capacity to undertake the grant-matching requirements, the capability to seek and administer federal grants, and the familiarity with the grant process and requisites. A lack of participation, however, does not mean communities cannot or will not seek or receive future funding. As seen in Table 6-4, four jurisdictions in the region have received HMGP funds in the past and only one jurisdiction has received Severe Repetitive Loss (SRL) Program grants. Four communities have received grants from or participated in projects with the U.S. Army Corps of Engineers (USACE). It should be noted that the region is not an area of priority planning and project focus of the USACE, particularly after planning and construction of the James River Floodwall in the City of Richmond.

Table 6-4. Participation in Federal Mitigation Funding Programs by Jurisdiction, 2002 to Present

Jurisdiction	HMGP	SRL	USACE
Charles City County	No	No	Unknown
Chesterfield County	Yes	Yes	No
City of Colonial Heights	No	No	Yes (study)
Dinwiddie County	No	No	Yes
City of Emporia	No	No	No
Goochland County	No	No	Unknown
Greensville County	No	No	No
Hanover County	Yes	No	Unknown
Town of Ashland	No	No	No

Table 6-4. Participation in Federal Mitigation Funding Programs by Jurisdiction, 2002 to Present

Jurisdiction	HMGP	SRL	USACE
Henrico County	No	No	Unknown
City of Hopewell	No	No	No
New Kent County	No	No	Unknown
City of Petersburg	No	No	Yes (dredging)
Powhatan County	No	No	Unknown
Prince George County	No	No	Yes (wetlands impact)
City of Richmond	Yes	No	Floodwall installed in early 1990's
Surry County	Yes	No	No
Sussex County	No	No	No

6.5 Policy and Program Capability

6.5.1 Previous Mitigation Efforts

The region does not actively participate in VDEM/FEMA Hazard Mitigation Assistance Programs with the exception of the City of Richmond, though some highlights of past grant-funded projects and other mitigation projects are presented below. Most localities in the region do not apply for HMA grants but instead incorporate mitigation strategies and action into other regulatory and non-regulatory programs and support activities. Such programs include but are not limited to emergency preparedness outreach, floodplain management and building inspections.

6.5.2 Hazard Mitigation Activity Highlights

The region's Hazard Mitigation Technical Advisory Team is comprised mainly of the Central Virginia Emergency Management Alliance which is supported by an emergency management planner from the Richmond Regional Planning District Commission. Since local adoption of the 2011 plan which merged the previous Crater PDC and Richmond Regional PDC plans, local mitigation has been intertwined with emergency management activities, especially for outreach and messaging. Some regional mitigation program highlights include:

Education and Outreach: Local emergency managers keep a busy calendar of outreach festivals and events which center on hazards-based safety outreach. Some of these are nationally branded which the HMTAC customizes to their localities. Examples include tornado awareness month in March with preparedness drills, the June 1 beginning of Hurricane Season, and promotion of Virginia preparedness supply sales tax free weekends.

On August 27, 2016, a regional PreparAthon community festival was sponsored by local media and corporations and conducted at the Virginia Science Museum in Richmond Virginia. Preparedness was celebrated by teaching participants on how to prepare for and react to disasters and emergencies to become more resilient. Participants who signed up for a Disaster Preparedness Workshop received a free kit worth $45.

Early Warning and Notification: Most communities refined their early warning and notification systems to allow cell phone and sometimes text notifications and other technological advances. Those localities with river flood stage monitoring use river and stream gage data to inform warning messaging. Virginia Commonwealth University uses a loudspeaker system as well as digital notification.

Plan Integration: The 2011 plan was used by some locality planners to inform sections of local comprehensive plans. Geographic Information System technicians used some data-layers from the 2011 plan. The 2017 plan's maps were reformatted to more current scales, legend formats and map templates so should be more easily integrated into local government emergency management and plan documents. The Crater Planning District Commission Director of Planning and Information Technology provides GIS technical support to any Crater PDC jurisdictions so will ensure integration of hazard information. The new flood analysis, based on actual building footprints and true tax assessment property values will allow planners to have greater awareness of flood risks.

The region has robust floodplain program administrators who perform daily activities to adhere to their local floodplain management ordinances in accordance with the National Flood Insurance Program. Due to significant floods from the 1980's through 2006's Tropical Depression Ernesto, building officials also work to ensure adherence to hazard related regulations and criteria in the Uniform Statewide Building Code.

Community Rating System (CRS): FEMA's Community Rating System Program rewards National Flood Insurance participating communities with reductions in flood insurance premiums for NFIP insurance policy holders in the floodplain. Reductions are allocated in five percent increments following a rigorous, comprehensive floodplain management program review by FEMA. The City of Richmond enjoys a CRS Rating of 8, meaning its NFIP policy holders receive a 10% reduction in their annual flood insurance premiums. The Town of Ashland was recognized as a CRS community during the mitigation plan cycle and received a CRS Rating of 9, giving its policy holders a five percent annual flood insurance policy reduction.

Critical and Public Facilities Protection: Due to increased power outages from more frequent severe storms with high winds causing tree loss, the region's local governments have intensified efforts to provide redundant power to critical facilities such as public safety buildings, 911 communications centers, health care facilities and schools used as shelters. Additionally, redundant power or backflow wiring or "quick connects" so that public buildings are able to accept temporary generators are becoming a local priority. While sometimes eligible for FEMA HMA grant support, most of the generator quick connects and installations have been done through local funding. Most new critical facilities are pre-wired for generator acceptance if a permanent generator is not installed.

Specific 2011 mitigation strategy status is addressed in tables within Appendix C organized by each participating jurisdiction. Some specific local government mitigation highlights follow.

6.5.3 Local Government Highlights

Charles City County

Charles City County tests emergency service delivery processes biannually as an integral part of the Virginia Department of Emergency Services' test response to Surry nuclear power plant emergencies. All community critical facilities have adequate generator capabilities. The county has established an effective emergency operations center within its new Judicial Center. Emergency communications are being enhanced by the addition of a communication tower in the vicinity of the Judicial Center.

Chesterfield County

Chesterfield County has acquired four repetitive loss properties along Beach and Old Beach Road in the central part of the county. FEMA mitigation grant funds were used for this project.

Goochland County

Goochland County has been working with VDOF to promote best management practices among landowners in the county. The department and the county have offered joint courses on forestry management and wetlands protection. In addition, the county has thinned more than 160 acres of flammable pine plantations vulnerable to wildfire and insect infestation while instituting best management practices on county-owned property.

Hanover County

Fire Station #5, the location of the Hanover County Emergency Operations Center, has been updated since the first regional hazard mitigation plan to address its electrical power capacity issues. The county also used the proceeds of a bond to improve its communication system and its interoperability. However, the basement of the Hanover County Sheriff's Office is still subject to flooding through the windows. This flooding could affect the emergency communications ability of the Sheriff's Office. Hanover County has also used FEMA mitigation funds for minor, localized drainage improvement projects.

Henrico County

Henrico County has implemented higher standards in floodplain management, including a prohibition on new residential structures in identified floodplains. As a FEMA Cooperative Technical Partner, the county has mapped floodplain drainage areas in 100 acre units, providing far more discrete floodplain modeling than industry standards of 1 square mile (640 acres). Development or redevelopment is prohibited if it will cause a rise in the base flood elevation (or 100-year flood level). In addition, the lowest floor of new development and substantially improved structures must be one foot above the base flood elevation. Finally, through the Chesapeake Bay Preservation Act, a mandatory stream buffer further prohibits development adjacent to streams and wetlands.

In 2005, the county purchased several properties in the Bloomingdale neighborhood along with the property at the intersection of Brook and Lakeside Avenues that were high- risk repetitive damage sites.

City of Richmond

Following numerous floods from the 1970's through 1990's, the US Army Corps of Engineers performed a study and ultimately constructed a flood wall to protect the Shockoe Bottom area and a small area of the south bank from James River flooding. The City of Richmond has been very active since 2011 with new mitigation projects and programs to help reduce its vulnerability to future events. The city received about 14 inches of rain from Tropical Storm Gaston, which the stormwater system was not able to manage effectively. Drainage features such as the East Gravity Outlet, which are part of the floodwall project, were found to contribute to increased damages on the protected side of the floodwall. The occurrence of back-to-back flooding brought attention to the city's older infrastructure system and its need for a dedicated source of funding. Using Capital Improvement Program (CIP) funds in 2008–2010, the city completed many improvements to the Shockoe Bottom area.

During the additional budget cycles, the City of Richmond added three gate structures on the Northeast Interceptor to prevent the transfer of flow from the Arch Sewer to the main Box Sewer, which is the primary sewer collector in the Shockoe Bottom area. The city also installed or modified approximately 100 curb inlets to improve the capture of stormwater from the steeper slopes leading to the Shockoe Bottom watershed, helping to prevent flooding in the lowest parts of the Shockoe Bottom area. In addition, the city redesigned the storm drainage system in Pine Alley to capture a significant portion of the stormwater that would normally enter the alley and flood area businesses. Separation of the East Gravity Outlet from the combined sewer overflow system was also done to eliminate the need for gate operations to minimize interior flooding, increase the reliability of both the flood-reduction system and environmental protection system, and allow the operation of the system with a fail-safe mode. City contractors also connected the Box Sewer to the East Gravity Outlet to provide a high-rate overflow, and restored the Upper Shockoe Creek Retention Basin to further improve the capacity of the Shockoe Bottom Drainage system.

The major improvements in the Shockoe Bottom area were facilitated by the creation of a stormwater utility controlled by the Department of Public Utilities in 2009. This new utility transferred maintenance and improvements of the city's stormwater system from Public Works to Public Utilities and created a long-term source of funding. The new utility now creates an annual CIP list of projects and has begun working to improve the various systems throughout the city to reduce the potential loss of life and damages from future events.

Tropical Storms Gaston and Ernesto also led the City of Richmond to complete two large residential mitigation projects that helped reconstruct and remove homes from the floodplain. The first was Broad Rock Creek Floodway Mitigation Project. This project assisted in the acquisition, demolition, and relocation of several homes. The project also identified other structures in the city that were then reconstructed to move their systems out and above the base flood elevation (BFE). All properties were located in the Broad Rock Creek floodway and were adjacent to a 100-year floodplain that sustained severe damage as a result of the remnants of Tropical Storm Gaston in 2004.

The second project occurred with the acquisition and relocation of families in the Battery Park community. The historic city park and several homes immediately adjacent to it sustained heavy damage during Tropical Storm Ernesto in 2006. The project resulted in the removal of homes from the floodplain and the creation of new parkland.

Richmond successfully used HMGP grant funds to add several stream monitoring gaging stations to augment its flood warning system. These are tied to the Commonwealth's IFLOWs system.

Sussex County

Following the early 2016 tornado which killed three in Waverly, a Waverly Tornado Recovery Urgent Needs Study focused on long term recovery efforts for the Pocahontas Neighborhood through initiation of a Neighborhood Improvement Study. Meetings were conducted in late 2016 with the objective of submission of HUD grant applications to support neighborhood recovery and manufactured housing rehabilitation/mitigation.

6.5.4 Emergency Operations Plan

A comprehensive emergency management operations plan (or emergency operations plan) typically predetermines actions to be taken by government agencies and private organizations in response to an emergency or disaster event. The plan describes the jurisdiction's capabilities to respond to emergencies and establishes the responsibilities and procedures for responding effectively to the actual occurrence of a disaster.

Hazard mitigation is included as a functional annex to some of the emergency operations plans developed by the participating jurisdictions in the Richmond-Crater region. These annexes describe the responsibilities of various departments and agencies, private businesses, and the public. The annex will outline a concept of operations that explains what activities will be undertaken before and after a disaster. Specific tasks are assigned to the Board of Supervisors/City Council (or other local governing body), Department of Emergency Services, Department of Health, Building Officials/County Engineer/Planning and Zoning, Law Enforcement, Fire Department and Emergency Crew, Superintendent of Schools, and Public Information Officer. Emergency operations plans in the Richmond-

Crater region address mitigation in varying detail or simply reference the Richmond-Crater PDC mitigation plan. "Pull-outs" summarizing the counties and cities in the region's demographics, hazard vulnerability and mitigation actions were produced during the 2011 combined PDC plan update and will be updated as part of the 2017 plan update process.

The counties and cities participating in the 2011 plan update process adopted that plan as well as the 2006 Richmond Regional or Crater PDC mitigation plans respectively. Additionally, Ashland, Claremont and Stony Creek adopted hazard mitigation plans in 2011 and 2006.

6.5.5 Floodplain Management

Communities that regulate development in floodplains are able to participate in the NFIP. In return, the NFIP makes federally backed flood insurance policies available for properties in the community. Table 6-5 shows the history of NFIP jurisdiction participation. The table also provides current Flood Insurance Rate Map (FIRM) in effect for each community. The maps were developed by FEMA or its predecessor (HUD) and show the boundaries of the one-percent (100-year) and 0.2% (500-year) predicted floods. As the table shows, most of the FIRMs have been updated since the 2011 plan update. The FIRM updates incorporated new modeling which documented existing development, in many cases extensive development has occurred since the first FIRMs were produced.

Table 6-5. Communities Participating in the NFIP as of April 27, 2017

County/City Name	Jurisdiction Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
Charles City County	Charles City County	01/17/75	09/05/09	07/06/15	09/05/90
Chesterfield County	Chesterfield County	01/10/75	03/16/83	12/18/12	03/16/83
City of Colonial Heights	City of Colonial Heights	06/14/74	09/02/81	08/02/12	09/02/81
Dinwiddie County	Dinwiddie County	11/15/74	01/17/79	06/16/11	01/17/79
	Town of McKenney	-	*06/16/11*	*(NSFHA)*	*11/20/81*
City of Emporia	City of Emporia	07/23/76	02/02/89	07/07/09	09/30/77
Goochland County	Goochland County	02/21/75	03/01/79	12/02/08	03/01/79
Greensville County	Greensville County	12/20/74	09/29/78	07/07/09	09/29/78
	*Town of Jarratt**	*07/30/76*	*10/08/82*	*07/07/09(M)*	*10/08/82*
Hanover County	Hanover County	12/13/74	09/02/81	12/02/08	09/02/81
	Town of Ashland	*05/24/74*	*12/02/08*	*12/02/08*	*05/26/78*
Henrico County	Henrico County	11/22/74	02/04/81	12/18/07	02/04/81
City of Hopewell	City of Hopewell	06/14/74	09/05/79	07/16/15	09/05/79
New Kent County	New Kent County	01/31/75	12/05/90	08/03/15	12/05/90
City of Petersburg	City of Petersburg	05/31/74	03/16/81	02/04/11	03/16/81

Table 6-5. Communities Participating in the NFIP as of April 27, 2017

County/City Name	Jurisdiction Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
Powhatan County	Powhatan County	09/13/74	09/15/78	02/06/08	09/15/78
Prince George County	Prince George County	01/24/75	05/01/80	06/02/15	05/01/80
City of Richmond	City of Richmond	12/06/74	06/15/79	07/16/14	06/15/79
Surry County	Surry County	12/06/74	11/02/90	05/04/15	11/02/90
	Town of Claremont	*04/04/75*	*11/02/90*	*05/04/15*	*10/16/90*
	*Town of Dendron***	*11/15/74*	*11/02/90*	*04/02/09*	*12/02/92S*
	*Town of Surry***		-	-	-
Sussex County	Sussex County	06/09/78	03/02/83	07/07/09	03/02/83
	Town of Stony Creek	*08/09/74*	*09/16/82*	*07/07/09*	*09/16/82*
	Town of Wakefield	*08/26/77*	*07/23/82*	*07/07/09(M)*	*03/12/14*
	*Town of Waverly***	-	-	-	-

Source: FEMA Community Status Book http://www.fema.gov/cis/VA.html
(M) No elevation determined
(S) Sanctioned ; NFIP insurance not available
*Town of Jarratt is listed in Greensville County in the FEMA Community Status Book Report
**Town not in FEMA Community Status Book Report

The Commonwealth of Virginia statutes provide cities, counties and town with land use authority. In particular, issues such as floodwater control are empowered through §15.2-2223 and §15.2-2280. All jurisdictions in the region have adopted a local floodplain ordinance as a requirement of participation in the NFIP.

The Towns of Surry, McKenney and Waverly did not have initial identified floodplain management boundaries as shown on Table 6-5. Several other towns in the region are not NFIP participants due to a lack of FEMA-identified flood hazards.

Each community has designated staff who enforce their floodplain management ordinance, in some cases which is included in the zoning ordinance. The Department of Conservation and Recreation's Floodplain Management Program, including their NFIP Coordinator and his staff, conduct Community Assistance Visits or Community Assistance Calls (CACs) to review program administration locally on about a two year rotation. During the planning period, numerous communities in the region received preliminary Flood Insurance Studies and Flood Insurance Rate Maps which initiated a formal local public review process which the community supported with DCR and FEMA Region III through public display of the new flood hazard products and public meetings prior to revision of local floodplain management ordinances and adoption of the revised ordinance, Flood Insurance Study and Flood Insurance Rate Maps by the elected governing body.

The Community Rating System (CRS), administered by FEMA, was implemented in 1990 as a program for recognizing and encouraging community floodplain management activities that exceed the minimum NFIP standards. Residents of communities that participate in the CRS receive a reduction in flood insurance premiums. There are ten CRS classes: class 1 requires the most credit points and gives the largest premium reduction; class 10 receives no premium reduction.

One of the CRS requirements is a community floodplain management plan. The City of Richmond and the Town of Ashland are the only jurisdictional participants in the Community Rating System. The Richmond-Crater Multi-Regional Hazard Mitigation Plan is intended to fulfill the CRS mitigation planning requirement should any additional participating jurisdictions decide to enter the CRS. Several communities added mitigation actions for this planning cycle to explore joining the CRS.

6.5.6 Local Government Outreach of Repetitive Loss Properties

Chesterfield County

According to the Virginia Department of Conservation and Recreation, Chesterfield County has one Repetitive Loss property. It is an apartment complex built in the early 1970's long before any floodplain mapping was done. One side of the complex is within the 100-year floodplain. The complex, which provides low-income housing, has transferred property owners but has never pursued any mitigation measures. While the county's Environmental Engineering division is aware of the building being in the floodplain, this is not a property that has seen many complaints or flooding inside the units. There is no recollection of the property flooding during hurricanes Isabel or Gaston that brought large amounts of rain over several days, but mainly short heavy thunderstorm events and none in the past decade.

Town of Claremont

According to the Virginia Department of Conservation and Recreation, the Town of Claremont, which is located in Surry County, has one Repetitive Loss/Severe Loss Property. This residential structure has sustained flood damage from multiple storms. Repairs have been made per Virginia building code and Town of Claremont Floodplain Management ordinance requirements.

Colonial Heights

According to the Virginia Department of Conservation and Recreation, the City of Colonial Heights has two Repetitive Loss properties; both are apartments. The flooding to these apartments was due to a creek that overflowed during Hurricane Isabel in 2003. The flood waters rose above the 1st floor onto the 2nd floor. In 2004 the City did debris cleanup in the creek to remediate the problem. Since that time there has been little to no flooding.

Henrico County

According to the Virginia Department of Conservation and Recreation, Henrico County has six Repetitive Loss properties. They are all privately-owned residence. The County provides informational mailers to the addresses on flood hazards and information as developed by FEMA on flood insurance and flood preparedness, and plans to continue this practice. None of these property owners have requested specific information or assistance from the County in the wake of any river flooding on their properties since the last plan update. The County has no current plan to invest in the purchase these properties at this time, as the purchase would not be in the +1 or more positive for the cost benefit analysis.

City of Richmond

According to the Virginia Department of Conservation and Recreation, the City of Richmond has two Repetitive Loss/Severe Repetitive Loss properties. Both properties are commercial and are protected by the floodwall. Both properties are in an area that suffered from storm water flooding issues in the past. In 2009 the City completed several drainage improvement projects in this area to help alleviate drainage backups.

Those projects include:

1. Enlarged to drop inlets in the area to take on greater surface flow.
2. Rerouted a drainage pipe from the upper part of the drainage area from the Northeast interceptor to the Arch sewer.
3. Provided a relief over from the large Shockoe Box Sewer to the east gravity outlet, and
4. Separated a large cross over chamber to bypass overflow gates to speed up the process of water being intercepted during large weather events.

All of these projects have resulted in a decrease in nuisance flooding in the area overall and in this drainage area.

6.5.7 Comprehensive Plans

A community's comprehensive plan provides the future vision for the community regarding growth and development. However, many of the plans include land use or environmental protection goals that could support future mitigation efforts. For example, limiting development in the floodplain (which is considered mitigation) may also help meet open space goals laid out in a comprehensive plan. Several comprehensive plans address mitigation, resiliency and long-term community sustainability. These are new inclusions, and as communities continue to update their comprehensive plans it is anticipated that mitigation and resiliency issues will be more comprehensively addressed.

For the most part, these strategies address development in the floodplain or otherwise flood-prone areas. In addition, the plans indicate that communities in the Richmond-Crater region are experienced with and willing to use growth management tools such as zoning, subdivision regulations, and preferential tax assessment. Section 4.0 Community Profile includes summaries of comprehensive plan status in each participating county and city. Demographic information, land use characteristics and growth projections found in the most current available local comprehensive plans were used to update Section 4.0 Community Profile. It should be noted that growth projections can be as limited as no projections at all, using zoning use categories to designate areas for preferred growth and actual growth projections. Some plans use growth projections from either the Virginia Employment Commission or the Weldon Cooper Institute. The Richmond Regional and Crater PDCs do not currently provide growth projection analysis for their communities.

Table 6-6. Local Planning Mechanisms and Their Relationship to Hazard Mitigation

Locality	Disaster Recovery Plan	Comprehensive Plan Adoption Date & Horizon	Floodplain Management Ordinance	Stormwater Mgmt. Plan	Emergency Operations Plan	Other
Charles City County	Moderate	Moderate Adopted August 8, 2014 - 2034	07/06/15	None	High	Chesapeake Bay Preservation Program
Chesterfield County	Limited	High Adopted October, 2012 – 2017; currently under revision.	12/18/12	None	High	Continuity of Operations (COOP); Evacuation Plan; Wetlands Preservation Program; Open Space Program; Riparian Buffers Program
City of Colonial Heights	High	Adopted January, 2015 - 2040	08/02/12	Yes	High	Historic preservation ordinance; Chesapeake Bay Preservation Program (wetlands)
Dinwiddie County	None	Moderate Adopted February, 2014 - 2019	06/16/11	None	High	
City of Emporia	None	Moderate Adopted 2015 - 2035	07/07/09	None	High	Transportation plan, 1984

Table 6-6. Local Planning Mechanisms and Their Relationship to Hazard Mitigation

Locality	Disaster Recovery Plan	Comprehensive Plan Adoption Date & Horizon	Floodplain Management Ordinance	Stormwater Mgmt. Plan	Emergency Operations Plan	Other
Hanover County**	Moderate	Moderate Adopted 2012 - 2032	12/02/08	High	High	Chesapeake Bay Preservation Program
*Town of Ashland***		Moderate Adopted December 20, 2016 - 2021	12/02/08		High	CRS
Henrico County	Moderate	High Adopted 2006 - 2026	12/18/07	High	High	Chesapeake Bay Preservation Program
Goochland County	Moderate	High Adopted August, 2015 - 2035	12/02/08	Moderate	High	
Greensville County	Limited	High Adopted May, 2008 - 2028	07/07/09	None	High	Erosion control and sediment ordinance
City of Hopewell	High	Moderate Adopted 2001 – currently under revision	07/16/15	Moderate	High	COOP, 2001 Evacuation plan
New Kent County	None	High Adopted October 12, 2009 - 2020	08/03/15	High	High	Chesapeake Bay Preservation Program
City of Petersburg	Low	Moderate Adopted September 15, 2015 - 2020	02/04/11	Low	Low	Transportation plan; Chesapeake Bay Preservation Program Riparian buffers Open space program and plan
Powhatan County	Moderate	Moderate Adopted 2003 – 2018; reviewed every 5 years	02/06/08	Moderate	High	Open Space; Natural Resources Inventory; Debris Management Plan

Table 6-6. Local Planning Mechanisms and Their Relationship to Hazard Mitigation

Locality	Disaster Recovery Plan	Comprehensive Plan Adoption Date & Horizon	Floodplain Management Ordinance	Stormwater Mgmt. Plan	Emergency Operations Plan	Other
Prince George County	Moderate	High 2014 - 2025	06/02/15	Moderate	High	Chesapeake Bay Preservation Program Riparian buffers
City of Richmond	Moderate	Moderate 2010 – Under revision	07/16/14	High	High	Chesapeake Bay Preservation Program; CRS
Surry County**	None	Moderate 2000 to unspecified horizon	05/04/15	None	High	Chesapeake Bay Preservation Program Evacuation plan
Sussex County**	None	Moderate Adopted Oct 20, 2005, amended 2007 under revision	07/07/09	None	High	Evacuation plan Transportation plan, 1997

High = Specifically includes hazard mitigation.
Moderate = Elements could be used to support hazard mitigation.
Limited = No mention of hazard mitigation. Does not contain elements that would support hazard mitigation or includes elements that would hinder hazard mitigation.
Localities** - 2011 HMP Update Ranking; 2016 Capacity Survey not returned.

6.6 Legal Authority

Local governments in Virginia, including those in the Richmond-Crater region, have a wide range of tools available to them for implementing mitigation programs, policies, and actions. A hazard mitigation program can use any or all of the four broad types of government powers granted by the State of Virginia, which are (a) regulation, (b) acquisition, (c) taxation, and (d) spending. The scope of this local authority is subject to constraints; however, as all of Virginia's political subdivisions must not act without proper delegation from the state. All power is vested in the state and can only be exercised by local governments to the extent it is delegated (in accordance with Dillon's Rule). Thus, this portion of the capabilities assessment will summarize Virginia's enabling legislation that grants the four types of government powers within the context of available hazard mitigation tools and techniques.

6.6.1 Regulation

General Police Power

Virginia's local governments have been granted broad regulatory powers in their jurisdictions. Virginia State Statutes bestow the general police power on local governments, allowing them to enact and enforce ordinances that define, prohibit, regulate or abate acts, omissions, or conditions detrimental to the health, safety, and welfare of the people, and to define and abate nuisances (including public health nuisances). Since hazard mitigation can be included under the police power (as protection of public health, safety, and welfare), towns, cities, and counties may include requirements for hazard mitigation in local ordinances. Local governments also may use their ordinance-making power to abate "nuisances," which could include, by local definition, any activity or condition making people or property more vulnerable to any hazard.

All of the jurisdictions located in the Richmond-Crater region have enacted and enforce regulatory ordinances designed to promote the public health, safety, and general welfare of its citizenry.

Land Use

Regulatory powers granted by the state to local governments are the most basic manner in which a local government can control the use of land within its jurisdiction. Through various land use regulatory powers, a local government can control the amount, timing, density, quality, and location of new development. All these characteristics of growth can determine the level of a community's vulnerability in the event of a natural hazard. Land use regulatory powers include the power to plan, enact and enforce zoning ordinances, floodplain ordinances, and subdivision controls. Each local community in the Richmond-Crater region possesses legal authority to prevent unsuitable development in hazard-prone areas.

Planning

According to State Statutes, local governments in Virginia may create or designate a planning agency. The planning agency may perform a number of duties, including:

- making studies of the area;
- determining objectives;
- preparing and adopting plans for achieving those objectives;
- developing and recommending policies, ordinances, and administrative means to implement plans; and
- performance of other related duties.

The importance of the planning powers of local governments is illustrated by the requirement that zoning regulations be made in accordance with a comprehensive plan. While the ordinance itself may provide evidence that zoning is being conducted "in accordance with a plan," the existence of a separate planning document ensures that the government is developing regulations and ordinances that are consistent with the overall goals of the community.

All but one of the cities and counties (City of Emporia) within the Richmond-Crater region have planning departments and comprehensive plans. Most of the towns in the region, with the exception of Ashland, have no formal planning and limited zoning authority; these small towns rely on the county in which they are located to enforce most planning and zoning regulations.

FEMA Region III, in partnership with the Central Virginia Emergency Management Alliance made up of most Richmond Regional and Crater PDC jurisdictions, conducted a Resiliency Workshop on July 12, 2016 in Chesterfield, Virginia. The workshop promoted the concept that resilient communities have the ability to "bounce back" from hazardous events, successfully respond to stressors, and adapt well to change. During the interactive, day-long workshop, participants discussed priorities that informed not just how communities can respond to hazardous events, but also identified actions to spur future activities or projects to build resilience and reduce risk. Some of these actions, particularly regarding infrastructure hardening, are included as local 2017 – 2022 mitigation actions.

The workshop included an *Open House* segment where participants informally discussed programs, funding opportunities, and resources with a variety of local, State, and Federal agencies. It was attended by local, regional and state agency professionals across disciplines who shared information through formal presentations and afternoon informal break-out sessions. Planners, environmental, emergency management, transportation, and economic development professionals and local, State, and Federal agency representatives were among the attendees who are working in or are interested in hazard mitigation, comprehensive and community planning, risk reduction, and sustainable community development. The Central Virginia Resiliency Workshop was the first of six conducted throughout the Commonwealth.

Zoning

Zoning is the traditional and most common tool available to local governments to control the use of land. Broad authority is granted for municipalities and counties in Virginia to engage in zoning. Land "uses" controlled by zoning include the type of use (e.g., residential, commercial, and industrial) as well as minimum specifications that control height and bulk such as lot size, building height and setbacks, and density of population. Local governments are authorized to divide their territorial jurisdiction into districts, and to regulate and restrict the erection, construction, reconstruction, alteration, repair or use of buildings, structures, or land within those districts. Districts may include general-use districts, overlay districts, and special-use or conditional-use districts. Zoning ordinances consist of maps and written text.

Most jurisdictions in the Richmond-Crater region implement floodplain regulations via the zoning ordinance. An overlay district is used to impose additional requirements on properties within the designated floodplain area; in most cases this is done through the Chesapeake Bay Preservation Act buffer areas with restrictive stream buffers. Some jurisdictions implement floodplain regulations as stand-alone ordinances.

Subdivision Regulations

Subdivision regulations control the division of land into parcels for the purpose of building development or sale. Flood-related subdivision controls may prohibit the subdivision of land subject to flooding unless flood hazards are overcome through filling or other measures. Subdivision regulations, however, generally prohibit filling of floodway areas. The regulations also typically require that sub-dividers, once construction begins, install adequate drainage facilities and design water and sewer systems to minimize flood damage and contamination.

All Richmond Regional PDC jurisdictions continue enforcement of their adopted subdivision ordinances and in many instances, have updated those ordinances during the past five years. Some of the ordinances contain floodplain-specific provisions. For instance, Powhatan County requires a 100-foot natural vegetative buffer along all perennial streams as well as setbacks for residential structures from the floodplain. In New Kent County, new subdivisions with 50 or more homes are required to have at least two ingresses and egresses. This requirement will allow an alternate route if one is blocked in case of emergency. Since subdivisions of four lots or more trigger major subdivision review standards in Charles City County, most subdivisions are smaller to avoid these more rigorous standards.

Likewise, the jurisdictions in the Crater PDC have adopted subdivision ordinances. Many of the ordinances require that land be suited for development, and specifically, that land platted for residential use not be subject to flooding. The City of Emporia and Surry County require that utilities be buried underground. Greensville and Sussex Counties and the City of Emporia require stormwater management or flood control plans.

Floodplain Management Regulations

All communities with a FEMA-designated Special Flood Hazard Area (SFHA) in the Richmond-Crater region have adopted floodplain management regulations. Powhatan County's regulations have been in place since 1973, prior to joining the NFIP. The other jurisdictions adopted floodplain regulations after joining the NFIP (see Table 6-5 for date of entry).

Generally, the regulations adopted by the study communities do not go beyond the minimum standards of the NFIP. Goochland and Powhatan Counties restrict uses in the floodplain. Henrico County prohibits new development in the floodplain and restricts redevelopment or rehabilitation projects from having any impact on the base (100-year) event. The majority of communities set design criteria for utilities and other public infrastructure.

Goochland County and the City of Richmond prohibit manufactured homes in all or portions of the floodplain. Chesterfield County prohibits new manufactured home parks while Greensville County prohibits new manufactured homes unless located in an existing park. Hanover County requires manufactured homes to be elevated and anchored.

Twelve of the ordinances in the Richmond-Crater region describe procedures for structures built before the regulations were in place. All localities that allow development in the floodplain require at least a 1-foot freeboard for development with some localities having higher freeboard requirements. The City of Hopewell requires a 2-foot freeboard for all new and substantially reconstructed homes in the floodplain, Greensville County requires 18 inches of freeboard in its ordinance, and Surry County includes a 1-foot freeboard. Goochland County has the highest freeboard with a level of 3 feet above the base flood elevation for construction within the regulated floodplain. The Town of Ashland and the City of Richmond are FEMA Community Rating System communities; this designation gives flood insurance policy holders a discount on their annual flood insurance premiums based on evaluation of the community's enhanced floodplain management program.

Resiliency

The Commonwealth of Virginia has begun to address resiliency issues to reduce impacts of climate change, sea level rise, emergencies and disasters upon communities and the state. Resilient Virginia, a collaborative project of the Virginia Municipal League in cooperation with the Virginia Association of Counties was created ten years ago to foster resiliency concepts with local governments. A Resiliency Checklist to the Go Green Virginia initiative which allows local governments to compete in the "Go Green Challenge" (gogreenva.org) which encourages implementation of environmental policies and practical actions to reduce carbon emissions and save local funds. The Resiliency Checklist is organized into the following six sections:

(1) Policy & Leadership; (2) Preparation for Natural & Man-Made Hazards; (3) Energy Security; (4) Strengthening Critical Infrastructure; (5) Strengthening the Local Economy; and (6) Health & Well Being

While all sections have relevance to a local hazard mitigation plan, (2) Preparation for Natural & Man-made Hazards and (4) Strengthening Critical Infrastructure track to a mitigation plan analysis. The Cities of Petersburg and Richmond were certified Platinum, the highest ranking, during 2015.

North Atlantic Coast Comprehensive Study

The U.S. Army Corps of Engineers recently completed a report detailing the results of a two-year study to address coastal storm and flood risk to vulnerable populations, property, ecosystems, and infrastructure affected by Hurricane Sandy in the United States' North Atlantic region.

This, the North Atlantic Coast Comprehensive Study, is designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. It builds on lessons learned from Hurricane Sandy and attempts to bring to bear the latest scientific information available for state, local, and tribal planners.

The conclusions of the study, as detailed in the final report, include several findings, outcomes, and opportunities, such as the use of a nine-step Coastal Storm Risk Management Framework that can be customized for any coastal watershed. The study ranked localities risk impacts as to High, Medium or Low Impact. Within the Richmond Regional – Crater PDC area, Henrico, Charles City, Chesterfield, Prince George and Sussex Counties were ranked "Low" and Surry County was ranked "Medium." This comprehensive study can provide planners with additional information on long-term impacts of coastal storms.

Other Ordinances

The State of Virginia encourages local governments to adopt stormwater regulations under land use authorities. Stormwater regulations are most often used to control runoff and erosion potential that results from small-scale development of less than 5 acres. In the Richmond-Crater region, Chesterfield, Dinwiddie, Goochland, Hanover (including the Town of Ashland), Henrico, New Kent, Powhatan, and Prince George Counties and the Cities of Colonial Heights, Emporia, and Richmond have regulations that deal with stormwater management. Charles City County does not regulate stormwater. Virginia is also a signatory to the Chesapeake Bay Agreement, a unique regional partnership aimed at restoring the Chesapeake Bay. Communities in certain parts of the state are required to implement local land use controls to minimize runoff and other adverse impacts that degrade the water quality of the bay. Five of the seven jurisdictions in the Richmond region are considered part of the Tidewater area and therefore are required to implement local Chesapeake Bay Preservation Program requirements. These jurisdictions are Charles City, Hanover (including the Town of Ashland), Henrico, and New Kent Counties, and the City of Richmond. Goochland and Powhatan Counties are not considered to be part of the Chesapeake Bay area. In the Crater region, six of the eleven jurisdictions are considered part of the Tidewater area and therefore are required to adhere to locality Chesapeake Bay Preservation Program requirements. These jurisdictions are Chesterfield, Prince George, and Surry Counties and the Cities of Colonial Heights, Hopewell, and Petersburg. Dinwiddie and Greensville Counties and the City of Emporia are not in the Chesapeake Bay Watershed.

Chesapeake Bay Preservation Act

The Chesapeake Bay Preservation Act (Bay Act) was enacted by the Virginia General Assembly in 1988 as a critical element of Virginia's non-point source management program.

The Bay Act program is designed to improve water quality in the Chesapeake Bay and other waters of the State by requiring the use of effective land management and land use planning.

Virginia designed the Bay Act to enhance water quality with continued reasonable development. The Bay Act balances state and local economic interests and water quality improvement by creating a unique cooperative partnership between state and Tidewater local governments to reduce and prevent nonpoint source pollution. Local governments retain the primary responsibility for land use decisions, expanding local government authority to manage water quality, and establishing a more specific relationship between water quality protection and local land use decision-making.

The Bay Act Program is the only program in Virginia state government that deals comprehensively with the relationships between water quality, and land use planning and development. It is also the only program that assists local governments with land use planning needs to meet water quality goals: the development of land use regulations, ordinances and comprehensive plans.

The Chesapeake Bay Preservation Area Designation and Management Regulations were originally adopted in 1989 and were amended in 1991, 2001 and in 2012 as part of the Integration Bill. The Bay Act charges the State Water Control Board with the following responsibilities:

- *Promulgating and keeping current regulations that establish criteria for local Bay Act programs*
- *Ensuring that local government comprehensive plans, zoning ordinances, and subdivision ordinances are in compliance with the Bay Act regulations*
    - These land use ordinances and plans comprise the local Bay Act program and must meet the requirements of the regulations.
- *Providing technical and financial assistance to Tidewater local governments*
    - Technical assistance has been provided in a number of ways, including: publications, research projects, provision of computer equipment, providing training for local government planners and engineers, and other direct staff assistance. Financial assistance has been provided through (1) a competitive grants program for localities and planning district commissions that began in 1990, and (2) a grant program for Soil and Water Conservation Districts in Tidewater to develop agricultural soil and water quality conservation plans on farmlands within Chesapeake Bay Preservation Areas.
- *Providing technical assistance and advice to regional and state agencies on land use and water quality protection*
    - Bay Act staff help the board and Tidewater local governments, planning district commissions, and Soil and Water Conservation Districts participating in the program. The staff also provides assistance in other regional efforts, including the

development of watershed restoration plans and participation on committees and work groups of the Chesapeake Bay Program.

Local Bay Act programs include:

1. A map generally depicting Chesapeake Bay Preservation Areas.
2. An ordinance containing performance criteria pertaining to the use, development and redevelopment of land.
3. A comprehensive plan or revision that incorporates the protection of Chesapeake Bay Preservation Areas and of the quality of state waters.
4. A zoning ordinance that incorporates measures to protect the quality of state waters.
5. A subdivision ordinance that incorporates measures to protect the quality of waters of the state.
6. A plan of development process prior to the issuance of a building permit to assure that the use and development of land in Chesapeake Bay Preservation Areas is accomplished in a manner that protects the quality of state waters.

Localities within the plan update region who participate in the program include Charles City, Chesterfield, Hanover, Henrico, New Kent, Prince George, Surry and Sussex Counties, the Cities of Colonial Heights, Hopewell, Petersburg and Richmond and the towns of Ashland, Claremont, and Surry.

Building Codes and Building Inspection

Many structural mitigation measures involve constructing and retrofitting homes, businesses, and other structures according to standards designed to make the buildings more resilient to the impacts of natural hazards. Many of these standards are imposed through building codes.

All of the jurisdictions have adopted the 2012 Virginia Statewide Uniform Building Code effective July, 2014. While municipalities and counties may adopt codes for their respective areas if approved by the state as providing "adequate minimum standards," none of the participating jurisdictions have chosen to do so.

Local governments in Virginia are also empowered to carry out building inspections. The Code of Virginia directs cities and counties to create an inspection department, and enumerates its duties and responsibilities, which include enforcement of state and local laws relating to the construction of buildings; installation of plumbing, electrical, and heating systems; building maintenance; and other matters. Each of the Richmond-Crater PDC region jurisdictions has established either a building inspections or code compliance office to carry out its building inspections.

Fire Codes

Virginia has a statewide fire code. The code establishes statewide standards to safeguard life and property from the hazards of fire or explosion arising from the improper maintenance of life safety, and fire prevention and protection of materials, devices, systems, and structures. The Virginia State Fire Marshal's Office is charged with enforcement of the code statewide except in those localities that choose to enforce the code locally. Those localities that choose to enforce the code locally must employ their own certified fire official.

6.6.2 Acquisition

The power of acquisition can be a useful tool for pursuing local mitigation goals. Local governments may find that the most effective method for completely "hazard-proofing" a particular piece of property or area is to acquire the property (either in fee simple or a lesser interest, such as an easement), thus removing the property from the private market and eliminating or reducing the possibility of inappropriate development. Virginia legislation empowers cities, towns, and counties to acquire property for public purpose by gift, grant, devise, bequest, exchange, purchase, lease, or eminent domain (Code of Virginia 15.2-1901).

The City of Richmond completed acquisition projects after 2006's Tropical Depression. Ernesto in both the Broad Rock Creek and Battery Park neighborhoods. All projects were completed without using FEMA mitigation funds. Virginia Urgent Needs block grant funds were used following Tropical Depression Ernesto to acquire and demolish flood-damaged properties. Once the structures were demolished the lots were dedicated to permanent open space. In some instances, Richmond has used city funds available to the Building Official to acquire and demolish disaster-impacted properties as has been done with some trailer park communities and a residence impacted by a landslide on Church Hill following Tropical Depression Gaston. Chesterfield County acquired several repetitive loss properties along Beach and Old Beach Roads using FEMA Hazard Mitigation Grant Program funds following Hurricane Isabel. Development of an acquisition program is proposed in the City of Petersburg Comprehensive Plan. The City of Colonial Heights continues to consider a voluntary acquisition program along high-risk creeks to eliminate repetitive flood claims in the city.

6.6.3 Taxation

The power to levy taxes and special assessments is an important tool delegated to local governments by Virginia law. The power of taxation extends beyond merely the collection of revenue, and can have a profound impact on the pattern of development in the community. Communities have the ability through special legislation to set preferential tax rates for areas that are more suitable for development in order to discourage development in otherwise hazardous areas (Code of Virginia 15.3-2404).

Local governments also have the ability to levy special assessments on property owners for all or part of the costs of acquiring, constructing, reconstructing, extending, or otherwise building or improving flood protection works within a designated area (Code of Virginia 15.2-1104). This can serve to increase the cost of building in such areas, thereby discouraging development. Because the usual methods of apportionment seem mechanical and arbitrary, and because the tax burden on a particular piece of property is often quite large, the major constraint in using special assessments is policy-oriented. Special assessments seem to offer little in terms of control over land use in developing areas. They can, however, be used to finance the provision of necessary services within municipal or county boundaries. In addition, they are useful in distributing the costs of the infrastructure required by new development to the new property owners.

According to the Code of Virginia 58.1-3389, local governments are authorized to levy taxes on real property with no upper limit imposed. Additionally, Section 58.1-3201 requires that an assessment be 100% of fair market value. A building that increases in value of more than $500 due to repairs or additions must be assessed as new (Code of Virginia 58.1-3291). At the same time, the code allows the abatement of local real estate taxes for buildings unusable for at least 30 days during the year (Code of Virginia 58.1-3222). Real estate tax is a significant source of local revenue.[23]

According to the State Corporation Commission, "the E911 tax is imposed by localities to pay for the cost of an emergency response communications system that identifies both the caller and the location of the call. The tax rate is set by the locality. The General Assembly also authorized a 75¢ per month charge on wireless and wired telephone customers. This money will pay for highly sophisticated equipment that pinpoints, by satellite, the location of a wireless 911 caller."[24]

6.6.4 Spending

The fourth major power that has been delegated from the Virginia General Assembly to local governments is the power to make expenditures in the public interest. Hazard mitigation principles should be made a routine part of relevant spending decisions made by the local government, including the adoption of annual budgets and the Capital Improvement Plan (CIP).

A CIP is a schedule for the provision of municipal or county services during a specified period of time. Capital programming, by itself, can be used as a growth management technique, with a view to hazard mitigation. By tentatively committing itself to a timetable for the provision of capital to extend services, a community can control growth to some extent, especially in areas where the provision of on-site sewage disposal and water supply are unusually expensive.

In addition to formulating a timetable for the provision of services, a local community can regulate the extension of and access to services. A CIP that is coordinated with extension and access policies can provide a significant degree of control over the location and timing of growth. These tools can also influence the cost of growth. If the CIP is effective in directing

[23] Knapp, John L. and Stephen C. Kulp. *Tax Rates in Virginia's Cities, Counties, & Selected Towns: 2003 Tax Rates.* December 2003. Retrieved from www.virginia.edu/coopercenter/vastat/taxrates2003/taxrates03.html

[24] Virginia Department of Taxation. Tax *Facts*. Retrieved on July 1, 2011 from http://www.tax.virginia.gov/site.cfm?alias=communicationstaxes

growth away from environmentally sensitive or high-hazard areas, for example, it can reduce environmental costs.

The majority of the jurisdictions in the Richmond-Crater region have some form of a CIP. The construction or renovation of capital facilities, such as schools, municipal offices, and police/fire stations is often a highlight of their capital improvements. Investments in stormwater and sewer systems are included in the capital improvements program for most municipalities. Some jurisdictions also have included open space and other park acquisition costs as part of their CIP.

6.7 Summary

Most of the information in the capability assessment was provided by the jurisdictions in the study area through a capability assessment survey. Table 6-7 summarizes the self-reported capability and priority assessment; note that several jurisdictions did not return the 2016 update capability assessment survey. Full result may be found on a table in Appendix I.

Table 6-7. Mitigation Capability & Priority Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
Richmond Regional PDC	Planning High	Moderate	Moderate	N/A	Moderate
Crater PDC	Planning High	Moderate	Moderate	N/A	Moderate
Charles City County*	Moderate	Moderate	Moderate	Moderate	Moderate
Chesterfield County	High	High	High	High	High
City of Colonial Heights	Moderate	Moderate	Moderate	Moderate	Moderate
Dinwiddie County	Moderate	Moderate	Moderate	Moderate	Moderate
*Town of McKenney**	Limited	Limited	N/A	Limited	Limited
City of Emporia	Moderate	Moderate	Moderate	Moderate	Moderate
Goochland County	Moderate	Moderate	Moderate	Moderate	Moderate
Greensville County	Moderate	Moderate	Not Provided	Moderate	Moderate
*Town of Jarratt**	Limited	Limited	N/A	Limited	Limited
Hanover County*	Moderate	Moderate	N/A	Moderate	Moderate
*Town of Ashland**	Moderate	High	N/A	Limited	Moderate
Henrico County	High	High	High	High	High
City of Hopewell	Moderate	Moderate	Moderate	Limited	Moderate
New Kent County	Moderate	High	Moderate	Moderate	Moderate
City of Petersburg	Limited	Limited	Moderate	Limited	Limited

Table 6-7. Mitigation Capability & Priority Self-Assessment by Jurisdiction

Jurisdiction	Planning and Regulatory Capability	Administrative Capability	Technical Capability	Fiscal Capability	Overall Capability
Powhatan County	Moderate	High	Moderate	Moderate	Moderate
Prince George County	Moderate	Moderate	Moderate	Moderate	Moderate
City of Richmond	Moderate	Moderate	Moderate	Limited	Moderate
Surry County*	High	High	N/A	High	High
*Town of Claremont**	Limited	Limited	N/A	Limited	Limited
*Town of Dendron**	Limited	Limited	N/A	Limited	Limited
*Town of Surry**	Limited	Limited	N/A	Limited	Limited
Sussex County*	Moderate	Limited	N/A	Limited	Limited
*Town of Stony Creek**	Limited	Limited	N/A	Limited	Limited
*Town of Wakefield**	Moderate	Moderate	N/A	Moderate	Moderate
*Town of Waverly**	Limited	Limited	N/A	Limited	Limited

High: No increase in capability needed (e.g., extensive regulations on development in place).

Moderate: Increased capability desired but not needed (e.g., funding exists for mitigation but availability fluctuates).

Limited: Increased capability needed (e.g., additional staff are needed to successfully implement mitigation projects).

N/A: not available.

Source: Capability Assessment Survey Results.

*Based on 2011 Self-Assessment; 2016 Survey not returned.

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7 Mitigation Strategy

The hazard mitigation planning process conducted by the HMTAC used a typical problem-solving methodology:

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

This section of the hazard mitigation plan describes the most challenging part of any such planning effort – the development of a mitigation strategy. It is a process of:

- Setting mitigation goals, and
- Developing a mitigation action plan.

7.1 Setting Mitigation Goals

When a community decides that certain risks are unacceptable and that certain mitigation actions may be achievable, the development of *goals* and *actions* takes place. *Goals* are long-term and general statements. *Actions* are detailed and specific methods to meet the goals.

The HMTAC reviewed the goals from the 2006 and 2011 Crater and Richmond Regional Hazard Mitigation Plan at the HMTAC meeting on October 26, 2016. The committee discussed whether to modify or add a resiliency goal as well as a goal to incorporate the new Threat, Hazard Identification Risk Analysis (THIRA) into the mitigation plan. It was decided by the HMTAC who is comprised largely of members of the Central Virginia Emergency Management Alliance to realign the 2017 hazard mitigation plan update goals with the priorities of the Central Virginia Emergency Management Alliance. An additional 'goal number one (1.)' was added to focus on 'mitigation actions responsive to hazards' analyzed in the revised vulnerability analysis. The goals are broad and applicable to the regions served by the Richmond Regional and Crater Planning District Commissions and mirror the priorities of the Central Virginia Emergency Management Alliance. The goals which follow are not presented in a priority order.

1. Reduce risk exposure and vulnerabilities to hazards ranked "medium" and "high" by focusing on regional and local mitigation actions on priority hazards.

2. Prepare and protect the whole community within the Central Virginia Emergency Management Alliance (CVEMA) region through all-hazards planning staff, outreach publications and activities, and through training, and exercising volunteers and the general public.
3. Strengthen and sustain response coordination and collaboration through planning, equipment, training, and exercises to increase interoperability between all stakeholders in the CVEMA region and other regions/entities that impact interoperability within the region, to include, but not limited to voice, video, and data.
4. Provide support for public health and human service needs of the whole community through robust and coordinated sheltering capability, to include planning, resources, equipment, training, and exercises to include support of client needs tracking, family reunification services, information sharing, and public health response support.
5. In the aftermath of a catastrophic incident, provide restoration of basic services, long term housing, and revitalization of a sustainable economy that includes the health, social, cultural, historic, and environmental fabric of the community, through planning, staffing, equipment, training, and exercises.
6. Enhance and maintain public safety and incident management response capabilities to all hazard emergencies including acts of terrorism, through planning, staffing, equipment, training, and exercises.
7. Protect the critical infrastructure of the CVEMA region, and enhance the capability to disrupt criminal or terrorist threats through effective information and intelligence gathering and sharing, outreach, planning, equipment, training, and exercises.

7.2 Selecting Mitigation Actions

Actions are simple statements that identify projects, activities or processes to support the goals set out in the mitigation plan.

The status of the actions from the previous 2006 and 2011 plans were updated through in-person meetings with locality staff or via email or phone interviews. The status of the 2011 actions can be found in Appendix C. A "notes" column was added to provide additional explanation for actions where clarity on status was uncertain. In some instances, localities did not respond to multiple attempts for status updates and this is recorded for those few instances.

Table 7-1. STAPLE/E Prioritization Criteria for Actions to be Taken

Social
• Is the proposed action socially acceptable to the community(s)? • Are there equity issues involved that would mean that one segment of a community is treated unfairly? • Will the action cause social disruption?
Technical
• Will the proposed action work? • Will it create more problems than it solves? • Does it solve a problem or only a symptom? • Is it the most useful action in light of other community(s) goals?
Administrative
• Can the community(s) implement the action? • Is there someone to coordinate and lead the effort? • Is there sufficient funding, staff, and technical support available? • Are there ongoing administrative requirements that need to be met?
Political
• Is the action politically acceptable? • Is there public support both to implement and to maintain the project?
Legal
• Is the community(s) authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? • Are there legal side effects? Could the activity be construed as a taking? • Is the proposed action allowed by a comprehensive plan, or must a comprehensive plan be amended to allow the proposed action? • Will the community(s) be liable for action or lack of action? • Will the activity be challenged?
Economic
• What are the costs and benefits of this action? • Do the benefits exceed the costs? • Are initial, maintenance, and administrative costs taken into account? • Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? • How will this action affect the fiscal capability of the community(s)?

• What burden will this action place on the tax base or local economy? • What are the budget and revenue effects of this activity? • Does the action contribute to other community goals, such as capital improvements or economic development? • What benefits will the action provide?
Environmental
• How will the action affect the environment? • Will the action need environmental regulatory approvals? • Will it meet local and state regulatory requirements? • Are endangered or threatened species likely to be affected?

The actions from the 2011 plan formed the starting point for discussion about what mitigation actions are needed for the 2017 plan. Many 2011 actions were carried forward to the 2017 – 2022 plan cycle. In addition, a range of new action alternatives were identified by each jurisdiction in individual local government meetings. These alternatives are presented in Appendix D. It should be noted that while some actions specifically address the indicated hazard, many outreach and more general mitigation actions can address multiple or "all" hazards and are noted as such.

Generally, the jurisdiction representatives evaluated the actions for inclusion in the plan with the following criteria:

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

Some jurisdictions selected fewer actions than in the 2011 plans, which will allow them to be more focused on their implementation of the actions. Other jurisdiction with expanded local resources added actions to their 2017 suite of mitigation actions. After the 2017 actions were selected, the STAPLE/E (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) criteria (Table 7-1) were used to inform prioritization the most appropriate actions for the Richmond-Crater communities. This methodology requires that social, technical, administrative, political, legal, economic, and environmental considerations be taken into account when reviewing potential actions for the area's jurisdictions to undertake. This process was used to help ensure that the most equitable and feasible actions would be undertaken based on a jurisdiction's capabilities.

As part of the STAPLE/E criteria, the anticipated level of cost-effectiveness of each measure was a primary consideration when developing mitigation actions. Because mitigation is an investment to reduce future damages, it is important to select measures for which the reduced damages over the life of the measure are likely to be greater than the project cost. For structural measures, the level of cost-effectiveness is primarily based on the likelihood of damages occurring in the future, the severity of the damages when they occur, and the level of effectiveness of the selected measure. Although a detailed analysis was not conducted during the mitigation action development process, these factors were of primary concern when selecting measures. For those measures, such as public education and outreach, that do not result in a quantifiable reduction of damages, the relationship of the probable future benefits and the cost of each measure was considered when developing the mitigation actions.

Priority was assigned based on a relative score using the STAPLE/E criteria with strong emphasis on the economic criteria. For the most part, local jurisdictions did not rank mitigation actions high if the financial likelihood of action implementation was low. Each criterion was assigned a rating using the following scale: 2=Very beneficial, 1=Favorable, 0=None/Not applicable, -1=Not Favorable. The numbers were summed and then a priority assigned using the scheme shown in Table 7-2.

Table 7-2. Priority Scoring System

Priority	Score Range
Limited	0 to 4, long-term implementation 7 – 10 years, high cost.
Medium	5 to 8, 5 – 7 year implementation, moderate cost
High	9 to 12, short-term implementation within 5 years, lower cost

In addition to the actions identified by the individual jurisdictions, the Regional PDCs identified regional actions for each specific PDC to support plan implementation or their jurisdictions.

7.3 Developing a Mitigation Action Plan

Mitigation action plans were developed for all of the identified actions. Each mitigation action plan includes:

- the goal(s) it is intended to help achieve,
- the hazard(s) it is designed to mitigate,
- the agency assigned responsibility for carrying out the strategy,
- general resources needed,
- a timeframe for completion, and
- Priority level for its implementation (high, medium, or low).

The timeframes are defined in Table 7-3 and mirror those used in the 2011 Richmond Regional – Crater Hazard Mitigation Plan Update.

Table 7-3. Timeframes Defined

Timeframe	Definition
Short-term	Less than three years
Long-term	More than three years
As funding becomes available	Project timeline is dependent on funding
Ongoing	Project is continuous with no designated end date

The mitigation action plans for each jurisdiction follow in alphabetical order for the Richmond Regional and Crater Planning District Commissions may be found in Appendix D.

8 Plan Maintenance Procedures

The long-term success of the 2017 Richmond-Crater Multi-Regional Hazard Mitigation Plan depends on routine monitoring, evaluating, and updating of the plan so that it will remain a current, flexible tool for regional and community use.

8.1 Formal Plan Adoption

Twenty-six local governments in central Virginia participated in the plan update process and will formally adopt this plan by resolution of each governing board. The adoption process is expected to take several months, as significant coordination by the HMTAC will be necessary to: 1) place the plan review and adoption on the appropriate meeting agendas in each jurisdiction, 2) produce and provide copies in official meeting packets, 3) facilitate the actual adoption, 4) collect the adoption resolutions, and 5) incorporate the adopted resolutions into the final hazard mitigation plan. As local governments adopt the plan, the Richmond Regional Planning District Commission will forward locality Resolutions of Adoption to VDEM.

8.2 Implementation

Upon adoption, the plan faces its biggest test: ***implementation***. While the plan includes many worthwhile and “High” priority recommendations, the decision of which action to pursue first will be the primary issue that the Richmond-Crater communities face.

Each participating jurisdiction is responsible for incorporating their own actions into various planning documents, processes and budgets pursuant to locally-administered governing policies and procedures. Each action is assigned a responsible department or departments that will work together to implement designated actions.

There are always resource considerations that impact implementation and funding always seems to be central to this. Therefore, pursuing low- or no-cost, high-priority recommendations may be a way to achieve progress sooner rather than later while allowing time to strategize on possible grant funding or future resource allocations to implement more challenging actions. An example of a low-cost, high-priority recommendation would be to install flood level markers on bridges to warn motorists, pedestrians and cyclists of high water levels.

Another implementation approach is to prioritize those low-cost actions that can be completed in a relatively short amount of time. Being able to publicize accomplishment of a successful project can build momentum to implement the other parts of the plan. An example of an effective but easy-to-implement strategy is to distribute brochures from localities, the PDCs, FEMA and VDEM on mitigation and preparedness topics.

It is important to the long-term implementation of the plan that its underlying principles are incorporated into other community plans and mechanisms, such as:

- comprehensive planning
- resiliency planning
- disaster recovery planning and
- Capital Improvement Program (CIP) budgeting.

Section 4.0 Community Profile provides insight into the comprehensive plan status for each community. Members of the HMTAC representing each jurisdiction will provide an electronic link to this plan to their planning department to make them aware that the plan has been finalized and adopted by their governing board, and to begin the conversation of how best to incorporate appropriate information from the 2017 mitigation plan into the next update of the jurisdiction's comprehensive plan. Information from the HIRA, as well as mitigation goals and actions may be directly included as a comprehensive plan element or included in other local government programs and policies as appropriate. Projects that require large investments, such as acquisition or road retrofits, are candidates for inclusion in capital improvement plans. Hazard vulnerability analysis can be incorporated into local emergency operations plans, debris management, and disaster recovery plans. Floodplain management data and mitigation actions can be used to leverage Community Rating System (CRS) program participation or a better CRS rating.

Mitigation is most successful when it is incorporated within the day-to-day functions and priorities of government and development. This integration is accomplished by a constant effort to network and to identify and highlight the multi-objective, "win-win" benefits to each program, the communities, and their constituents. This effort is achieved through monitoring agendas, attending meetings, and providing routine updates on the status and progress of mitigation efforts.

Simultaneous to these efforts, it is important to constantly monitor funding opportunities that can be used to implement some of the higher cost recommended actions. This includes creating and maintaining a repository of ideas on how any required local match or participation requirement can be met. Then, when funding does become available, the Richmond-Crater communities will be in a position to take advantage of an opportunity. Funding opportunities that can be monitored include special pre- and post-disaster funds, special district-budgeted funds, state or federal ear-marked funds, and grant programs, including those that can serve or support multi-objective applications.

With adoption of this plan, the Richmond-Crater communities commit to:

- Pursuing the implementation of the high-priority, low/no-cost recommended actions;
- Keeping the concept of mitigation in the forefront of community decision-making by identifying and stressing the recommendations of the hazard mitigation plan when other community goals, plans, and activities are discussed and decided upon;

- Maintaining a constant monitoring of multi-objective, cost-share opportunities to assist the participating communities in implementing the recommended actions of this plan for which no current funding or support exists;
- Incorporate hazard risk information, and priority mitigation actions into appropriate local initiatives and programs through collaborative interaction between all related community departments and staff; and
- Evaluating and assessing regional mitigation plan goal and local jurisdiction action effectiveness to reduce hazard risk exposure.

In addition, the communities of the Richmond-Crater region remain committed to the NFIP. They will continue to enforce floodplain regulations and undertake other actions to remain in compliance with the program such as continued flood hazard risk evaluation, participation in Community Assistance Visits (CAV's) with the Commonwealth of Virginia NFIP staff, and education and outreach activities directed at flood-prone residents and businesses.

8.3 Maintenance

Plan maintenance requires an ongoing effort to monitor and evaluate the implementation of the plan, and to update the plan as progress, roadblocks, or changing circumstances are recognized. The Richmond Regional and Crater Planning Districts will be responsible for monitoring this plan for the jurisdictions within their boundaries. They will work with the HMTAC or the Central Virginia Emergency Management Alliance or any appropriate regional multi-jurisdiction successor, to coordinate information gathering from the participating jurisdictions.

The Richmond Regional and Crater Planning Districts in conjunction with the HMTAC or CVEMA, within 60 days of adoption of the plan, will modify the monitoring process or schedule as drafted in Section 8.3 if necessary to allow monitoring and evaluation of plan implementation progress.

The Richmond Regional and Crater Planning District planning staff will make an annual request to the HMTAC members in November for an update to be provided by January 31, on the progress of the implementation of their mitigation actions under the guidance of VDEM. Annual review will include review of local and PDC mitigation action implementation, opportunities to incorporation plan information into relevant local and regional plans, documents and projects, lessons learned and outreach opportunities. Opportunities for member communities to leverage plan participation into Resilient Virginia or the Community Rating System, as appropriate, will also be explored.

Figure 8-1 shows a sample update form.

Jurisdiction:		
Updated through:		
Action number:	Status: Not started In progress (percent complete___) Completed for purposes of this plan Ongoing Activities Successes Effectiveness	Notes (e.g., changes in action/funding/responsible department/timeframe):
Action number:	Status: Not started In progress (percent complete___) Completed for purposes of this plan Ongoing Activities Successes Effectiveness	Notes (e.g., changes in action/funding/responsible department/timeframe):

Figure 8-1. Sample Update Form

Ongoing evaluation of implementation progress for the mitigations actions will be achieved by monitoring changes in the vulnerability identified in the plan. Changes in vulnerability can be identified by noting:

- lessened vulnerability as a result of implementing recommended actions;
- increased vulnerability as a result of failed or ineffective mitigation actions; and/or
- increased vulnerability as a result of new development/re-development.

The Richmond Regional and Crater Planning District Commissions, with the HMTAC in consultation with CVEMA, will determine annually if a more formal update of the plan is needed and the mechanism for doing so. Major changes to the plan will be submitted to VDEM and to ultimately to FEMA Region III with subsequent local re-adoption by each jurisdiction, as necessary. Factors to consider when determining if a formal update is necessary include:

- decreased vulnerability as a result of implementing recommended actions;
- increased vulnerability as a result of failed or ineffective mitigation actions;

- increased vulnerability as a result of new development (and/or annexation);
- new state/federal laws, policies, or programs; and/or changes in resource availability.

Ongoing Public Outreach will continue and public participation will be encouraged, at a minimum, through available web postings and press releases to the local media outlets, primarily newspapers and radio stations. In addition, progress reports of the mitigation actions will be considered as part of Survivor Day training, a free, half-day preparedness class that is offered in multiple locations across the region each year. Local government staffs will also provide routine updates to their governing body.

Table 8-1. Richmond Regional – Crater Multi-Regional Hazard Mitigation Plan Update Maintenance Schedule

Timeframe	Activity	Leadership
2017	Jurisdictions Adoption	Local jurisdictions; Richmond Regional PDC submit to FEMA
2018	Annual implementation review	HMTAC or CVEMA
2019	Annual implementation review	HMTAC or CVEMA
2020	Annual implementation review; seek FEMA HMA funding for 2022 plan update	HMTAC or CVEMA
2021	Annual implementation review initiate 2022 Plan update process;	HMTAC or CVEMA; Richmond Regional PDC
2022	Continue 2022 Plan update process	HMTAC, Richmond Regional and Crater PDC

9 References

Note: some of this source material for the 2011 plan had not been updated and was used as background material for the 2017 Plan update.

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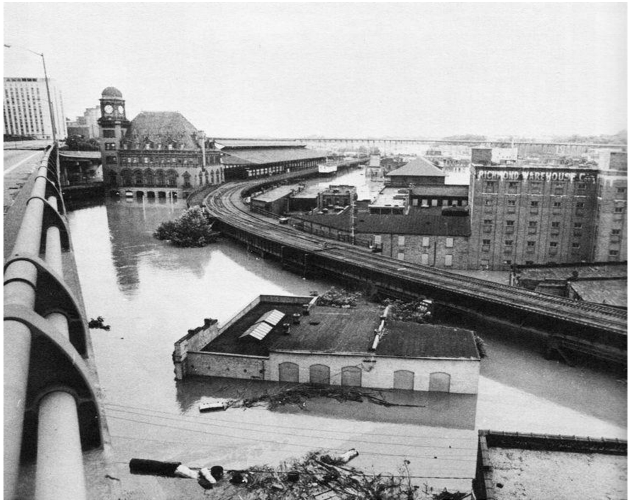


City of Richmond

Emergency Operations Plan (EOP)

Updated April 2017


PREFACE

The City of Richmond is vulnerable to a variety of hazards such as flooding, hurricanes, winter storms, hazardous materials incidents, acts of terrorism, and resource shortages. A planned and coordinated response can save lives, protect property, and more quickly restore essential services.

The *Virginia Emergency Services and Disaster Laws* require that state and local governments develop and maintain current emergency operations plans (EOPs) in order to be prepared for a variety of natural and man-made hazards.

The City of Richmond Emergency Operations Plan provides the structure and mechanisms for the coordination of support to impacted communities and affected individuals and businesses. It is compatible with the National Response Framework and provides the structure for coordinating with the state government in the delivery of disaster assistance. The plan improves the City of Richmond's capability to respond to and recover from threatened or actual natural disasters, acts of terrorism, or other man-made disasters.

COMPONENTS OF THE CITY OF RICHMOND EMERGENCY OPERATIONS PLAN

The Basic Plan, using an all-hazards approach to incident management, describes the concepts and structures of response and recovery operation; identifies agencies with primary and support emergency management functions; and defines emergency prevention, preparedness, response and recovery duties and responsibilities. There are 12 appendices to the plan that give definition to the terms and acronyms used throughout the Plan, and provide supporting figures, maps, and forms.

The Emergency Support Functions (ESFs) provide the structure for interagency emergency operations in support of disaster-affected communities. ESF annexes describe the roles and responsibilities for departments and agencies and non-governmental organizations (NGOs). The Plan identifies sixteen (15) emergency support functions; assigns primary, support, and cooperating agencies and organizations for each function; and explains in general terms how the City of Richmond will organize and implement those functions. ESF #5, Emergency Management, is the lead ESF in any activation or augmentation of the Emergency Operations Center (EOC) and responsible for command and control and overall coordination of all assets and resources.

Support Annexes address those functions that are applicable to every type of incident and that provide support for all ESFs. They describe the framework through which departments and agencies, volunteer organizations and nongovernmental organizations coordinate and execute the common functional processes and administrative requirements necessary to ensure efficient and effective incident management.

Incident Annexes address contingency or hazard situations requiring specialized response and recovery procedures. They describe policies, situations, concepts of operations and responsibilities pertinent to incidents such as hurricanes, winter storms or acts of terrorism.

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LETTER OF AGREEMENT

The City of Richmond Emergency Operations Plan (EOP) establishes a single, comprehensive framework for the management of emergencies and disasters within the City. The plan is implemented when it becomes necessary to mobilize the resources of the identified departments and agencies to save lives and protect property and infrastructure. In order for the city to respond effectively, the plan requires planning, training, and exercising prior to a real world event. Concurrence with this plan represents a major commitment by each agency's leadership.

By signing this letter of agreement city departments and agencies agree to:

- Perform assigned emergency roles and responsibilities as identified in this plan;
- Conduct operations in accordance with the Incident Command System, applicable Homeland Security Directives, National Disaster Recovery Framework and the National Response Framework;
- Familiarize and train all personnel with their emergency responsibilities and procedures on a regular basis.
- Conduct planning and training in cooperation with identified agencies (Emergency Support Function (ESF) coordinating and cooperating agencies) and the Office of Emergency Management (OEM);
- Maintain financial records in accordance with guidance from the Department of Finance and the Department of Procurement (ESF 7);
- Establish, maintain and exercise emergency notifications;
- Provide senior representatives to the Emergency Operations Center (EOC), command post or other identified emergency locations when activated and requested;
- Participate in approved tests, drills and exercises;
- Maintain an approved agency-specific Continuity of Operations (COOP) Plan in accordance with city guidelines and standards, including identifying and preparing an alternate site(s) for the efficient relocation of operations;
- Safeguard vital records including computer digital data at all times;
- Establish stand-by contracts for services, equipment, and other resources with private industry IAW using Procurement guidelines and procedures; and
- Periodically review all emergency plans, polices, and procedures.

Signatories

Bobby Vincent – Interim Director, Department of Public Works

____

Chip Decker – CEO, Richmond Ambulance Authority

____

Charles Todd – Interim Director, Department Information Technology

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Robert Steidel – Director, Department of Public Utilities

____

David Daniels – Interim Chief, Fire and Emergency Services

____

Albert Durham – Chief, Police Department

____

C.T. Woody – Sheriff, Richmond Sheriff's Office

____

Shunda Giles - Director, Department of Social Services

____

Stephen Willoughby – Director, Department of Emergency Communications

____

James Nolan – Press Secretary to the Mayor

____

John Wack – Director, Department of Finance

____

C. Edward Gibbs – Director, Procurement Office

____

Christie Peters – Director Animal Care and Control

____

Dr. Danny Avula - Director, Richmond City Health District

____

Lee Downey – Deputy Chief Administrative Officer, Economic Community Development

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Deborah Morton – Deputy Director, Parks Recreation and Community Facilities

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Mark Olinger – Director, Planning and Development Review

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John P. Lindstrom, Ph.D. – CEO, Richmond Behavioral Health Authority

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City of Richmond Emergency Operations Plan
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Basic Plan

Approval and Implementation

The Code of Virginia, § 44-146.19, requires each local jurisdiction and inter-jurisdictional agency to prepare and keep current a local emergency operations plan (EOP). Every four years, each local agency will conduct a comprehensive review and revision of its emergency operations plan to ensure that the plan remains current. The revised plan shall be formerly adopted by the locality's governing body.

Each instance in which the plan is used, whether it be in training/exercises or an incident, the plan shall be reviewed by the Emergency Management (EM) staff to identify any corrective actions to be implemented.

Purpose

The purpose of this plan is to establish the legal and organizational basis for emergency and disaster operations in the City of Richmond. All essential entities are to utilize any and all available resources when preventing, protecting and mitigating against, preparing for, responding to and recovering from an all-hazards incident. At the direction of the Mayor, the EOP may be revised and amended as needed to conform with any changes in local, state and/or federal laws, or when the plan is used (ex: exercise or incident) and corrective actions are identified.

Scope and Applicability

This plan and all of its contents apply to the entire jurisdiction and its citizens, to include those with access and functional needs. All city departments who have an identified role in the plan will have access to and be knowledge of the EOP.

It is the responsibility of the City of Richmond to protect life, property and the environment from the effects of an all-hazards incident as a function of public safety. Local government has the primary responsibility for emergency management activities, however, when the emergency exceeds the resources of local government to respond, assistance can be requested from the state or federal government as appropriate.

The city incorporates the National Incident Management System (NIMS) and the Incident Command System (ICS) to manage an all-hazards incident. The Emergency Operations Center (EOC) will be activated for major emergencies and disasters, as directed by the Emergency Management Director or his/her designee. The EOC staff will act as a coordination function and assist in the determination of priorities throughout the city. The on-scene Incident Commander(s) (IC) will provide reports to, and coordinate with the EOC. The EOC staff will provide support to the on-scene IC and coordinate required support from other localities, state and federal agencies as needed in support of the incident.

Planning Assumptions

- The Plan is based on the planning assumptions, situations, considerations, and risk assessments presented in this section.
- Incidents are typically managed at the local level.
- Incident management activities will be initiated and conducted using the principles contained in the National Incident Management System (NIMS).
- Departments' capabilities to carry out response and recovery tasks are enhanced through the creation and testing of adequate department continuity of operations (COOP) plans and procedures.
- The combined expertise and capabilities of government at all levels, the private sector, and the nongovernmental organizations will be required to prevent, prepare for, respond to, and recover from incidents of major or catastrophic proportions.
- Incidents including major emergencies or catastrophic events will require full coordination of operations and resources, and might:
- Occur at any time with little or no warning;
    - Require significant information-sharing across multiple jurisdictions and between the public and private sectors;
    - Involve single or multiple jurisdictions and/or geographic areas;
    - Require significant inter-governmental resource coordination and/or assistance;
    - Span the spectrum of incident management to include prevention, preparedness, response, recovery, and mitigation;
    - Involve multiple, highly varied hazards or threats on a local, regional, statewide or national scale;
    - Result in numerous casualties, fatalities, displaced people, property loss, significant damage to the environment, and disruption of economy and normal life support systems, essential public services, and basic infrastructure;
    - Impact critical infrastructures across sectors;
    - Overwhelm capabilities of the city and private-sector infrastructure owners and operators;
    - Attract a sizeable influx of independent, spontaneous volunteers and supplies;
    - Require extremely short-notice asset coordination and response timelines; and
    - Require prolonged, sustained incident management operations and support activities requisite to long term community recovery and mitigation.
- Top priorities for incident management are to:
    - Save lives and protect the health and safety of the public, responders, and recovery workers;
    - Ensure security of the city;
    - Protect and restore critical infrastructure and key resources;
    - Protect property and mitigate damages and impacts to individuals, communities, and the environment;
    - Facilitate recovery of individuals, families, businesses, communities, and the environment; and
    - Manage public expectations regarding response activities.
- Requests for assistance from entities including, but not necessarily limited to, nursing homes, colleges and universities, and authorities will be submitted to the Coordinator of

Emergency Management. Requests for assistance will be submitted to the Virginia Emergency Operations Center by the Coordinator only when the city's capabilities are exceeded.

- The severity of the impact on state and local resources might necessitate a request for federal assistance; factors that might determine the need for federal involvement in response and recovery might include:
  - State or local needs that exceed available resources;
  - The economic ability of the state and the affected localities to recover from the incident;
  - The type or location of the incident;
  - The severity and magnitude of the incident; and
  - The need to protect the public health or welfare or the environment.
- Special facilities (schools, nursing homes, adult day care and child care facilities) are required to develop emergency plans.
- Regulated facilities (Superfund Amendments and Re-authorization Act sites) posing a specific hazard will develop, coordinate, and furnish emergency plans and procedures to local, county and state departments and agencies as applicable and required by codes, laws, regulations or requirements.

Situation

Occupying 62.55 square miles and home to an estimated population of 220,289 (2015 U.S. Census estimate) citizens, the City of Richmond is the capital of the Commonwealth of Virginia and the cultural and commercial center of a Metropolitan Statistical Area (MSA) with more than 1.2 million people. Additionally, Richmond, because of its location in the middle of the eastern seaboard, is within 750 miles of two-thirds of the nation's population and less than 100 miles from the nation's capital. The City is intersected by Interstates 95, 64 and 295, two major freight lines and Amtrak passenger service. The Port of Richmond and Richmond International Airport provide water and air services to both the City and surrounding areas. The James River which travels through Richmond has made the City the only urban U.S. city with a conservation easement along its downtown river.

The City of Richmond is within 50 miles of both the Surry and North Anna Power Stations. If an accident were to occur at either of the stations, the area within 50 miles of the facility would be assessed to determine if there has been any impact on the environment. The City maintains a Radiological Response Plan.

This creates a diverse economic base, including research and development, manufacturing, retail services, tourism, banking and state government. Richmond is home to the Fifth District Federal Reserve Bank and the Fourth Circuit U.S. Court of Appeals. Richmond is also home to several Fortune 500 company headquarters and many Fortune 1000 companies.

Several higher education institutions, including Virginia Union University, Union Theological Seminary & Presbyterian School of Christian Education, J. Sergeant Reynolds Community College, University of Richmond and Virginia Commonwealth University (VCU) including its health system schools, are located within the City. Additionally, the VCU Health System is the largest Level 1 Trauma Center in the Commonwealth. The Office of Emergency Management houses copies of each of the institutions Emergency Operations Plans (EOPs).

The following population and housing characteristics are ones that affect plan implementation or the emergency response effectiveness (all data are from the U.S. Census, 2015 American Community Survey 1-year estimates):

- The city has 87,224 total households, of which:
  - 43,627 (49.2%) are family households
  - 18,190 family households include children (under 18), and 9,890, or 54%, of family households with children have only one parent present
  - 11,053 of households (13.8%) are 65+ householders living alone
  - 17,768 of all households (20.4%) have children (under 18) present
  - 21,481 of all households (26.7%) have at least one member age 65+
  - Average person per household is 2.33; average family household is 3.22
- The median age in Richmond is 32.6, which is younger than the state and national median ages
- 20.0% or 40,938 of the population are under 18
- 26,491 of the population are 65+
- 15.9% or 32,007 of the population has some form of disability (emotional, behavioral, intellectual, or physical)
- 48.1% or 12,275 of those 65+ have a disability
- The median household income is $40,758, about 1/3 less than state or national median incomes
- 25.5% or 46,100 of the population live in poverty
- 32.4% or 5,894 of families with children live in poverty
- 35.7% or 28,023 of households earn less than $25,000 annually
- 1955 is the median year built for all structures in Richmond
- 28.3% of all structures were built in 1939 or earlier
- The city has 92,282 total housing units;
- 91.6% or 84,549 housing units were occupied, leaving 8.4% vacant
- 53.86% of occupied housing units were occupied by renters, 46.14% by owners
- 21.6% of occupied housing units had no vehicle available; 42.2% of occupied housing units had only one vehicle available

Additional features that could affect the plan implementation include:

- A number of environmentally sensitive areas and features including wetlands, floodplains, streambanks, subaqueous bottomlands and diverse geological features such as steep slopes and soils of high erodibility.
- Much of the City fabric predates the Civil War and large areas were almost completely developed by the early 20th Century.
- Twenty-three National Register Districts with over 200 structures listed on the National Register of Historic Places.
- There are approximately 24 miles of James River waterfront within the City, most of which remains in a natural state. Development along the river is confined to areas within Downtown and portions of the western bank, south to the City limits.

Hazard Identification and Risk Analysis

Preparedness, response, recovery, and mitigation strategies are largely based on analyses of the known hazards in Virginia.

1. Natural Hazards – Based on the *Richmond-Crater Multi-Regional Hazard Mitigation Plan.*[1]

Hazard Type	Planning Consideration
Flooding	Moderate
Wind	Limited
Tornado	Significant
Hurricane	Significant
Winter Weather	Moderate
Thunderstorms (hail and lightning)	Moderate
Droughts (with extreme heat)	Limited
Mass evacuation	Limited
Wildfires	Limited
Earthquakes	Limited
Landslides/shoreline erosion	Limited
Land subsidence/karst/sinkholes	Limited

2. Human Caused Hazards - In addition to the natural hazards identified in the Hazard Identification and Risk Assessment, the City of Richmond has the potential for impact from human caused events.

[1] The *Richmond-Crater Multi-Regional Hazard Mitigation Plan* used historical analysis and data from the National Climatic Data Center's (NCDC) Storm Event Database to complete the Hazard Identification and Risk Assessment (HIRA) for the region.

Organization and Assignment of Responsibilities

The Code of Virginia, [§ 44-146.19] designates powers and duties for emergency management to political subdivisions. Each entity shall have a director of emergency management. As an independent city, the City of Richmond Mayor is the Director of Emergency Management. The Chief Administrative Officer (CAO) is the Deputy Director of Emergency Management.

Local authorities have primary responsibility for managing emergencies. In some cases, state and federal assets may be used to advise or assist. Additionally, mutual aid agreements provide mechanisms to mobilize and employ resources from neighboring jurisdictions to support the incident command.

When City of Richmond resources and capabilities are overwhelmed, assistance from neighboring jurisdictions may be requested. When local resources are overwhelmed, assistance from the state may be requested. When state resources are overwhelmed, the Governor may request federal assistance under a Presidential disaster or emergency declaration.

City of Richmond City Council

- Collectively reviews and ratifies local declaration of emergency.
- Collectively works in conjunction with the Emergency Management Director or Deputy Director to provide guidance to citizens concerning the response and recovery phase.
- Individually, host community meetings to ensure needs are being addressed and to provide information to residents.
- Individually, serve as advocates for constituent recovery efforts.
- Individually, maintains notification for their respective office and staff.

Emergency Management Director or Deputy Director

- May declare a local emergency.
- May suspend local laws and ordinances, such as, but not limited to, establish a curfew and direct evacuations.
- Provide leadership and play a key role in communicating to the public, and in helping people, businesses, and organizations cope with the consequences of any type of domestic incident within the City.
- Negotiate and enter into mutual aid agreements with other jurisdictions to facilitate resource-sharing.
- Coordinate with other elected officials at the regional, state and federal levels including the Congressional Delegation.

Policy Group

- Consists of the Emergency Management Deputy Director (CAO), Deputy Chief Administrative Officers, Command Staff and the Directors of departments responding to or aiding in the recovery from the incident.

- Provides policy guidance on priorities and objectives based on situational needs and the Emergency Operations Plan.
- Oversees resource coordination and support to the on-scene command from the Emergency Operations Center (EOC).

Coordinator of Emergency Management

- Serves as the lead for ESF #5 – Emergency Management.
- Coordinates resources to address the full spectrum of actions to prevent, prepare for, respond to, and recover from incidents involving all hazards including terrorism, natural disasters, accidents, and other contingencies.
- Receives and fulfills requests for assistance from entities including, but not necessarily limited to, nursing homes, colleges and universities, and authorities within the City until capabilities have been exceeded or exhausted.
- Activates and manages the Emergency Operations Center to coordinate response to disasters and ensure the most effective and efficient integration and utilization of activated assets to address the situation at hand.
- Develops standard operating procedures to facilitate the communications and operational interface during all phases of disaster management.
- Develops and maintain plans and procedures to address the full spectrum of hazards.
- Coordinates needs assessment and damage assessment operations.
- Coordinates disaster assistance and recovery operations.
- Requests state assistance when local capabilities have been exceeded or exhausted.
- Coordinates with state and federal officials after a disaster to implement recovery strategies and programs.

Department of Public Works

- Serves as the co-lead for ESF #1 – Transportation and ESF #3 – Public Works & Engineering.
- Develop and maintain plans and procedures to support ESF #1 in coordination with GRTC and ESF #3 in coordination with Department of Public Utilities.
- Support the implementation of traffic control measures.
- Support initial and, as necessary, more detailed damage assessments.
- Provide emergency engineering services.
- Coordinate evacuation needs.
- Coordinate and provide debris clearance and removal.

Department of Information Technology

- Serves as the co-lead for ESF #2 – Communication
- Develop and maintain plans and procedures to support ESF #2.
- Ensure the continuation and restoration of IT infrastructure.

Department of Emergency Communications

- Serves as the co-lead for ESF #2 – Communication
- Develop and maintain plans and procedures to support ESF #2.
- Ensure adequate communications throughout the city in support of response and recovery operations

Department of Public Utilities

- Serves as the co-lead for ESF #3 – Public Works and Engineering and lead for ESF #12 – Energy.
- Develop and maintain plans and procedures to support ESF #3 in coordination with Department of Public Works and ESF #12.
- Coordinate the conservation of resources, as necessary.
- Maintain and restore gas, water, wastewater and street light services.
- Provide utilities and power outage reports.

Department of Parks, Recreation and Community Facilities

- Serves as a support agency for ESF #3 – Public Works and Engineering and ESF #6 – Mass Care.
- Develop and maintain plans and procedures to support ESFs #3 and #6.
- Assist with damage assessments.

Department of Fire and Emergency Services

- Serves as the lead for ESF #4 – Firefighting, ESF # 9 – Search and Rescue and ESF #10 – Oil and Hazardous Materials.
- Develop and maintain plans and procedures to support ESFs #4, #9 and #10.
- Provide for the management and coordination of all activities as they relate to the prevention and suppression of fires.
- Develop specialized response resources and crews according to capabilities including hazardous materials response, search and rescue and other specialized equipment.
- Assist with damage assessments.
- Continually monitor the fire potential, on-going fire situation, and resources committed and available.

Department of Social Services

- Serves as the lead for ESF #6 – Mass Care.
- Develop and maintain plans to establish and manage mass care human services operation sites in a timely manner, in coordination with the Office of Emergency Management, Richmond Public School Systems and American Red Cross.

- Coordinate with the appropriate local, state and federal agencies and private partners, to facilitate the exchange of information and the provision of services to relatives of victims in a mass casualty event.
- As necessary, determine requirements for temporary housing.

Department of Finance/Department of Procurement Services

- Serve as the leads for ESF #7 – Resource Management.
- Develop and maintain plans and procedures to support ESF #7.
- Coordinate the framework for City resource management activities.
- Activate contracts with internal and external agencies to provide resources.
- Assist in overseeing and expediting the purchase of emergency equipment.

Richmond City Health District

- Serve as the co-lead for ESF #8 – Public Health and Medical Services.
- Develop and maintain plans and procedures to support ESF #8 in coordination with Richmond Ambulance Authority.
- Provide for Prevention of Disease to include surveillance and investigation of diseases.
- Assist Mass Fatality Management operations and coordination.
- Provide guidance and technical assistance regarding emergency evacuation of People with Access and Functional Needs.
- Dispense life-saving pharmaceuticals and medical supplies including the activation of the Strategic National Stockpile.

Richmond Ambulance Authority

- Serve as the co-lead for ESF #8 – Public Health and Medical Services.
- Develop and maintain plans and procedures to support ESF #8 in coordination with Richmond City Health District.
- Provide basic and advanced life support care.
- Transport patients to hospital facilities.
- Support the evacuation of patients with special needs.

Richmond Police Department

- Serve as the co-lead for ESF #13 – Public Safety and Security.
- Develop and maintain plans and procedures to support ESF #13 in coordination with the Sheriff's Office.
- Coordinate law enforcement component of incident response and recovery operations.
- Assist in evacuating areas at risk in coordination with other law enforcement authorities and emergency support functions.
- Implement traffic control actions in and around site.
- Establish the necessary security and accessibility policies around incident and evacuated areas.

- Coordinate the collection and preservation of evidence to support a criminal investigation during the response and recovery phases of an incident.

Sheriff's Office

- Serve as the co-lead for ESF #13 – Public Safety and Security.
- Develop and maintain plans and procedures to support ESF #13 in coordination with the Richmond Police Department.

City Security

- Provide security services at the Emergency Operations Center (EOC) and shelters.
- Develop and maintain plans and procedures to support ESF #13 in coordination with the Richmond Police Department and Sheriff's Office.

Department of Economic Development

- Serve as the lead for ESF #14 – Long Term Recovery.
- Develop and maintain plans and procedures to support ESF #14 in coordination with the Department of Planning and Development Review.
- Assess the social and economic consequences in the impacted area and coordinate state and Federal efforts to address long-term community recovery issues.
- Partner with disaster assistance agencies to implement short term recovery programs for private individuals and businesses as well as public services authorities and certain non-profit organizations.

Department of Planning and Development Review

- Serve as the lead for ESF #14 – Long Term Recovery.
- Develop and maintain plans and procedures to support ESF #14 in coordination with the Department of Economic Development.
- Support initial and, as necessary, more detailed damage assessments.
- Identify ways to support projects that mitigate further damage to redeveloped structures.

Office of the Press Secretary

- Serve as the lead for ESF #15 – External Affairs.
- Develop and maintain plans and procedures to support ESF #15.
- Coordinate the preparation and dissemination of public information releases.

Richmond Animal Care and Control

- Serve as the lead for ESF #16 – Animal Care and Control.
- Develop and maintain plans and procedures to support ESF #16.
- Provide and operate pet shelters.

- Coordinate animal search and rescue operations.
- Match lost animals with proper owners.
- Coordinate the evacuation of animals, if necessary.

Nongovernmental and Volunteer Organizations

Nongovernmental and voluntary organizations (NGOs) collaborate with first responders, governments at all levels, and other agencies and organizations providing relief services to sustain life, reduce physical and emotional distress, and promote recovery of disaster victims. Within the City of Richmond, designated non-government organizations, such as the American Red Cross, provide specific disaster relief services during response and recovery in cooperation with City departments.

The Virginia Voluntary Organizations Active in Disaster (VAVOAD) is a statewide consortium of faith-based and non-profit organizations that are active in disaster relief. The VAVOAD communicates with the many voluntary organizations that provide significant capabilities to incident management and response and recovery efforts at all levels. The Office of Emergency Management, in partnership with the Department of Social Services, will coordinate VAVOAD activities to address unmet needs during a declared local emergency. The City of Richmond operates through the Virginia Capital Area VOAD (VCAVOAD) in conjunction with the VAVOAD.

Private Sector

The roles, responsibilities, and participation of the private sector during major incidents vary based on the nature of the organization and the type and impact of the incident. They support the Emergency Operations Plan by sharing information with the various city departments, identifying risks, performing vulnerability assessments, developing emergency response and business continuity plans, enhancing their overall readiness, implementing appropriate prevention and protection programs, and donating or otherwise providing goods and services through contractual arrangement or government purchases to assist in response to and recovery from an incident.

Citizen Involvement

During an emergency, citizens within a community are the first to arrive and the last to leave the scene in response to the needs of their neighbors. Strong partnerships with citizen groups and organizations enable preparedness, response, recovery, and mitigation efforts within the City. Additionally, citizen groups can provide capabilities and expand available resources to augment the City’s response and recovery activities. Organizations such as Community Emergency Response Teams (CERTs) and the Medical Reserve Corps (MRC) provide for public education, outreach, and training; represent volunteers interested in helping to make their communities safer; and/or offer volunteer service opportunities to support first responders, disaster relief activities, and community safety efforts.

Prepared citizens are a priority of the City of Richmond. Outreach programs promote awareness of personal and community risks and also the principles of individual and family preparedness. Preparedness information is available to Richmond residents through many sources including www.richmondgov.com, Twitter and other local media outlets. Crisis emergency information is disseminated immediately when a threat or incident occurs.

Citizens groups are also critical to the community recovery process after a disaster. The programs designed and implemented by federal, state and local governments, insurance providers and NGOs can never completely meet the needs of every individual. Communities can provide an effective and efficient forum for pooling and coordinating the delivery of available resources to individuals and families in need. To date the City of Richmond CERT Program has trained more than 400 volunteers available to assist with emergency preparedness, response and recovery activities.

Concept of Operations

The City of Richmond EOP is based on the idea that emergency operations will begin at the city level and that outside assistance will be requested only when an emergency or disaster exceeds the city's capabilities. Situations in which several localities are threatened or impacted concurrently will usually involve requests for state assets from the onset.

In the event that an incident may exceed local capabilities and/or threaten public safety, the city can declare a local state of emergency. This declaration will be made by the Director of Emergency Management with the consent of the City Council. The local emergency activates the EOP and authorizes the provision of aid and assistance there under. It should be declared when a coordinated response among several local agencies/organizations must be directed or when it becomes necessary to incur substantial financial obligations in order to protect the health and safety of persons and property or to provide assistance to the victims of a disaster.

In the event the governing body cannot convene due to the disaster or other exigent circumstances, the Director, or in his/her absence, the Assistant Director, or in the absence of both the Director and Assistant Director, the Emergency Management Coordinator may declare the existence of a local emergency, subject to confirmation by the City Council at its next regularly scheduled meeting or at a special meeting within 45 days of the declaration, whichever occurs first.

Once a local emergency has been declared, the director of emergency management, if so authorized by the governing body, may:

- Control, restrict, allocate or regulate the use, sale, production and distribution of food, fuel, clothing and other commodities, materials, goods, services and resource systems which fall only within the boundaries of the City of Richmond and which do not impact systems affecting adjoining or other political subdivisions;
- Enter into contracts and incur obligations necessary to combat such threatened or actual disaster;

- Protect the health and safety of persons and property and provide emergency assistance to the victims of such disaster, and proceed without regard to time-consuming procedures and formalities prescribed by law (except mandatory constitutional requirements) pertaining to the performance of public work; and
- Entering into contracts, incurring of obligations, employment of temporary workers, rental of equipment, purchase of supplies and materials, and other expenditures of public funds, provided such funds in excess of appropriations in the current approved budget, unobligated, are available.

The Director of Emergency Management, when in his/her judgment all emergency actions have been taken, shall take appropriate action to end the declared emergency. Confirmation should be accomplished at either a special meeting of the City Council or during a regularly scheduled meeting that will occur within the 45-day period following a declaration. The declaration of local emergency must be in accordance with Section 44-146.21, Chapter 3.2 – Code of Virginia. Preceding the declaration of emergency, the Emergency Management Coordinator should advise VDEM of this action as soon as possible through telephone, email or WebEOC.

Coordination of the Emergency Operations Center

During normal operations, it is the responsibility of the Office of Emergency Management (OEM) to manage the EOC from which the Mayor, or designee, can direct and control emergency operations. The Coordinator of Emergency Management is the Mayor's designee to manage the EOC and to coordinate the city's response to all emergencies and disasters. OEM develops detailed procedures for EOC operations, manages an ongoing training program and maintains adequate facilities and equipment for EOC operations. Departments assigned responsibilities in the EOC designate staff to respond to the EOC and to participate in training.

In time of emergency, OEM provides centralized emergency operations in order to coordinate resources, advice and counsel to the Mayor, or the Mayor's designee, to formulate policy, establish priorities, collect and analyze information, and disseminate information, and communications with the state government related to conditions or developing situations related to the emergency.

The Director of Emergency Management, the Deputy Director of Emergency Management, the Emergency Management Coordinator or their designees implement the EOP.

The implementation of the EOP and activation of the EOC may occur simultaneously. The level of EOC and EOP activation will be based upon the severity and scope of the incident. The Incident Command System integrated with Emergency Support Functions (ESF's) and various annexes established by this plan may be selectively activated based upon initial or anticipated requirements.

The EOC will be under the control of the Coordinator of Emergency Management, who reports directly to the Deputy Director of Emergency Management (CAO) or designee. The supporting EOC staff is comprised of employees of OEM, other designated departments, representatives of VAVOAD, and designated private sector entities. Departments assigned primary, support, and/or cooperating emergency response or recovery duties and responsibilities must develop and maintain their designated part(s) of the City of Richmond Emergency Operations Plan.

Activation of the Emergency Operations Center (EOC)

The Coordinator of Emergency Management may activate the EOC based on discussions with the Deputy Director if:

- There is an imminent threat to public safety or health on a large scale;
- An extensive multiagency/jurisdiction response and coordination will be required to resolve or recover from the emergency or disaster event; and/or
- The disaster affects multiple political subdivisions within counties or cities that rely on the same resources to resolve major emergency events.

Availability of staff and operational needs may allow or require positions to be combined or positions to not be filled (responsibilities held by the next higher position).

Leadership from partner agencies or organizations may request that the EOC be activated to support emergencies that are being managed by their agency or organization. Any municipal police or fire chief, county administrator, manager or executive or city manager or their designee, from a jurisdiction adjacent to the city of Richmond may make a request to activate the EOC to support an emergency occurring in or affecting their jurisdiction directly to, or through, the Department of Emergency Communications. In addition, the Governor or his designee may request that the city of Richmond EOC be activated to support emergency events occurring with the Commonwealth.

All department and agency points-of-contact to include members of City Council will be notified of the EOC activation by OEM through the most appropriate method. In turn, agency EOC representatives will be notified through their agency's internal notification process.

Upon notification, identified EOC representatives shall report to the EOC at the appointed time and be prepared to carry out their roles and responsibilities. Departments and agencies will provide appropriate representation to the EOC based upon the level of activation. Agency representatives shall be prepared to staff the EOC until they are relieved by other personnel or the incident is terminated.

The EOC may be partially or fully activated depending upon the nature and scope of the incident or potential incident. The EOC may also be activated for a planned event. The Director Emergency Management or Deputy Director of Emergency Management, in cooperation with the Coordinator of Emergency Management, will designate the level of emergency and ensure appropriate notifications are made.

Preparatory Actions for City Departments (ESF's) will consist of but are not limited to the following:

- Review plans and procedures including response and individual agency emergency action plans.

- Check critical equipment and supplies.
- Backup critical data and address how to protect vital records.
- Consider your role in recovery.
- What critical resources will you need to maintain a service level.
- Stay informed, monitor all possible sources of weather information.
- Prepare for a possible change in our readiness level later in the week. If that occurs, departments will be expected to:
    - Report daily on departmental preparedness actions.
    - Report on critical resources and issues.
    - Report on departmental priorities, and activities.
    - Identify staffing for the EOC should an activation occur.

The levels of emergency, operation category and minimum required actions are listed in the following table.

Level of Emergency

Category	Minimal Actions
Routine Operations - Daily operations at normal staffing level.	1. Public information and educational materials will be provided via municipal newsletters, brochures, municipal web-sites and other media. 2. Maintain, update and exercise the Emergency Operations Plan. 3. Assure the viability and accuracy of emergency contact lists, resource lists and emergency contracts.
Increased Readiness - Coordinator of Emergency Management receives notice of a potential emergency from the Virginia Department of Emergency Management, National Weather Service watches and/or warnings or other reliable sources.	1. Monitor the situation. 2. Provide updates as necessary via text or email. 3. Alert emergency response personnel and develop a staffing pattern for a minimum of 72 hrs, as necessary. 4. Issue Preparatory Actions to ESF's. 5. Disseminate preparatory actions to members of City Council and emergency response personnel. 6. Determine any protective action measures that need to be implemented in preparation for the situation. 7. Discuss activation of the EOC with the Deputy Director. 8. **When Central Virginia is in the National Weather Service five day forecast zone begin disseminating preparedness information to citizens via ESF# 15 in preparation for possible power outage**. 9. Participate in State level conference calls, as necessary 10. Brief Policy Group, as necessary
Response Operations - Coordinated response to preserve life, property, the social, economic, and political structure of the City.	1. Partial or full activation of ESFs within the EOC. Partial activation will be dependent on the incident or event. 2. Daily functions that do not contribute directly to the emergency operation may be suspended for the duration of the emergency response. 3. Efforts and resources may be redirected to accomplish an emergency task. 4. Implement evacuation orders as needed. 5. Open and staff emergency shelters as needed. 6. Conduct daily EOC briefings. 7. Develop periodic Situation Reports (SitRep). 8. Brief Policy Group, as necessary 9. Produce daily situation report for dissemination.
Recovery Operations - After the initial response is completed assist affected individuals and communities return to a normal state.	1. Within 72 hours of incident stabilization, complete an Initial Damage Assessment and submit to the VEOC. 2. Assess infrastructure and determine viability for re-entry of residents. 3. Begin repairs to electric, water and sewer lines and stations. 4. Implement Initial Damage Assessment (IDA) procedures to support 72 hour submission request of the IDA Report to the Virginia Emergency Operations Center (VEOC). 5. Support State/Federal Preliminary Damage Assessment visit, as necessary.
Mitigation - Reduce or eliminate long-term risk to people and property from hazards and their side effects.	1. Review Regional Hazard Mitigation Plan and update as necessary any mitigation actions that could be of assistance in preventing similar impacts for a future disaster. 2. Work with the Virginia Department of Emergency Management Mitigation Program to develop mitigation grant projects to assist in areas most at risk. 3. Implement mitigation measures in the rebuilding of infrastructure damaged in the event.

Plan Development and Maintenance

The City of Richmond Emergency Operations Plan, including all annexes, is the core plan for emergency operations, and provides the structures and processes for coordinating incident management activities for natural disasters and other emergencies. Following the guidance provided by the National Response Framework, President Preparedness Directive 8, National Incident Management System, Incident Command System and other supporting documents.

Accordingly, departments must incorporate key concepts and procedures for working interfacing with the plan's organizational elements when developing or updating incident management and emergency response plans. All additional emergency response and recovery plans and procedures developed by departments should be compatible with the plan.

The Office of Emergency Management maintains the EOP. The plan is reviewed on a continuous basis and updated periodically as required to incorporate policy changes, new directives, legislative changes, and procedural changes based on lessons learned from exercises and actual events. The plan will be reviewed and adopted in its entirety by the Mayor and City Council every five years.

The section below establishes procedures for interim changes and full updates of the plan.

- Changes include additions of new or supplementary material and deletions. No proposed change should contradict or override authorities or other plans.
- Any department may propose and develop a change to the Plan. OEM is responsible for coordinating review of the proposed change among the primary and support agencies of each affected ESF and any associated department program areas as required.
- OEM developed and will maintain a procedure for changes that will include:
    - Obtaining the official written approval for the change from the appropriate officials of the affected departments; and
    - A process to notify and receive approval from the Mayor or designee for all requested changes.
    - Ensure appropriate notification is made about the changes and maintain a record of changes.
- Prior to the four-year revision, OEM may revise areas of the plan. OEM will send the final draft of the revised Plan to the Chief Administrative Officer (CAO) for review and concurrence prior to submitting the plan to the Mayor for approval and promulgation.

The Coordinator of Emergency Management will ensure that this document is subject to annual maintenance, review, and update based on selective evaluations, after-action reports, and new guidance.

Training and Exercises

The purpose of the Multi-year Training and Exercise Plan (TEP) is to document the city's overall training and exercise program priorities for a specific multi-year time period. It is considered to be a living document that can be updated and refined annually. These priorities are linked to corresponding core capabilities, and, if applicable, a rationale based on existing strategic guidance, threat assessments, corrective actions from previous exercises, or other factors. This Multi-year TEP identifies the training and exercises that will help Richmond build and sustain the core capabilities needed to address its training and exercise program priorities.

The Multi-year TEP will lay out a combination of progressively building exercises – along with the associated training requirements – which address the priorities identified in the Training and Exercise Planning Workshop (TEPW). A progressive, multi-year exercise program will enable the city to participate in a series of beneficial exercises, with each successive exercise building upon the previous one. Further, by including training opportunities in the planning process, the city can address known gaps and areas of improvement prior to exercising capabilities.

OEM will conduct at least one exercise annually to improve the overall emergency response organization and capability of the city. The exercise will test not only the EOP but also train the appropriate officials, emergency response personnel and City of Richmond employees. Dependent upon the scenario, private sector partners will be encouraged to participate. Any planning deficiencies, findings, areas recommended for corrective action or improvement arising from the exercise will be considered and corrected by appropriate training, plan update, and/or demonstration in any subsequent exercise or postulated event.

Additionally after each real-world incident, a hot wash and/or after-action review will take place. Any findings from these post-event reviews will be incorporated into an update of the plan.

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Appendix 1 – Glossary

For the purposes of the City of Richmond Emergency Operations Plan, the following terms and definitions apply:

Amateur Radio Emergency Services - Public service organization of licensed amateur radio operators who have voluntarily registered their qualifications and equipment to provide emergency communications for public service events as needed.

American Red Cross - Humanitarian organization led by volunteers, that provides relief to victims of disasters and helps prevent, prepare for, and respond to emergencies. It does this through services that are consistent with its Congressional Charter and the Principles of the International Red Cross Movement.

Area Command – Organization established to oversee the management of multiple incidents that are each being handled by an ICS organization or to oversee the management of large or multiple incidents to which several incident management teams have been assigned.

Biological Agent – Living organisms or the materials derived from them (such as bacteria, viruses, fungi and toxins) that cause disease in or harm to humans, animals or plants or cause deterioration of material.

Catastrophe (catastrophic incident) – Any natural or human caused incident, including acts of terrorism, that results in extraordinary levels of mass casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy and/or government functions.

Command Staff – In an incident management organization, the Command Staff consists of the Incident Commander and the special staff positions of the Public Information Officer, Safety Officer, and other positions as required that report directly to the Incident Commander.

Command Post - That location at which primary Command functions are executed; usually collocated with the Incident Base. Also referred to as the Incident Command Post.

Community Emergency Response Team (CERT) - Component of the national Citizen Corps program, which aims to make communities safer, stronger and better prepared through education, training and volunteer service. The Community Emergency Response Team (CERT) program trains you to prepare for and respond to emergencies in your community.

Community Recovery – The process of assessing the effects of a disaster or catastrophic event, defining resources, and developing and implementing a course of action to restore and revitalize the socioeconomic and physical structure of the community.

Consequence Management – A predominantly emergency management function that includes measures to protect public health and safety, restore essential government services and provide emergency relief to individuals, businesses and governments affected by the consequences of terrorism. (See also Crisis Management)

Continuity of Government (COG) – A process of identifying the essential functions of government, including the critical functions of government offices and departments, and developing and implementing plans to ensure the continuation of those functions in the face of disruptions from any cause.

Continuity of Operations (COOP) – A process of identifying the essential functions - including staff, systems and procedures - that ensure the continuation of the department's ability to operate.

Comprehensive Resource Management - Maximizes the use of available resources, consolidates like resources and reduces the communications load on the Incident Command Operation.

Crisis Management – A predominantly law enforcement function that includes measures to identify, acquire and plan the use of resources needed to anticipate, prevent, and/or resolve a threat or act of terrorism.

Critical Infrastructure – Systems and assets, whether physical or virtual, so vital to the community, the Commonwealth, or the nation that the incapacity or destruction of such systems and assets would have a debilitating impact on security, economic security, public health or safety, or any combination of those matters.

Decontamination – The physical or chemical process of reducing and preventing the spread of contaminants from persons and equipment used at a hazardous materials incident.

Department – A division of government with a specific function offering a particular kind of assistance.

Department Representative – A person assigned by a primary, supporting or cooperating department or nongovernmental organization or private entity who has been delegated authority, in consultation with the leadership of that department, to make decisions affecting that department's or organization's participation in incident management activities.

Emergency - Any occurrence, or threat, whether natural or man-made, which results or may result in substantial injury or harm to the population or substantial damage to or loss of property or natural resources.

Emergency Alert System (EAS) – A network of broadcast stations interconnecting facilities authorized by the Federal Communications Commission to operate in a controlled manner to inform the public of needed protective actions in the event of an emergency or disaster situation**.**

Emergency Management – The coordination of efforts to prepare for and carry out the functions to prevent, minimize, respond to and recover from incidents caused by natural hazards, man-made hazards and acts of terrorism.

Emergency Operations Center (EOC) – The physical location at which the coordination of information and resources to support incident management activities takes place.

Emergency Operations Plan (EOP) – The plans for managing all-hazards incidents. The *Code* requires the Commonwealth and its jurisdictions to prepare and maintain emergency operations plans.

Emergency Responder – Includes local, state and federal emergency services, public safety, law enforcement, emergency medical services (prehospital and hospital), search and rescue, fire services, and related personnel, agencies and authorities.

Emergency Services – The preparation for and carrying out of the functions to prevent, minimize and repair injury and damage resulting from natural or man-made disasters, together with all other activities necessary or incidental to the preparation for and carrying out of the forgoing functions.

Emergency Support Function (ESF) – A grouping of government and certain private and voluntary organization capabilities into an organizational structure to provide the support, resources, program implementation and services that are most likely to be needed to save lives, protect property and the environment, restore essential services and critical infrastructure, and help victims and communities return to normal, when feasible, following incidents.

Evacuation – Organized and supervised withdrawal, dispersal or removal of people from dangerous or threatened areas, and their reception and care in safe areas.

Federal Disaster Assistance - Aid to disaster victims and/or state and local governments by federal agencies under provisions of the Robert T. Stafford Relief and Emergency Assistance Act of (PL 93-288).

Federal Emergency Management Agency (FEMA) – Component of the U.S. Department of Homeland Security responsible for providing technical support to states and local governments to respond to and recover from emergencies and disasters caused by any hazard.

First Responder – Skilled personnel who in the early stages of an incident are responsible for the protection and preservation of life, property, evidence and the environment, such as government and non-governmental police, fire, emergency medical, search and rescue, emergency management, public health, public works and others.

Geographic Information System (GIS) - A computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e.- data identified according to their locations.

Hazard Mitigation – Any action taken to reduce or eliminate the long-term risk to human life or property.

Hazardous Material (hazmat) – A substance or material, including a hazardous substance that has been determined to be capable of posing an unreasonable risk to health, safety and property when released into the environment.

Incident – An occurrence or event, natural or human caused that requires an emergency response to protect life or property.

Incident Action Plan (IAP) – An oral or written plan containing general objectives reflecting the overall strategy for managing an incident.

Incident Command Post (ICP) – The field location at which the primary tactical-level, on-scene incident command functions are performed.

Incident Command System (ICS) – A standardized on-scene emergency management construct specifically designed to provide for the adoption of an integrated organizational structure that reflects the complexity and demands of single or multiple incidents. ICS is the combination of facilities, equipment, personnel, procedures and communications operating within a common organizational structure. It is designed to aid in the management of resources during incidents.

Incident Commander (IC) – The individual responsible for all incident activities. The IC has overall authority and responsibility for the management of all incident operations and is responsible for the management of all incident operations at the incident site.

Incident Management Team (IMT) – The Incident Commander and appropriate command and general staff personnel assigned to an incident.

Infrastructure – The manmade physical systems, assets, projects, and structures publicly and privately owned, that are used by or provide benefit to the public. Examples of infrastructure include utilities, bridges, levees, water systems, roads, etc.

In-kind Donations – Donations other than cash, usually materials or volunteer service, for people and communities impacted by disasters.

Integrated Flood Observing and Warning System (IFLOWS) – An information system that collects and analyzes real-time data from rain and stream gages placed throughout the City of Richmond watersheds. IFLOWS is a federal-state-local partnership that links the National Weather Service and local governments in order to provide flood alerts and warnings.

Joint Field Office (JFO*)* – A temporary federal facility established near a declared disaster area to provide a central point for federal, state, voluntary and local officials with responsibilities for incident oversight, direction and assistance.

Joint Information Center (JIC*)* – A facility established to coordinate all incident-related public information activities. It is the central point of contact for all news media for information related to the incident. Public information officials from all participating federal and state agencies will collocate at the JIC.

Joint Operations Center (JOC) – The JOC is the focal point for all federal investigative law enforcement activities during a terrorist or potential terrorist incident or any other significant criminal incident, and is the point of coordination with state and local law enforcement officials. The JOC becomes a component of the JFO when the National Response Framework (NRF) is activated.

Local Emergency – The condition declared by the local governing body when in its judgment the threat of actual occurrence of an emergency or disaster is or threatens to be of sufficient severity and magnitude to warrant coordinated local government action to prevent or alleviate the damage, loss, hardship or suffering threatened or caused thereby.

Local Emergency Planning Committee (LEPC) - Appointed representatives of local government, private industry, business, environmental groups, and emergency response organizations responsible for ensuring that localities comply with the hazardous materials planning requirements of the Superfund Amendments and Reauthorization Act of 1986 (SARA Title III).

Mitigation - Activities that actually eliminate or reduce the chance occurrence or the effects of a disaster. Examples of mitigation measures include, but are not limited to, the development of zoning laws and land use ordinances, State building code provisions, regulations and licensing for handling and storage of hazardous materials, and the inspection and enforcement of such ordinances, codes and regulations.

Mutual Aid Agreement - Written agreement between agencies, organizations and/or jurisdictions that they will assist one another on request by furnishing personnel, equipment and/or expertise in a specified manner.

National Incident Management System (NIMS) – A system mandated by the federal Homeland Security Presidential Directive (HSPD) #5 that provides a consistent, nationwide approach for governments (federal, state and local), voluntary agencies and the private sector to work effectively and efficiently together to prepare for, respond to, and recovery from incidents, regardless of cause, size or complexity. NIMS uses a core set of concepts, principles and terminology.

National Response Framework (NRF) - Is a guide to how the Nation conducts all-hazard response. It is built upon scalable, flexible and adaptable coordinating structures to align key roles and responsibilities across the nation.

National Weather Service (NWS) - The federal agency which provides localized weather information to the population, and during a weather-related emergency, to state and local emergency management officials.

Nongovernmental Organization (NGO) – A nonprofit entity that is based on interests of its members, individuals or institutions and that is not created by the government, but may work cooperatively with government. Such organizations serve the public purpose, not a private benefit.

Preparedness - As defined in the NRF, preparedness is the range of deliberate, critical tasks and activities necessary to build, sustain and improve the operational capability to prevent, protect against, respond to, and recover from incidents. Preparedness is a continuous process involving efforts by and among governments and other organizations and by the general public.

Public Information Officer (PIO) - A member of the Command Staff in the VEOC and the JFO responsible for interfacing with the public and media with incident related information.

Radio Amateur Civil Emergency Services (RACES) – An amateur radio communications system organized to provide temporary emergency communications support to federal, state, and local governments during periods of imminent or actual emergency.

Recovery – Activities that address the short-term and long-term needs and the resources to assist, restore, strengthen and rebuild affected individuals and communities.

Response – Activities that address the short-term, direct effects of an incident. Response includes immediate actions to save lives, protect property and meet basic human needs.

Stafford Act, The – *The Robert T. Stafford Disaster Relief and Emergency Assistance Act, 93 Pub. L. No.288 Stat. 143 as amended*, establishes the programs and processes for the federal government to provide disaster and emergency assistance to states, local governments, tribal nations, individuals and qualified private nonprofit organizations. The provisions cover all hazards including natural disasters and terrorist events.

State of Emergency – The condition declared by the Governor when, in his judgment, the threat or actual occurrence of an emergency or a disaster in any part of the Commonwealth is of sufficient severity and magnitude to warrant disaster assistance by the Commonwealth to supplement the efforts and available resources of the several localities and relief organizations in preventing or alleviating the damage, loss, hardship or suffering threatened or caused thereby and is so declared by him. (*Code* § 44-146.16)

Statewide Mutual Aid (SMA) – A program to assist cities, counties and eligible towns to more effectively and efficiently exchange services and resources, especially in response to a major disaster wherein assistance needs to be provided from one area or region of the state to another.

Threat –Any indication of possible violence, harm or danger.

Unaffiliated Volunteer – An individual who is not formally associated with a recognized voluntary disaster relief organization; also known as a "spontaneous" or "emergent" volunteer.

Unified Command – An application of the Incident Command System (ICS) used when there is more than one agency with incident jurisdiction or when incidents cross political jurisdictions. Agencies work together through the designated members of the Unified Command to establish their designated Incident Commanders at a single Incident Command Post.

Unsolicited Goods – Donated goods offered by or sent to the incident site by the public or a private source that have not been requested by government or nonprofit disaster relief coordinators of that incident. State and local plans include procedures to manage unsolicited goods.

VDEM – Virginia Department of Emergency Management – The state agency responsible for coordinating the preparations and actions required to prevent and minimize the impact of hazards and to respond to and recover from emergencies and disasters.

VAVOAD – Virginia Voluntary Organizations Active in Disasters – A statewide organization, affiliated with the National VOAD, composed of voluntary organizations, faith-based and sectarian, that have developed specific disaster response and/or recovery programs as part of their overall mission.

Volunteer – Any individual accepted to perform services by any agency that has authority to accept volunteer services when the individual performs services without promise, expectation, or receipt of compensation for services performed.

Appendix 2 – List of Acronyms

ARC	American Red Cross
ARES	Amateur Radio Emergency Services
CAO	Chief Administrative Officer
CDC	Center for Disease Control
CEM	Civil Emergency Message
CERT	Community Emergency Response Team
CICF	Criminal Injury Compensation Fund
COG	Continuity of Government
COOP	Continuity of Operations
COVEOP	Commonwealth of Virginia Emergency Operations Plan
DCPD	Department of Community Planning and Development
DHS	Department of Homeland Security
DIT	Department of Information Technology
DPU	Department of Public Utility
DPW	Department of Public Works
DSS	Department of Social Services
EAP	Emergency Action Plan
EAS	Emergency Alert System
ECC	Emergency Communications Center
EM	Emergency Management
EMAC	Emergency Management Assistance Compact
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
EPCRA	Emergency Planning and Community Right to Know Act
ESF	Emergency Support Function
FAC	Family Assistance Center
FEMA	Federal Emergency Management Agency
GIS	Graphic Information System
GRTC	Greater Richmond Transit Company
HHS	Health and Human Services

IA	Individual Assistance
IAP	Incident Action Plan
ICP	Incident Command Post
ICS	Incident Command System
IDA	Initial Damage Assessment
IFG	Individual and Family Grants
IMT	Incident Management Team
IFLOWS	Integrated Flood Observation and Warning System
JFO	Joint Field Office
JIC	Joint Information Center
JOC	Joint Operations Center
LEPC	Local Emergency Planning Commission
MMRS	Metropolitan Medical Response Network
MOA	Memorandum of Agreement
MRC	Medical Reserve Corps
MSA	Metropolitan Statistical Area
NCP	National Contingency Plan
NGO	Nongovernmental Organization
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NRF	National Response Framework
NWR	NOAA Weather Radio
NWS	National Weather Service
OCME	Office of the Chief Medical Examiner
OEM	Office of Emergency Management
OPS	Office of the Press Secretary
PA	Public Assistance
PDA	Preliminary Damage Assessment
PIO	Public Information Officer
PSAP	Public Safety Answering Point
RAA	Richmond Ambulance Authority
RACES	Radio Amateur Civil Emergency Services
RCHD	Richmond City Health District

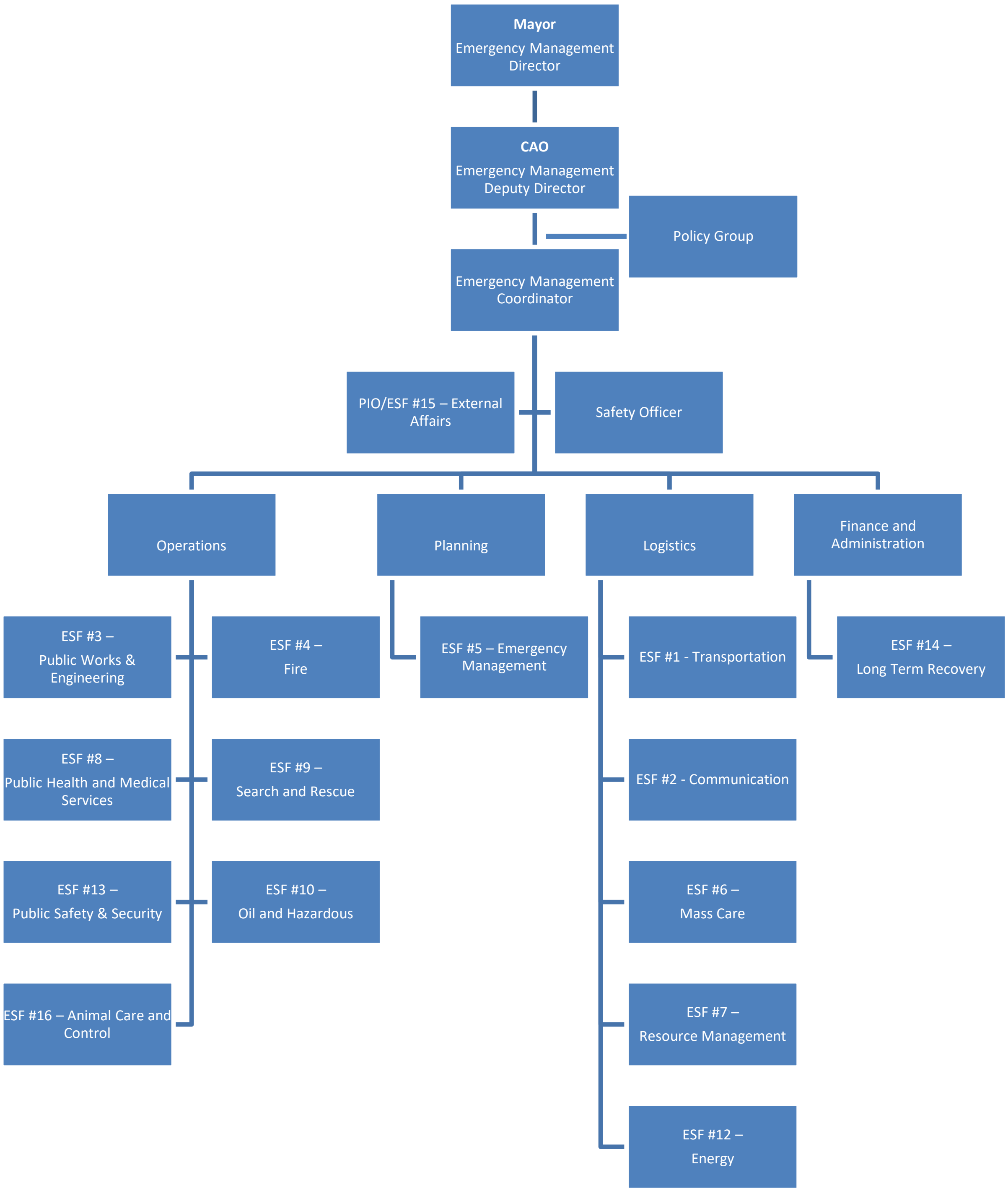
RFD	Richmond Fire Department and Emergency Services
RHMO	Regional HazMat Officer
RPD	Richmond Police Department
RPSS	Richmond Public School System
RSS	Remote Storage Site
SAR	Search and Rescue
SARA	Superfund Amendments and Reauthorization Act
SMA	Statewide Mutual Aid
SME	Subject Matter Expert
SNS	Strategic National Stockpile
SOP	Standard Operating Procedures
TEP	Training and Exercise Plan
TEPW	Training and Exercise Planning Workshop
USG	United States Government
VAVOAD	Virginia Voluntary Organizations Active in Disaster
VCAVOAD	Virginia Capital Area Voluntary Organizations Active in Disaster
VCU	Virginia Commonwealth University
VDEM	Virginia Department of Emergency Management
VDH	Virginia Department of Health
VEOC	Virginia Emergency Operations Center
VERC	Virginia Emergency Response Council
VSP	Virginia State Police
WHO	World Health Organization

Appendix 3 – Emergency Support Function Matrix

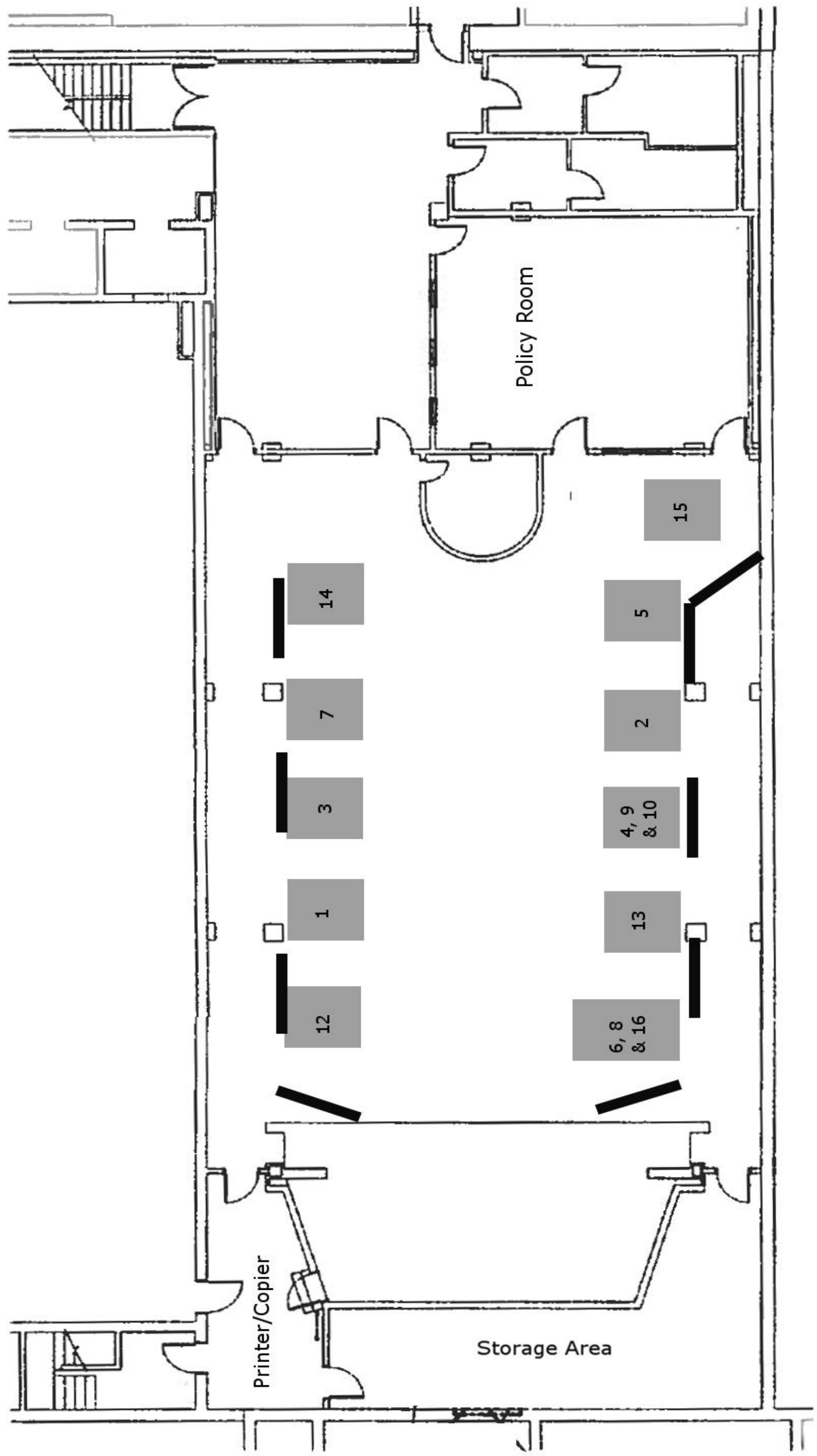
Emergency Support Function (ESF)	Scope
ESF #1 – Transportation **Primary Agencies:** Department of Public Works (Traffic Engineer), Greater Richmond Transit Company (GRTC) **Support Agencies and Organizations:** Richmond Public School System, Richmond Police Department, Port of Richmond, CSX, Amtrak, Greyhound, Private Charter Bus Companies	• Report damage to transportation infrastructure as a result of the incident • Coordinate alternate transportation services • Coordinate the restoration and recovery of the transportation infrastructure • Assist ESF #13 with evacuation of impacted areas within the City of Richmond • Coordinate traffic control measures
ESF #2 – Communication **Primary Agencies:** Department of Information Technology, Department of Emergency Communication	• Coordination with telecommunications industry • Restoration/repair of telecommunications infrastructure. • Protect, restore, and maintain cyber and information technology resources • Assist with GIS capability during EOC operations.
ESF #3 – Public Works & Engineering **Primary Agencies:** Department of Public Works, Department of Public Utilities **Support Agencies and Organizations:** Department of Planning and Development Review, Richmond City Health District, Department of Parks, Recreation and Community Facilities	• Conduct pre and post incident assessments of public facilities and infrastructure • Execute emergency contract support for life-saving and life-sustaining services • Provide technical assistance to include engineering expertise, construction management, and real estate services • Providing emergency repair of damaged infrastructure and critical facilities • Implement and manage the cost recovery programs for public works and infrastructure • Lead for debris management (including snow removal)
ESF #4 – Firefighting **Primary Agencies:** Department of Fire and Emergency Services **Support Agencies and Organizations:** Department of Public Utilities, Community Emergency Response Team (CERT), Salvation Army, American Red Cross, Fire Corps	• Manages and coordinate firefighting activities, including detection and suppression • Provide training, guidance and assistance to citizens, the private/business sector and local governments in the promulgation and maintenance of appropriate fire protection programs and systems
ESF #5 – Emergency Management **Primary Agencies:** Office of Emergency Management **Support Agencies and Organizations:** Fire and Emergency Services Department, Richmond Police Department, Department of Public Works, Department of Public Utilities, Department of Social Services, Richmond City Health District, Finance Department, Department of Information Technology, Richmond Animal Care & Control, Richmond Ambulance Authority, Richmond Sherriff's Office, Economic and Community Development, Department of Planning and Development Review	• Directs, controls and manages emergency operations • Coordinates with neighboring jurisdictions and the Virginia Emergency Operations Center • Coordinates the response of all departments within the City and the use of City resources to provide emergency response • Supports use of the Mobile Command Post
ESF #6 – Mass Care, Housing, Human Services **Primary Agencies:** Department of Social Services **Support Agencies and Organizations:** American Red Cross, Richmond City Health District, Richmond Public School Systems, Virginia Voluntary Organizations Active in Disasters, Department of Parks, Recreation and Community Facilities	• Mass care and sheltering • Temporary housing • Recovery assistance to individuals and households • Family Assistance Center
ESF #7 – Resource Management **Primary Agencies:** Department of Finance, Department of Procurement	• Resource Support (facility space, office equipment and supplies, contracting services, etc.) • Statewide Mutual Aid
ESF #8 – Public Health and Medical Services **Primary Agencies:** Richmond City Health District, Richmond Ambulance Authority	• Public health services • Medical services

Support Agencies and Organizations: American Red Cross, Capital Area Health Network, Community Emergency Response Team (CERT), Crossover Ministries, Department of Social Services, Local Hospitals and Pharmacies, Central Virginia Healthcare Coalition, Office of the Chief Medical Examiner (OCME), Richmond Academy of Medicine, Richmond Behavioral Health Authority, Richmond City Medical Reserve Corp (MRC), Richmond Public School System (RPSS), Rubicon Rehab, Inc., The Daily Planet, Virginia Department of Health (VDH), Virginia Funeral Directors' Association, Virginia Hospital and Healthcare Association, Virginia Veterinary Medical Association, Richmond Behavioral Health Authority	• Mental health services • Mortuary services
ESF #9 – Search and Rescue **Primary Agencies:** Richmond Fire and Emergency Services Department **Support Agencies and Organizations:** Richmond Police Department, Richmond Ambulance Authority, Department of Community Planning and Development, Department of Public Works, Civil Air Patrol, Volunteer Search and Rescue Groups, GIS Department, Virginia State Police, OEM, VDEM	• Rescue Company 1 – Swift Water and Dive Rescue • Rescue Company 2 – Trench Rescue, Confined Space Rescue, Structural Collapse Rescue and High Angle Rescue • Rescue Company 3 – Hazardous Materials Response (See ESF #10)
ESF #10 – Oil and Hazardous Materials **Primary Agencies:** Richmond Fire and Emergency Services Department **Support Agencies and Organizations:** Richmond City Health District	• Oil & hazardous materials (chemical, biological, radiological, etc.) response • Environmental safety and short- and long-term cleanup • Health and safety of emergency workers
ESF #12 – Energy **Primary Agencies:** Department of Public Utilities **Support Agencies and Organizations:** Dominion Virginia Power	• Energy infrastructure assessment, repair, and restoration • Energy industry utilities coordination • Energy forecast
ESF #13 – Public Safety and Security **Primary Agencies:** Richmond Police Department, Sheriff's Office **Support Agencies and Organizations:** City Security, Division of Capital Police, Federal Law Enforcement Agencies, J. Sergeant Reynolds Police Department, University of Richmond Police Department, U.S. Marshall, Virginia Commonwealth University Police Department, Virginia State Police, Virginia Union University Police Department	• Maintain law and order • Coordinate public warning • Provide security of community facilities • Control traffic under normal conditions and for special events or disruptive incidents • Provide security of unsafe areas or potential crime scenes • Assist with evacuation of buildings or the City • Provide security at City managed shelters
ESF #14 – Long Term Recovery **Primary Agencies:** Department of Economic Development, Department of Planning and Development Review **Support Agencies and Organizations:** Office of Emergency Management, Department of Social Services, Richmond Fire and Emergency Services, Department of Public Works, Department of Public Utilities, Virginia – Voluntary Organizations Active In Disasters (VAVOAD)	• Social and economic impact assessment • Long-term community recovery assistance • Coordinate reconstruction and redevelopment of impacted areas • Mitigation analysis and program implementation
ESF #15 – External Affairs **Primary Agencies:** Office of the Press Secretary **Support Agencies and Organizations:** Department of Public Utilities, Richmond Fire and Emergency Services, Richmond Police Department, Department of Public Works, Human Services, Department of Parks and Recreation, Richmond City Health District, Richmond Ambulance Authority, Amateur Radio Groups	• Coordinate the dissemination of emergency public information and protective action guidance with ESF #5 and ESF #2 • Incident information to the public • Media and community relations • Elected officials liaison
ESF #16 – Animal Care and Control **Primary Agencies:** Richmond Animal Care and Control **Support Agencies and Organizations:** Local Animal Welfare/Rescue Organizations, Local Veterinarians, Local Animal Boarding Facilities, Local Animal Crematoriums, Voluntary Organizations Active in Disaster (VOAD), Virginia Department of Agriculture and Consumer Services	• Animal care and control • Animal sheltering

Appendix 4 – Emergency Operations Center Organization Chart



Appendix 5 – Emergency Operations Center Floor Plan



Appendix 6 – Emergency Contact Telephone Numbers

Situation/Question	Number
Emergency Operations Center	804-646-0362
To request **immediate** assistance from the police, fire department or ambulance.	9-1-1
Non-emergency police number	804-646-5100
To request assistance, report a downed tree, high water on roads or for information about available resources and open shelters in your area.	3-1-1
To report strong, persistent gas odors, a major water leak in your home, or in the street, a sewer backup in your home, a broken sewer line or a streetlight that is broken or out	804-646-7000 Or 911
Senior Help Line – To assist older adults in their quest for services within city departments.	804-646-1082
To report a power outage to Virginia Dominion Power	1-866-366-4357
American Red Cross	804-780-2250

Appendix 7 – Authorities and References

- **Federal**
  - The Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288, as amended
  - The Homeland Security Act of 2002
  - National Response Framework
  - Developing and Maintaining Emergency Operations Plans; Comprehensive Preparedness Guide 101 v.2
  - Threat and Hazard Identification and Risk Assessment Guide – CPG 201
  - Presidential Policy Directive 8
  - Americans with Disabilities Act of 2010

- **State**
  - Commonwealth of Virginia Emergency Services and Disaster Law of 2000, as amended
  - The Commonwealth of Virginia Emergency Operations Plan (COVEOP) – 2012

- **Local**
  - Richmond-Crater Multi-Regional Hazard Mitigation Plan, March 2017
  - All applicable City Department Directive Manuals

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INTRODUCED: July 13, 2009

A RESOLUTION No. 2009-R90 - 103

To adopt the City of Richmond's Emergency Operations Plan in accordance with the Commonwealth of Virginia Emergency Services and Disaster Law of 2000.

Patron – Mayor Jones

Approved as to form and legality
by the City Attorney

PUBLIC HEARING: JUL 27 2009 AT 6 P.M.

WHEREAS, section 44-146.19(E) of the Code of Virginia (1950), as amended, requires the City of Richmond to conduct a comprehensive review and revision of its emergency operations plan every four years to ensure that the plan remains current; and

WHEREAS, section 44-146.19(E) of the Code of Virginia (1950), as amended, requires that the City Council formally adopt the City's emergency operations plan, as revised, every four years; and

WHEREAS, the City Administration has conducted a comprehensive review and revision of the City's emergency operations plan; and

AYES: 9 NOES: 0 ABSTAIN: ______

ADOPTED: JUL 27 2009 REJECTED: ______ STRICKEN: ______

WHEREAS, the Council believes that it is in the best interests of the citizens of the City of Richmond that the Council adopt the City's emergency operations plan as section 44-146.19(E) of the Code of Virginia (1950), as amended, provides;

NOW, THEREFORE,

BE IT RESOLVED BY THE COUNCIL OF THE CITY OF RICHMOND:

That the City of Richmond's Emergency Operations Plan, a copy of which is attached to this resolution, is hereby adopted in accordance with section 44-146.19(E) of the Code of Virginia (1950), as amended.

A TRUE COPY:
TESTE:

Lyon Brown Ali
City Clerk

INTRODUCED: NOV 2 2 2004

A RESOLUTION No. 2004-R 282-271

ADOPTED: DEC 1 3 2004

To adopt the National Incident Management System ("NIMS") established by the United States Department of Homeland Security pursuant to Homeland Security Presidential Directive HSPD-5 as the City's standard for incident management.

Patron – City Manager

Approved as to form and legality
by the City Attorney

PUBLIC HEARING: DEC 1 3 2004 AT 6 P.M.

BE IT RESOLVED BY THE COUNCIL OF THE CITY OF RICHMOND:

WHEREAS, the President of the United States of America, in Homeland Security Presidential Directive HSPD-5, directed the Secretary of Homeland Security to develop and administer a National Incident Management System ("NIMS"), which would provide a consistent nationwide approach for federal, state, and local governments to work together more effectively and efficiently to prevent, prepare for, respond to and recover from domestic incidents; and

WHEREAS, the collective input and guidance from all federal, state, and local homeland security partners has been, and will continue to be, vital to the development, effective implementation and utilization of a comprehensive NIMS; and

AYES: 9 NOES: 0 ABSTAIN: ________

REJECTED: ________ STRICKEN: ________

WHEREAS, it is necessary and desirable that all federal, state, and local emergency agencies and personnel coordinate their efforts to effectively and efficiently provide the highest levels of incident management; and

WHEREAS, in order to facilitate the most efficient and effective incident management, it is critical that federal, state and local organizations utilize standardized terminology, standardized organizational structures, interoperable communications, consolidated action plans, and unified command structures; and

WHEREAS, the NIMS standardized procedures for managing personnel, communications, facilities and resources will improve the City's ability to utilize federal funding to enhance local agency readiness, maintain first responder safety, and streamline incident management processes; and

WHEREAS, the Incident Command System components of NIMS are already an integral part of various City incident management activities, including current emergency management training programs; and

WHEREAS, the National Commission on Terrorist Attacks, also known as the 9-11 Commission, recommended adoption of a standardized Incident Command System; and

WHEREAS, it is in the best interests of the citizens of the City of Richmond that the City Council act on behalf of the City to adopt the NIMS.

NOW THEREFORE,

BE IT RESOLVED BY THE COUNCIL OF THE CITY OF RICHMOND:

That the National Incident Management System ("NIMS") established by the United States Department of Homeland Security pursuant to Homeland Security Presidential Directive HSPD-5 is hereby adopted as the City's standard for incident management.

A TRUE COPY:
TESTE:
Lana Leyo-Chavez
CITY CLERK

Appendix 10 – Virginia Criminal Injuries Contact Funds (VCICF)

In the event of an emergency when there are crime victims involved as defined by §19.2-11.01 of the Code of Virginia the City of Richmond will contact the Virginia Department of Virginia Criminal Justice Services(DCJS) and the Virginia Criminal Injuries Contact Fund(VCICF) to deploy. Both entities will serve as the lead for coordinating services and assistance to the victims.

Criminal Injury Compensation Fund

Jack Ritchie, Director, CICF
Criminal Injuries Compensation Fund (CICF) Department
Virginia Workers' Compensation Commission
1000 DMV Drive
Richmond, VA 23220
CICF Toll Free: 1-800-552-4007
Phone: (804) 367-1018
Email: Jack.Ritchie@cicf.virginia.gov
804-307-5431 (after hours)

Leigh Snellings, Acting Director, CICF (alternate)
800-552-4007 (normal business hours)
804-212-4232 (after hours)
Email: leigh.snellings@cicf.virginia.gov

Virginia Department of Criminal Justices Services

Melissa Roberson
Training and Critical Incident Response Coordinator
1100 Bank Street
Richmond, VA 23219
Phone: (804) 840-4276
Fax: (804) 786-3414

Appendix 11 – Record of Changes

Change Number	Date of Change	Page or Section Changed	Summary of Change	Name of Person Authorizing Change
1	11/13/13	Pg 36-37	Added EOC floor plan and Emergency Contact Numbers to Appendices adjusted appendix numbers to follow	Bonnie Scott
2	1/7/14	Pg 105	Updated Dominion Contact Number	Bonnie Scott
3	5/29/14	Pg 44	Updated CICF Contact Info	Steven Pyle
4	9/16/14	Pg IV	Updated Dept Director Signatory Info	Steven Pyle
5	7/21/15		ESF 12 Contact Info	Bonnie Snyder
6	1/14/16	Appendix 2	Updated Acronyms to include additional city depts	Bill Lawson
7	03/13/2017	ESF information	Met and updated all information for ESF. Included WebEOC	Bill Lawson

Change Number	Date of Change	Page or Section Changed	Summary of Change	Name of Person Authorizing Change

Appendix 12 – Plan Distribution

Mayor

Chief Administrative Officer (5)
Deputy Chief Administrative Officer – Operations
Deputy Chief Administrative Officer – Human Services
Deputy Chief Administrative Officer – Finance
Deputy Chief Administrative Officer – Community Development

Chief, Fire and Emergency Services (30)
Deputy Chief, Operations
Deputy Chief, Administration
Battalion Chief, (6)
Chief of Staff
Fire Station (20)

Chief, Police Department (9)
Deputy Chief, Operations
Deputy Chief, Administration
Deputy Chief, Support Services
Chief, Chief of Staff
Precinct (4)

City Attorney Office

Office of Press Secretary

Director of Finance

Director of Procurement

Director of Information Technology

Director of Libraries
All City Libraries (9)

Director Richmond Behavioral Health Authority

Director of Richmond City Health District

Director of Planning and Development Review

Director of Public Utilities

Director of Public Works

Director of Emergency Communications

Director of Parks, Recreation and Community Facilities

Director of Social Services

Director of Economic and Community Development

Sheriff’s Office

Richmond Ambulance Authority (3)

Richmond Public School (5)
Superintendent of Schools
Assistant Superintendent of Schools
Chief Operations Officer
Plant Services Division
Emergency Planner

Colleges and Universities (4)
J. Sergeant Reynolds Community College
University of Richmond
Virginia Commonwealth University
Virginia Union University

City Council (9)

Virginia Department of Emergency Management

Emergency Support Function #1 – Transportation

Primary Agency

- Department of Public Works (Traffic Engineer)

Support Agencies

- Greater Richmond Transit Company (GRTC)
- Richmond Public Schools
- Richmond Police Department
- Port of Richmond
- CSX
- Amtrak
- Greyhound

Purpose

Emergency Support Function (ESF) #1 – coordinates the City of Richmond's transportation resources during the response to and recovery from an actual or potential emergency.

Scope

ESF 1 (Transportation) provides transportation support to assist in incident management. This support can include, but is not limited to, the following:

- Reporting damage to transportation infrastructure as a result of the incident.
- Coordinate the restoration and recovery of the transportation infrastructure.
- Coordinate transportation services of evacuees throughout the city to include to and from a city shelter.
- Coordinate and implement traffic control/plan measures.

Concept of Operations

- Any parts of the transportation network or any facilities not fully operational due to the emergency or disaster situation should be reported. Any existing or potential factors or conditions impairing efficient operations should be identified.
- Departments shall advise ESF #1 of all transportation movements independently arranged.
- Access routes should remain clear to permit a sustained flow of emergency relief.
- All requests for transportation support will be submitted to the City of Richmond Emergency Operations Center for coordination, validation, and/or action.

- For purposes of coordination, GRTC and other support organizations may need to report to the City of Richmond Emergency Operations Center to support ESF #1 operations.
- All departments and agencies with transportation-related responsibilities will be coordinated with each other as needed in order to manage transportation resources efficiently and complete task assignments. Overall coordination is effected by ESF #1.

Organization and Assignment of Responsibilities

The City of Richmond has the overall responsibility for the management and coordination of Transportation functions. Each agency's responsibilities are as follows:

Public Works

- Develop, maintain, and update transportation plans and procedures for use during an emergency.
- Identify viable transportation routes to, from and within the emergency or disaster area.
- Coordinate with the Department of Rail and Public Transportation and railroad companies to maintain the rail system.
- Coordinate with the Virginia Port Authority and Port of Richmond to assist in restoring Port operations if damaged during an event.

Police Department

- Coordinate with ESF 1 leader to provide traffic control and evacuation coordination throughout the city as requested
    - Coordinate with Virginia State Police (VSP) on interface of evacuation between city roads and interstates.

Greater Richmond Transit Company and Richmond Public Schools

- Provide an agency representative to the EOC, as needed.
- Assist, and provide buses, as needed, in transportation of evacuated citizens to city-designated areas or facilities.
- Provide current agency situational awareness to ESF 1 leader.

Port of Richmond, CSX, Amtrak and Greyhound

- Provide an agency representative to the EOC, as needed.
- Provide current agency situational awareness to ESF 1 leader.

Attachment 1
Public Works Action Checklist

Routine Operations

- Develop and maintain this annex in coordination with all primary and support agencies.
- Prepare and maintain resource listings.
- Develop and maintain plans, policies and procedures.
- Educate drivers, staff and the public on evacuation routes.
- Maintain and update GIS maps.

Increased Readiness

- Review plans, resource listings, and procedures. Update as needed. Review applicable codes and regulations.
- When requested, provide persons with public works expertise to staff Needs Assessment Teams and Damage Assessment Teams.
- Assure that personnel and equipment are operationally ready and available.

Response Operations

Mobilization Phase

- Assemble teams and prepare for deployment.
- Procure needed supplies and arrange for logistical support. Designate potential staging areas.
- Encourage mitigation efforts such as the movement of essential equipment to high ground and the sandbagging of public works facilities.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Dispatch teams to the disaster area as needed and as requested by the EOC. Maintain communications and operational control.
- Modify traffic patterns along evacuation routes and impacted areas.
- Provide directional signs on roadways.
- Analyze Needs Assessment and Initial Damage Assessment to determine the extent of damage to transportation infrastructure and equipment.
- Clear debris from primary roads and evacuation routes.

- Coordinate with state and federal officials to provide additional manpower and equipment.

Recovery Operations

- Determine structural damage to roadways and transportation infrastructure.
- Determine re-entry routes.
- Provide traffic control support and security on re-entry routes.
- Assist in clearing debris from roadways.
- Facilitate contract arrangements.

Emergency Support Function #2 - Communications

Primary Agencies

- Department of Emergency Communications
- Department of Information Technology

Purpose

The purpose of Emergency Support Function (ESF) 2 is to assure the provision of adequate communications throughout the city in support of response and recovery operations.

Scope

Communications is information transfer and involves the technology associated with the representation, transfer, interpretation, and processing of data among persons, places and machines. It includes transmissions, emission, or reception of signs, signals, writing, images, and sounds or intelligence of any nature by wire, radio, optical, or other electromagnetic systems.

ESF 2 plans, coordinates and assists with the provision of communications support to city disaster response and recovery elements. It will also coordinate emergency warnings and communications equipment and services from neighboring localities, state agencies, military installations, the private sector and volunteer groups.

Concept of Operations

During an emergency, the City of Richmond can alert and warn with life-saving information quickly. Multiple alert mechanisms are used by the City of Richmond to provide public safety officials with an effective way to alert and warn the public of timely, pertinent information about serious emergencies from a single interface.

- Local news stations (Channels 6, 8 & 12)
- City website
- City television station
- Social Media
    - Facebook and Twitter
- Emergency Alert System (EAS) and the currently used City of Richmond emergency notification system.

The following City officials will be trained and are authorized to issue an imminent alert to the public:

- Emergency Management Director or designee
- Emergency Management Coordinator
- Public Information Officer
- Office of Emergency Management personnel
- Department of Emergency Communications Director or designee

Interoperable Communications

City of Richmond first responders use 800 MHz, trunked radio systems and thus, can communicate with surrounding localities in Central Virginia as well. Each first responder vehicle as well as the EOC has color-coded sheet which shows what channels and zones are available on their respective radios.

Emergency Communications (911) and 311 Call Center

The City of Richmond Emergency Communications Center, which operates 24 hours a day, 7 days a week, is the City of Richmond warning point (point of contact for receipt of all warnings and notification of actual or impending emergencies or disaster) and is often the first point of contact for the public.

During active incidents, the 911 Center can become inundated with an above-average call load from citizens reporting various emergencies and non-emergencies. To assist in facilitating and prioritizing calls, the Fire Department and Police Department are encouraged, if feasible, to provide a representative to the 911 Center and take calls or assist the dispatcher they are assigned to.

To alleviate call volume, citizens are encouraged to use the City's 311 Call Center for non-emergencies and general city-specific questions. Please reference ESF 15 for further information on the 311 Call Center.

Non-city resources

City departments in conjunction with public and volunteer organizations, and public/public-private partnerships can be used to support on-scene operations and to provide auxiliary communications on a local or sub-regional basis.

One example of that is Amateur Radio Emergency Services (ARES) which can provide backup communications capabilities to the City. ARES operates a VHF and UHF base station from the EOC to communicate with pertinent partners. The ARES field units may be assigned by Emergency Management to key locations such as shelters, command posts, distribution centers, government buildings, etc. ARES is also the point of contact for CB radio communications.

Organization and Assignment of Responsibilities

Information Technology

- Perform, in conjunction with Office of Emergency Management staff to perform an IT equipment check in the EOC monthly
    - Reference Appendix 1 of this annex for additional information.
- Ensure that the city maintains the ability to notify the community of an emergency or disaster through the currently approved and used method of notification system.
- Provide GIS capability and support to EOC personnel, as needed.
- Support the city with the restoration and reconstruction of telecommunications equipment, computers, and other technical assistance.

Emergency Communications (911)

- Serve as the initial warning point for all city emergencies.
- Initiate notification and warning of appropriate personnel according to the Standard Operating Procedures (SOP)
    - Ex: Notify Hazardous Materials Team Coordinator of mutual aid request.
- Develop and maintain a method of multilanguage support.

Appendix 1 – EOC Monthly IT Equipment Check

One of our most significant challenges in ensuring that the Emergency Operations Center (EOC) maintains an acceptable state of resiliency during an extended activation is in maintaining depth in the number of personnel who are capable of supporting the information technology (IT) equipment needed to operate the center. The intent of these monthly checks is to familiarize personnel with all of the hardware, software, and systems in the EOC.

Designated city personnel from Emergency Management and the Department of Information Technology (DIT) will make up the personnel teams; these teams will be responsible to conduct a monthly check of the IT equipment in the in the EOC. These teams will be assigned to complete this task on a rotating schedule that calls for each team to be responsible for the check once every 4 months. The teams will be allowed to schedule the check to accommodate the convenience of the members of the team as long as the check is completed sometime during the first week of the assigned month.

The goal of this plan is to make sure that each member of these teams has hands-on contact with the EOC IT equipment at least 3 times a year. Individuals or teams may exchange dates as long as this principle is not violated. Anyone can come for additional experience during any check.

Attachment 1
Action Checklist – Department of Information Technology

Routine Operations

- Develop and maintain this annex in coordination with all primary and support agencies.
- Prepare and maintain resource listings.
- Participate in mitigation and preparation activities.

Increased Readiness

- Review plans, resource listings, and procedures. Update as needed.
- Assure that personnel and equipment are operationally ready and available.

Response Operations

Mobilization Phase

- Procure needed supplies and arrange for logistical support.
- Encourage mitigation efforts.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Assign additional staff and resources as needed.
- marProvide technical advice and resource coordination.
- Assist the EOC in obtaining appropriate resources to restore services.

Recovery Operations

- As needed, plan for long-term recovery and restoration of services to pre-disaster levels.
- Continue to provide technical support in the recovery of facilities and services.
- Fully document all recovery actions.

Attachment 2
Action Checklist – Department of Emergency Communications

Routine Operations

- Prepare and maintain resource listings.
- Participate in mitigation and preparation activities.

Increased Readiness

- Review plans, resource listings, and procedures. Update as needed.
- Assure that personnel and equipment are operationally ready and available.

Response Operations

Mobilization Phase

- Procure needed supplies and arrange for logistical support.
- Encourage mitigation efforts.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.
-

Emergency Phase

- Assign additional staff and resources as needed.
- Support damage and needs assessment.
- Provide technical advice and resource coordination.

Recovery Operations

- As needed, plan for long-term recovery and restoration of services to pre-disaster levels.
- Continue to provide technical support in the recovery of facilities and services.
- Fully document all recovery actions.

Emergency Support Function #3 – Public Works and Engineering

Introduction

Primary Agencies:

- Department of Public Works
- Department of Public Utilities

Support Agencies and Organizations:

- Department of Planning and Development Review
- Richmond City Health District
- Department of Parks, Recreation and Community Facilities

Purpose:

Emergency Support Function (ESF) #3 – Public Works and Engineering and Department of Public Utilities - coordinates and organizes the capabilities and resources of the City of Richmond to facilitate the delivery of essential services, technical assistance, engineering expertise, construction management and operation of water and sewage treatment facilities to prevent, prepare for, respond to, and/or recover from an incident.

Scope:

ESF #3 is structured to provide support for the changing requirements of all-hazards incident management. Activities include, but are not limited to, conducting pre and post incident assessments of public facilities and infrastructure; executing emergency contract support for life-saving and life-sustaining services; providing technical assistance to include engineering expertise, construction management, and real estate services; providing emergency repair of damaged infrastructure and critical facilities; and implementing and managing the cost recovery programs for public works and infrastructure.

Concept of Operations

A. An incident may cause severe property damage. Structures may be destroyed or severely weakened. Homes, public buildings, bridges and other facilities may have to be reinforced or demolished to ensure safety. Equipment in the immediate disaster area may be damaged or inaccessible.

B. City resources may not be adequate to meet emergency requirements. The City of Richmond may need assistance with damage assessments, structural evaluations, emergency repairs to essential public facilities, stabilizing or demolishing of structures to reduce hazards, and the provision of water for human health needs and firefighting.

C. The Emergency Operations Center (EOC) will organize and deploy Damage and/or Needs Assessment Teams to any impacted communities. Time permitting, these teams can be organized and readied for deployment during the Increased Readiness or crisis buildup period.

D. Professional engineering, architectural, and preservation organizations may be available to assist. Statewide Mutual Aid (SMA), Emergency Management Assistance Compact (EMAC) and Virginia Water/Wastewater Agency Response Network (VA WARN) will be used to request additional assistance. If a City water shortage or outages is logistics related, the Virginia Department of Emergency Management (VDEM) can assist with and expedite the procurement of needed supplies, such as chlorine, pipe, or generators.

E. Access to the impacted area will be dependent upon the re-establishment of ground routes. Debris clearance and emergency road repairs will be given top priority.

F. All water-related problems will be evaluated for their impact on public health. The most serious threats to public health will be corrected first. In the absence of other guidelines, the following priorities will apply:

1. First - Provision of safe drinking water.
2. Second - Ensuring sanitary human waste disposal.
3. Third – Contain flooding.
4. Fourth - Maintaining general sanitation.

G. Water outage emergencies are caused by a failure at some point(s) within the water impounding, intake, processing and distribution system. Usually, the drinking water supply to a known service area is stopped until the facility or system break can be repaired.

H. A backup or interruption of a sewage system could cause flooding and contamination that could lead to an emergency event.

I. When a water contamination emergency is localized, the City must, in coordination with state authorities (VDH and VDEM), take action to restrict use during the emergency period.

J. The City must also restrict water use in a severe and widespread water outage or water contamination situation. If appropriate, the Governor may declare an emergency to facilitate coordinated action between state and local governments and to permit the state to provide emergency assistance to supplement local efforts

J. All departments should continue to monitor the activities of their personnel when they have an emergency assignment. Accurate records must be maintained of all disaster related expenses in order to receive any potential disaster reimbursement aid.

Organization and Assignment of Responsibilities

A. The Department of Public Works will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Direct and coordinate all public works mitigation, response and recovery strategies leading up to, during, and following a disaster situation.
2. Coordinate resource allocation to support damage assessment and provide technical support.
3. Provide the necessary equipment and resources needed to address the incident.
4. Identify and activate private contractors and procurement procedures, as needed.
5. Identify and prioritize debris removal.
6. Post appropriate signage to address road closures and closed buildings.

B. The Department of Public Utilities will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Direct and coordinate all water and sewer mitigation, response, and recovery strategies leading up to, during, and following a disaster situation.
2. Coordinate resource allocation to support damage assessment and provide technical support.
3. Identify and address essential water needs (potable water).
4. Implement appropriate measures regarding the efficient utilization and distribution of limited water resources (conservation measures).
5. Maintain and enforce regulatory standards for the treatment and disposal of waste, as necessary.
6. Assess and restore flood protection and control facilities.
7. Develop and maintain plans and procedures to address water-related emergency situations to include provisions for repairing system failures quickly and for mandatory conservation in the event of water shortages.
8. Keep the EOC informed about the status of any potential or occurring water system-related problem in the City and recommend appropriate actions, such as an emergency declaration, when necessary.
9. Assist the EOC in identifying and obtaining needed resources to supplement the supply of safe drinking water and ensure sanitation.
10. Provide the required interface with state and federal agencies during emergency operations.
11. Determine the potential impact of the disaster on water and waste water systems.

C. The Department of Planning and Development Review will provide the following services as appropriate. They, too, will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Provide technical assistance in the identification, evaluation, stabilization, rehabilitation, and/or demolition of buildings and facilities.
2. Assess and develop strategies to protect, stabilize, and restore buildings and facilities of historic significance.

3. Assist in the management and coordination of emergency contracting services.
4. Ensure that all construction and redevelopment complies with the appropriate building codes, zoning and land use regulations, as well as local and regional comprehensive plans.
5. Assess existing building codes and standards and recommend revisions to mitigate future damage.
6. Develop procedures to effectively license and monitor the work of building contractors.
7. Develop procedures to effectively process the large number of building permits which may be required.

The Department of Parks, Recreation and Community Facilities will provide the following services as appropriate. They too will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Coordinate resource allocation to support damage assessment and provide technical support.
2. Develop and maintain plans and procedures to support debris removal.

Tab 1 to Emergency Support Function #3
Action Checklist – Department of Public Works

Routine Operations

- Develop and maintain this annex in coordination with all primary and support agencies.
- Prepare and maintain resource listings.
- Designate individuals with public works expertise to serve on Needs Assessment Teams and Damage Assessment Teams.
- Pre-identify critical public works facilities.
- Develop procedures about how to effectively manage and coordinate emergency contracting services.

Increased Readiness

- Review plans, resource listings, and procedures. Update as needed. Review applicable codes and regulations.
- Establish liaison with the EOC.
- When requested, provide persons with public works expertise to staff Needs Assessment Teams and Damage Assessment Teams.
- Assure that personnel and equipment are operationally ready and available.

Response Operations

Mobilization Phase
- Assemble teams and prepare for deployment.
- Procure needed supplies and arrange for logistical support. Designate potential staging areas.
- Encourage mitigation efforts such as the movement of essential equipment to high ground.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase
- Dispatch teams to the disaster area as needed and as requested by the EOC. Maintain communications and operational control.
- Review recovery procedures and resources listings. Update as needed.
- Analyze Needs Assessment and Initial Damage Assessment to determine the extent of damage to public works facilities and equipment.
- Clear debris from primary roads and other essential facilities.
- Coordinate with state and federal officials to provide additional manpower and equipment as needed to bring essential public works facilities back on line.

Recovery Operations

- Provide appropriate oversight to emergency repairs to critical infrastructure and to debris clearance and management.
- Assist in clearing debris and restoring public works facilities and equipment.
- Facilitate contract arrangements.
- Assure the implementation of codes and regulations as required.
- Make permanent repairs to damaged facilities, implementing improvements and mitigation measures, if appropriate.

Tab 2 to Emergency Support Function #3

Action Checklist – Department of Public Utilities
Water Supply and Wastewater Treatment, Floodwall and Storm Water

Routine Operations

- Plan for emergency water and wastewater operations.
- Train personnel to quickly coordinate the repair of damages to the DPU systems and infastructure.
- Participate in mitigation and preparation activities.

Increased Readiness

- Start documenting all actions.
- Identify key personnel for assignment to response and assessment duties.
- Provide technical advice as requested for the protection of the DPU systems and infrastructure.
- Review emergency response plans.

Response Operations

Mobilization Phase

- Determine the potential severity of event impacts and prepare appropriate response actions.
- Expedite administrative procedures to allow rapid deployment of personnel when needed.
- Encourage mitigation efforts such as the movement of essential equipment to high ground.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Coordinate activities with other key infrastructure response departments
- Assign additional staff and resources as needed.
- Support damage and needs assessment.
- Provide technical advice and resource coordination to deal with DPU systems and infrastructure.
- Assist the EOC in obtaining appropriate resources to restore services.
- Assist ESF #15 in the development and dissemination of public information relating to DPU systems and infrastructure.

Recovery Operations

- As needed, plan for long-term recovery and restoration of services to pre-disaster levels.
- Continue to provide technical support in the recovery of facilities and services.
- Fully document all recovery actions.

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Emergency Support Function #4 - Firefighting

Introduction

Primary Agency:

- Richmond Fire and Emergency Services Department

Support Agencies and Organizations:

- Community Emergency Response Teams (CERT)
- Fire Corps
- American Red Cross
- Salvation Army

Purpose:

Emergency Support Function (ESF) #4 – Firefighting - enables the detection and suppression of fires resulting from or occurring coincidentally with an incident.

Scope:

ESF #4 manages and coordinates firefighting activities, including detection and suppression and provides resource support to firefighting operations.

ESF #4 addresses three priorities: (1) life safety (for the public and response personnel); (2) incident stabilization; and (3) property conservation consistent with the tenets of the Incident Command System (ICS) outlined by the National Incident Management System (NIMS).

Concept of Operations

A. The City of Richmond Fire and Emergency Services Department provides firefighting equipment, personnel, resources, and technical expertise to prevent, control, and suppress structure fires within the City.

B. Should outside assistance be required, it is normally obtained through the implementation of mutual aid agreements with neighboring jurisdictions. Should a fire situation exceed all locally-available capabilities, the City may request additional support through the Virginia Emergency Operations Center (VEOC).

C. The City of Richmond's firefighting capabilities should be maintained in accordance with established standards such as those enumerated in the NIMS.

D. Firefighting units operating in their normal territory will continue their normal internal command relationship. Command relationships and control in operations under mutual aid agreements are in accordance with the terms of such agreements and should reflect expectations delineated in the NIMS and the National Response Framework (NRF). Where there are no mutual aid agreements, all firefighting units and organizations responding from other jurisdictions to support tactical operations should report to the operational Incident Commander for assignment. During firefighting operations, the Incident Commander will regularly appraise the appropriate local officials, to include the Coordinator of Emergency Management of all resources committed to operational assignments, including use of external and mutual aid resources.

E. Fire personnel who are not otherwise engaged in emergency response operations may assist in warning and alerting the public, evacuation, and communications as is necessary and appropriate during an emergency situation.

F. The Coordinator of Emergency Management in coordination with the Incident Commander and the Chief Administrative Officer (CAO) will determine the need to evacuate and issue orders for evacuation or other protective action as needed. The Incident Commander may order an immediate evacuation prior to requesting or obtaining approval, if in his/her judgment this action is necessary in order to safeguard lives and property. Warning and instructions will be communicated through the appropriate means.

Organization and Assignment of Responsibilities

A. The Fire and Emergency Services Department will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Develop and maintain plans and procedures to provide fire and rescue services in time of emergency.
2. Carry out the provisions of this annex and prepare and maintain supporting plans and SOPs to support this annex.
3. Provide available equipment, water supply, etc. to support suppression operations.
4. Provide available personnel for fire suppression operations.
5. A fire representative will be assigned to the EOC in order to coordinate the fire service response. The fire representative will be a part of the EOC staff and will assist with the overall direction and control of emergency operations.
6. Assist with any needed evacuations.
7. Follow established procedures in responding to fires and hazardous materials incidents and in providing rescue services.

Tab 1 to Emergency Support Function #4
Action Checklist

Routine Operations

- Encourage all employees to develop and maintain plans for personal and family disaster preparation.
- Each station develops and maintains Disaster Supply Cache.

Increased Readiness

- Start documenting all actions.
- Identify key personnel for assignment to response and assessment duties.
- Review emergency response plans.
- Initiate conditional readiness tests for all response equipment.

Response Operations

Mobilization Phase

- Conduct last minute checks of in-station preparations, ensuring all personnel are familiar with the on-site disaster plan.
- Suspended routine administrative operations so all personnel can be assigned to emergency roles.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Coordinate activities with other key infrastructure response departments.
- Prioritization and staffing of ancillary equipment determined.
- Based on the type of event, determine if the normal response matrix needs to be altered.
- Assign additional staff and resources as needed.
- Support damage and needs assessment.
- Assist the EOC in obtaining appropriate resources to restore services.

Recovery Operations

- As needed, plan for long-term recovery and restoration of services to pre-disaster levels.
- Continue to provide technical support in the recovery of facilities and services.
- Fully document all recovery actions.

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Emergency Support Function #5 – Emergency Management

Introduction

Primary Agencies:

- Chief Administrative Office
- Office of Emergency Management

Support Agencies and Organizations:

- Fire and Emergency Services Department
- Richmond Police Department
- Department of Public Works
- Department of Public Utilities
- Department of Emergency Communications
- Department of Social Services
- Richmond City Health District
- Finance Department
- Department of Information Technology
- Richmond Animal Care & Control
- Richmond Ambulance Authority
- Richmond Sherriff's Office
- Economic and Community Development
- Department of Planning and Development Review

Purpose:

Emergency Support Function (ESF) #5 – directs, controls and manages emergency operations to include coordinating with neighboring jurisdictions and the Virginia Emergency Operations Center.

Scope:

ESF #5 coordinates the response of all the departments within the City and the use of City resources to provide emergency response. Coordination can include, but is not limited to, the following:

- Identifying actions to be taken in the pre-incident prevention phase.
- Communicating with additional internal and outside agencies and organizations when capabilities are exceeded.
- Identifying post-incident response phase activities.
- Facilitating information management and requests for assistance.

Concept of Operations

A. The City must be prepared to bear the initial impact of a disaster on its own. Help may not be immediately available from the State or Federal governments after a natural or man-made disaster.

B. ESF #5 will act as the liaison for the City between state and federal agencies.

C. In the event a disaster occurs in the City of Richmond, where incident management or incident command capabilities have been exceeded, ESF #5 will support the overall coordination of resources through the activation of the Emergency Operations Center (EOC).

D. The Director of Emergency Management or designee, with support from key local officials, will exercise direction and control from the EOC during disaster operations. The EOC may be partially, or fully, staffed depending on the size of the disaster.

E. Each department or agency assigned ESF responsibilities will develop emergency operating procedures for providing personnel, resources and services as required to support the Plan.

F. All reasonable attempts will be made to use any available warnings to prepare the population, property and supplies from the effects of an impending emergency.

G. Day-to-day functions that do not contribute directly to the response to or recovery from the emergency may be suspended for the duration of the event.

H. Requests for assistance will be made through the VDEM Regional Coordinator/Virginia EOC to the State Coordinator.

Organization and Assignment of Responsibilities

The Office of Emergency Management, in coordination with the CAO, will provide the following services as appropriate. They will perform tasks as required by the event and their own initiative and authorities as applicable:

1. Maintain a notification roster of EOC personnel and their alternates.
2. Establish a system and procedure for notifying EOC personnel.
3. Coordinate mutual aid agreements with neighboring jurisdictions and applicable relief organizations.
4. Work with ESF #15 to maintain plans and procedures for providing timely information and guidance to the public in time of emergency.
5. Review emergency plans and procedures of key facilities and private organizations within the community.
6. Test, train to, and exercise the Plan and associated procedures.
7. Conduct outreach and mitigation programs for the City.
8. Define and encourage hazard mitigation activities to help reduce the impact of disasters.
9. Maintain emergency communications through the established communications network.

10. Provide reports and requests for assistance to the Virginia EOC.
11. Develop and maintain the Emergency Operations Plan (EOP) pursuant to §3.2 44-146 of the Code of Virginia.
12. In instances when there are criminal victims as defined by Code of Virginia §19.2-11.01, the City of Richmond, ESF #13 must contact the Department of Criminal Justice Services and the Virginia Criminal injury Compensation Fund immediately.

Tab 1 to Emergency Support Function #5
Action Checklist

Routine Operations

- Manage training and disaster preparedness activities.
- Manage federal and state emergency preparedness grant awards.
- Develop mutual support agreements with adjacent jurisdictions and with relief organizations, such as the non-governmental agencies.
- Develop plans and procedures for providing timely information and guidance to the public in time of emergency.
- Test and exercise plans and procedures with periodic exercises and drills. Review plans and provide training as indicated by test or exercise results.

Increased Readiness

- Brief Director of Emergency Management or Designee
- Discuss EOC setup with Department of Information Technology Management. If necessary, set up the EOC.
- Review emergency plans and procedures and update if necessary. Ensure the operational capability of the EOC facility and alert on-duty personnel.
- Alert appropriate department heads and/or designated department representatives of the situation and assure that appropriate mitigation and preparedness measures are being taken. Review the functional annexes in the EOP.
- Provide information relevant to EOC activation to prepare ESF staff.
- Begin to provide periodic reports internal and external via conference calls and emails.
- Prepare to provide emergency information to the public (ESF #15)
- Create incident in WebEOC.

Response Operations

Mobilization Phase

- Brief the Director of Emergency Management or Designee.
- Make recommendation to Director of Emergency Management or Designee to activate the EOC. Staff the EOC as required.
- Provide logistical support to on-site emergency response personnel.
- Conduct a meeting of department heads/or designated department representatives. Review actions already taken and expedite those necessary to conduct in-the-field mitigation and preparedness activities.
- If appropriate, via ESF #15, coordinate and disseminate emergency information and protective action guidance to the public.
- Establish and maintain communication with the Virginia EOC and neighboring jurisdictions. As necessary, provide daily situation report to the Virginia EOC.
- If situation warrants, coordinate the local emergency declaration.

- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Direct and coordinate emergency operations center activities.
- Provide situational awareness to Director of Emergency Management or Designee.
- Provide situation reports and requests for assistance to the Virginia EOC as the situation requires.
- Ensure that an accurate record of expenses and assisting resources is maintained.
- As appropriate, ensure that an initial damage assessment is completed and forwarded to the Virginia EOC within the established timeline.

Recovery Operations

- Continue to provide situational awareness to Director of Emergency Management or Designee.
- Coordinate the restoration of essential facilities and services.
- Identify needs of citizens and provide assistance as required.
- Continue to maintain a record of disaster related expenditures.
- Coordinate activities with the Virginia EOC. Provide supplementary damage assessment information as required. Request post-disaster assistance if appropriate.
- Continue to provide information to the public about on-going recovery efforts via ESF # 15.

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Emergency Support Function #6 – Mass Care, Housing, Human Services

Introduction

Primary Agencies:

- Department of Social Services

Support Agencies and Organizations:

- American Red Cross
- Department of Parks, Recreation and Community Facilities
- Richmond City Health District
- Richmond Public School System
- Virginia Voluntary Organizations Active in Disaster
- Richmond Behavioral Health Authority

Purpose:

Emergency Support Function (ESF) #6 - Mass Care, Housing, and Human Services - addresses the non-medical mass care, housing, and human services needs of individuals and/or families impacted by natural and/or technological incidents.

Scope:

ESF #6 promotes the delivery of services and the implementation of programs to assist individuals, households and families impacted by potential or actual incidents. This service delivery includes immediate relief, short-term housing and relocation assistance and direct financial services for individuals impacted by an incident within the City of Richmond. The three primary components of ESF #6 - Mass Care, Housing, and Human Services - are described below.

Mass Care

- *Coordination.* Bring together the non-medical human services of government and non-government organizations.

- *Shelter.* An emergency shelter is an immediate short-term accommodation either (1) designated by local officials for persons threatened by or displaced by an incident or (2) designated by state officials directing a mandatory evacuation across jurisdictional boundaries either before or after an incident. Public emergency shelters will provide accommodations for all population groups. Appropriate provisions must be made within the shelter facilities to accommodate people with access and functional needs that do not require hospital admission, people without their own transportation, and registered sex offenders. **Additionally, sheltering for pets and service animals must be included in planning and coordinated with ESF #16 *(Refer to ESF #16 for details regarding pet and animal sheltering).***

- *Feeding.* Feeding is provided to disaster victims and emergency workers through a combination of fixed sites, mobile feeding units, and bulk distribution of food. Feeding is based on sound nutritional standards and to the extent possible includes meeting the requirements of victims with special dietary needs.

- *Emergency First Aid.* Emergency first aid, consisting of basic first aid and referral to appropriate medical personnel and facilities, is provided at mass care facilities and at designated sites. Provision for services is coordinated with ESF #8.

- *Reunification Services.* This service collects information regarding individuals residing within the affected area and makes the information available to immediate family members outside the affected area. The system also aids in reunification of family members within the affected area.

- *Bulk Distribution.* Emergency relief items, limited to urgent needs, are distributed through sites established within the affected area. These sites are used to coordinate the distribution of food, and water to people living in areas where the normal supplies and distribution system are temporarily disrupted.

Housing

The ESF #6 housing function involves monitoring the need and availability of housing units to use temporarily for displaced people. The housing function is coordinated with ESF #14.

Human Services

The ESF #6 human services component coordinates various government and nongovernmental organizations that implement programs and provide services for people impacted by the disaster. These services may include:

- Provision of behavioral health services.
- Services to expedite benefit claims and financial assistance applications.
- Case management.
- Distribution of donated goods.
- Direct support services such as building clean-up, debris removal and family services.
- In large disasters, a Family Recovery Center may be established to provide a central location for the seamless delivery of services across multiple government and nongovernmental voluntary organizations.

Concept of Operations

A. The DSS is designated the lead agency for ESF #6 and maintains overview of ESF #6 activities, resolves conflicts, and responds to ESF #6 questions. The RPSS, ARC and VCAVOAD assist in the coordination of sheltering and feeding operations.

B. The City of Richmond may request assistance from non-governmental organizations to assist with ESF #6 functions.

C. As resources are exceeded, the City of Richmond may request assistance from the state.

D. Initial response activities focus on meeting urgent mass care needs of victims.

E. Recovery efforts are initiated concurrently with response activities. Close coordination is required among those agencies responsible for response operations and recovery activities, and other nongovernmental organizations providing assistance.

F. Medical care, long-term assisted living, mental health and residential facilities including prisons are responsible for developing and implementing plans for their patients/residents in an evacuation. Facility management should consult with the City of Richmond in the development of plans.

Organization and Assignment of Responsibilities

A. The Department of Social Services will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Development, maintenance and updates to plans and procedures for use during an emergency.
2. Maintaining education and training for personnel assigned to staff shelters.
3. Makes recommendations to open shelters.
4. Open and staff City of Richmond shelter(s).
5. Coordinate resource allocation to support shelter operations.
6. Coordinate activity to support the homeless community.
7. Provide follow-up services and financial assistance to impacted citizens.

B. The American Red Cross will provide the following services as appropriate. They will perform tasks as requested by the DSS and under their own initiative and authorities as applicable:

1. Maintaining education and training for personnel.
2. Assist the City of Richmond with shelter operations.

C. The Department of Parks, Recreation and Community Facilities will provide the following services as appropriate. They too will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. When necessary, coordinate with the Department of Social Services regarding available facilities for use as shelters.
2. Maintaining education and training for personnel.

D. The Richmond City Health District will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. When necessary, coordinate with the Department of Social Services regarding available medical staff for shelters.
2. Maintaining education and training for personnel.

E. The Richmond Public School System will provide the following services as appropriate. They will perform tasks as requested by the DSS and under their own initiative and authorities as applicable.

1. Coordinate with the Department of Social Services regarding available facilities for use as shelters.
2. When necessary, provide additional means of transportation for evacuation of impacted citizens.
3. Maintaining education and training for personnel.

Tab 1 to Emergency Support Function #6
Action Checklist

Routine Operations

- Develop plans and procedures to receive and care for evacuees.
- Designate shelter center(s). Determine maximum capacities for each.
- Designate shelter manager(s) and other key personnel.
- Review and update plans and procedures.

Increased Readiness

- Confirm task assignments and alert key personnel to stand-by status.
- Prepare the necessary forms.
- Anticipate and resolve special problems, such as receiving nursing home patients, closing of schools, etc.
- Begin record keeping of disaster related expenses and continue for the duration of the event.

Response Operations

Mobilization Phase

- Activate the shelter or activate agreements for other lodging, as required.
- Coordinate mass transportation, as required.
- Receive and care for evacuees/displaced persons. Register and maintain accurate records on their status. Provide mass feeding, as required.
- Provide status reports to the EOC.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Continue to receive and care for displaced persons until reentry to the impacted area(s) is granted. Provide mass feeding, as required.

Recovery Operations

- Provide long-term housing and care, as needed.
- Consolidate and report disaster-related expenses.

Emergency Support Function #7 – Resource Management

Introduction

Primary Agencies

- Department of Finance
- Department of Procurement Services

Purpose

Emergency Support Function (ESF) #7 – Resource Management - manages resources in support of the City of Richmond prior to, during, and/or after an incident in coordination with other ESFs in the Emergency Operations Center (EOC). “Resource Management” refers to logistics, people, places and things.

Scope

Resource management consists of emergency relief supplies, facility space, office equipment, office supplies, telecommunications, contracting services, transportation services, security services, and personnel required to support immediate response activities. ESF #7 provides support for requirements not specifically identified in other ESFs, including excess and surplus property. Resource management will continue until the disposition of excess and surplus property, if any, is completed. ESF #7 responds to resource needs by looking first to the resources of neighboring jurisdictions and the state, then to commercial contracts and finally to federal resources.

Concept of Operations

A. ESF #7 – Resource Management – Available resources are the Department of Procurement Services and the Risk Management and Accounts Payable/Receivable Divisions of the Department of Finance.

B. The City of Richmond will use its own resources and equipment during incidents and will maintain control over the management of the resources as needed to respond to the situation. If additional assistance is required, the City will request assistance from the Virginia EOC in accordance with the Virginia Department of Emergency Management’s Request Management Standard Operating Procedure through the Richmond Emergency Operations Center.

C. Each department with an emergency function is responsible for identifying its resources, including human resources that could be used in an emergency.

D. Individuals involved in distributing and/or obtaining resources will be aware of emergency procurement policies and have the authority to do so in an emergency situation.

Organization and Assignment of Responsibilities

A. The Department of Procurement Services, in coordination with the Department of Finance, will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Provide cost code information and guidance in support of disaster operations.
2. Manage contracts for disaster goods and services and work with city agencies to establish contracts for resources that might be needed for the event.
3. Identify policies and personnel responsible for supporting resource procurement and payment.
4. Provide cost tracking, property claims, documentation and recovery support to city departments.

Tab 1 to Emergency Support Function #7
Action Checklist

Routine Operations

- Maintain staff training financial and procurement systems.
- Identify actual or potential facilities and ensure they are ready and available to receive, store, and distribute resources.

Increased Readiness

- Confirm task assignments and alert key personnel.
- Anticipate initial requirements based on hazard analysis, historical data and forecasted intelligence.
- Provide service code for the event at earliest possible moment.

Response Operations

Mobilization Phase

- Transition to the Emergency Operations Center (EOC) for ESF #7 Operations.
- Provide contact information to ESF #5 for 24 hour operations.
- Using ICS Form 214, begin tracking all disaster-related expenditures and continue to do so for the duration of the event.

Emergency Phase

- Provide emergency procurement support as requested.
- Assign additional staff and resources as needed.
- All agencies should exhaust their own channels of support before turning to ESF #7.

Recovery Operations

- Provide cost tracking, property claims, documentation and recovery support to city departments.
- Fully document all recovery actions.

Tab 2 to Emergency Support Function #7
Emergency Procurement Procedures

Emergency Procurement
An emergency procurement may be approved by the DPS Director in accordance with City Code Section 21-39 (Emergency Purchases). The following are the circumstances described in City Code:

(1) A breakdown or failure of machinery or other equipment has occurred;
(2) A curtailment, diminution or termination of an essential service is threatened; or
(3) A dangerous condition has developed and that a procurement is: a) needed to prevent loss of life or property; b) essential to protect and preserve the interests of the City and its inhabitants; c) needed to maintain the proper functioning of the City government; or, d) needed to maintain the efficient rendering of public services.

Under the above circumstances, immediate action to obtain goods and/or services is permissible without recourse to competitive sealed bidding or competitive negotiations. However, competition should be sought to the extent practicable under the circumstances.

Department/Agency – Must conduct advance planning and preparation for emergencies. Some emergency events can be reasonably anticipated and managed, such as snow storms and hurricanes. Supplies needed to effectively manage such events should be stocked and available as necessary. However, if goods and services are needed and necessary, departments/agencies should coordinate with DPS as practicable under the circumstances. In the alternative, departments/agencies must ensure the procurement meets the requirements stated in City Code (e.g., needed to prevent loss of life or property), and obtain competition the extent practicable under the circumstances. If the department/agency makes the emergency procurement, the department/agency must submit an approved requisition and draft justification for Emergency Procurement to DPS within two (2) business days after the City resumes normal business operations.

Procurement – Upon receipt for the approved requisition and draft emergency justification, DPS will work directly with the department/agency to review and properly complete the Emergency Procurement justification. Once the draft justification is in final form, the department/agency will obtain the required signatures as directed by DPS.

Emergency Support Function #8 – Public Health and Medical Services

Introduction

Primary Agencies:

- Richmond City Health District (RCHD)
- Richmond Ambulance Authority (RAA)

Support Agencies and Organizations:

- American Red Cross
- Capital Area Health Network
- Crossover Ministries
- Department of Social Services
- Regional Healthcare Coordinating Center (RHCC)
- Office of the Chief Medical Examiner (OCME)
- Richmond Academy of Medicine
- Richmond Behavioral Health Authority
- Richmond City Medical Reserve Corp (MRC)
- Richmond Public School System (RPSS)
- The Daily Planet
- Virginia Department of Health (VDH)
- Virginia Funeral Directors' Association
- Virginia Hospital and Healthcare Association
- Virginia Veterinary Medical Association

Purpose:

Emergency Support Function (ESF) #8 – Public Health and Medical Services – provides the mechanism for coordinated assistance in response to public health and medical care needs. Coordination of mass fatality management operations is included, when appropriate.

Scope:

ESF #8 identifies and meets the public health and medical needs of victims of an incident. This support is categorized in the following core functional areas:

- Assessment of public health/medical needs (including behavioral health)
- Public health surveillance
- Medical care personnel
- Medical equipment and supplies
- Emergency Medical Services
- Environmental health monitoring and response

- Mass fatality management
- Patient evacuation
- Patient care
- Safety and security of drugs
- Food safety
- Behavioral health care

Concept of Operations

A. RCHD and RAA provide overall direction and coordination of activities performed under ESF #8.

C. During a threatened or actual emergency public health and medical care needs will be coordinated from the City of Richmond Emergency Operations Center by the RCHD and RAA. State assistance will be requested when emergency or disaster needs exceed the City of Richmond's capabilities.

D. Plans and procedures for the RCHD and supporting agencies define the roles of agencies and support organizations in mitigation and preparedness, response and recovery from a disaster or major emergency. They establish the concepts and policies under which all elements of their agency will operate during emergencies. They provide the basis for more detailed appendices and procedures that may be used in an emergency response.

E. RCHD has assigned emergency response and recovery duties and responsibilities as well as developed the VDH required all hazards plan(s) which contains more detailed procedures as needed, to include increased readiness action checklists and specific reporting requirements.

F. The RCHD maintains plans and procedures for management of mass fatalities under its jurisdictional authority for the state. Those plans and procedures work in conjunction with the Office of the Chief Medical Examiner (OCME) mass fatality management plan for deaths under Medical Examiner jurisdiction. The Commonwealth's subject matter expert (SME) in mass fatality management, the OCME provides written guidance on mass fatality management operations for deaths resulting from a naturally occurring disease outbreak, as well as natural and manmade disasters. The fatalities are the responsibility of the City of Richmond.

G. The RCHD and RAA have collaborated with local hospitals and the medical care system to address medical surge as a product of a disaster or emergency resulting in a large number of casualties. Additionally, planning efforts address a surge in medical supplies and equipment.

H. ESF #8 holds quarterly meetings to support ongoing planning efforts.

Organization and Assignment of Responsibilities

A. The Richmond City Health District will coordinate the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Prevention of disease, to include surveillance and investigation of diseases and other conditions, implementation of intervention measures and environmental and water quality response.
2. Coordinate provision of Strategic National Stockpile (SNS), medical supplies, equipment and dispensing of life-saving pharmaceuticals.
3. Mass patient care including prehospital emergency medical services.
4. Emergency mental health services including crisis counseling.
5. Mass fatality management operations and coordination to include post mortem disease surveillance, death scene management operations, forensic examinations and collections, victim identification services and ante mortem data collection with oversight provided by the OCME.
6. Provide guidance and technical assistance regarding emergency evacuation of people with special medical needs.
7. Assessment of public health and medical needs to include the needs of at-risk population groups such as language assistance services for limited English-proficient individuals and accommodations and services for individuals with disabilities.
8. Assist with the planning for and coordination of transporting seriously ill or injured patients and medical needs populations from casualty collection points in the impacted areas to designated reception facilities, as needed.
9. Together with ESF #6 (Mass Care), ESF# 9 (Search and Rescue), and ESF # 15 (Animal Care and Control) ensure an integrated response to provide for the safety and well-being of household pets and service and companion animals.

B. Richmond Ambulance Authority will coordinate the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Patient evacuation in cooperation with federal, state and private organizations.
2. Assist state and federal responders with a coordinated response in support of emergency triage and pre-hospital treatment, patient tracking, and distribution.
3. Technical assistance regarding emergency evacuation of people with special medical needs.

Tab 1 to Emergency Support Function #8
Action Checklist

Routine Operations

- Develop and maintain procedures for providing a coordinated response.
- Maintain a roster of key officials in each medical support area.
- Establish a working relationship and review emergency roles with the local hospitals and EMS agencies.

Increased Readiness

- Start documenting all actions.
- Review and update emergency response plans.
- Begin ICS planning process
- Identify and disseminate Public Health Information in coordination with ESF 15.

Response Operations

Mobilization Phase

- Alert personnel.
- Implement mutual aid agreements, if necessary.
- Aid in the development of the Incident Action Plan by providing timely information to ESF #5.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Coordinate medical, health and emergency medical services with the EOC.
- Obtain crisis augmentation of health/medical personnel and supplies as needed.
- Assist the EOC in obtaining appropriate resources to restore services.
- Provide health services such as testing food and controlling communicable diseases, as required.

Recovery Operations

- Maintain records and monitor the status of persons injured during the emergency.
- Assist the State Medical Examiner's Office in the identification and disposition of the deceased.
- Continue to provide technical support in the recovery of facilities and services.
- Fully document all recovery actions.

Tab 2 to Emergency Support Function #8
Hospitals, Clinics, and Medical Facilities

Hospitals

Bon Secours Richmond Community
1500 N. 28th St
Richmond, VA
804-225-1700

Children's Hospital of Richmond
2924 Brook Road
Richmond, VA 23220
804-321-7474

CJW-Chippenham
7101 Jahnke Road
Richmond, VA
804-320-3911

HealthSouth Rehabilitation Hospital
5700 Fitzhugh Ave
Richmond, VA 23226
(804) 288-5700

Kindred Hospital
2220 Edward Holland Drive
Richmond, VA 23230
804-678-7000

Retreat Hospital
2621 Grove Ave.
Richmond, VA 23220
804-254-5100

VCU Health System
1250 E. Marshall St.
Richmond, VA
804-828-9000

McGuire Veteran's Affairs Hospital
Hunter Holmes McGuire
VA Medical Center
1201 Broad Rock Blvd
Richmond, VA 23249
Phone: (804) 675-5000

Vernon J. Harris Medical Center
719 N 25th St
Richmond, VA 23223-6539
(804) 780-0840

Clinics

Richmond City Health District
400 E.Cary Street
Richmond, VA 23219
804-205-3500

Rubicon Rehab Center
2000 Mecklenburg St.
Richmond, VA 23223
(804) 359-3255
Fax (804) 359-5137

VCU Stony Point Clinic
9000 Stony Point Parkway
Richmond, VA 23235
804-628-2374

VCU Stony Point Surgery Center
8700 Stony Point Pkwy.
Suite 220
Richmond, VA 23235
Phone: 804-323-0830
Fax: 804-323-0829

VCU Massey Cancer Center
401 College Street, P.O. Box 980037
Richmond, Virginia 23298-0037
Phone: (804) 828-0450 Fax: (804) 828-8453

Hayes E. Willis Center of South Richmond (VCU)
4730 Southside Plaza St.
Richmond, Va. 23224

Nelson Clinic (VCU)
401 N. 11th Street
Richmond, VA 23298

VCU Sleep Disorder Center
2529 Professional Road
Richmond, VA 23235
ph: 804-323-2255
fx: 804-323-2262

VCU Sports Medicine
1300 W. Broad Street
Suite 113
Richmond, VA 23284
804.828.0713

VCU 10th Street Clinic
500 North 10th Street
Richmond, VA
(804) 646 - 6855

Community Health Centers

The Daily Planet
517 West Grace Street
Richmond, VA 23220
t 804.783.0678
f 804.783.2514

Capital Area Health Network CAHN
Main Office - Vernon J. Harris Medical Center
719 N. 25th Street
Richmond, VA 23223
Medical Tel: 804.780.0840
Medical Fax: 804.780.0862
Dental Tel: 804.253.1972
Dental Fax: 804.253.1998

CAHN Northside
2809 North Ave. Suite 206
Richmond, VA 23222
Tel: 804. 525.1800
Fax: 804.525.1811

CAHN Shockoe Bottom
2025 East Main Street
Richmond, VA 23223
Tel: 804.591.2890
Fax: 804.591.2895

The Healing Place
700 Dinwiddie Ave.
Richmond, VA 23224

Children's Health Involving Parents (CHIP) of Richmond
2922 W. Marshall Street
Richmond VA 23220
TEL (804) 233-2850/FAX (804) 233-3443

Planned Parenthood of Richmond
201 N Hamilton Street
Richmond, VA 23221
P: 804.355.4358

Richmond Regional Behavioral Health Authority
107 South Fifth Street
Richmond, Virginia 23219
Phone: (804) 819-4000
Crisis Services: (804) 819-4100

Crossover Ministry
108 Cowardin Ave
Richmond, VA 23224
Phone: 804.233.5016
Fax: 804.231.5723

Richmond Private Methadone Clinic
Substance Abuse Services
4926 West Broad Street
Richmond VA 23230
Phone: (804) 673-5241

Recovery Center of Richmond
Substance Abuse Services
9323 Midlothian Turnpike Suite S
Richmond VA 23235
Phone: (804) 560-5400
Hotline: (804) 560-5400

Richmond Healthy Start Initiative
900 E. Marshall Street, B-2 Level
Richmond, VA 23219

Virginia Premier
600 E. Broad Street., Suite 400
Richmond, VA 23219
804-819-5151

ChildSavers
200 North 22nd St.
Richmond, VA 23233
804-644-9590

Clinical Alternatives, P.C.
5412-F Glenside Drive
(Ph) 804-282-5880
(Fx) 804-288-2029

Commonwealth Catholic Charities
1512 Willow Lawn Dr.
Richmond, VA 23230
804-545-5907

Medical Home Plus, Inc.
8719 Forest Hill Ave.
Bon Air, VA 23235
804-330-5030

Emergency Support Function #9 - Search and Rescue

Introduction

Primary Agency:

- Richmond Fire and Emergency Services Department

Support Agencies and Organizations:

- Richmond Police Department, including Fixed Wing Unit
- Richmond Ambulance Authority
- Department of Community Planning and Development
- Department of Public Works
- Civil Air Patrol
- Volunteer Search and Rescue Groups
- GIS Department
- Virginia State Police

Purpose:

Emergency Support Function (ESF) #9 – Search and Rescue (SAR) - rapidly deploys to provide specialized lifesaving assistance during any type of incident. Search and Rescue activities include locating, accessing, stabilizing, and transporting lost, missing, stranded or trapped subjects to a place of safety or another provider within the chain of the emergency response system.

A Search and Rescue incident can occur regardless of a declared emergency and implied consent is assumed unless the missing person declines rescue or treatment.

Scope:

The Fire Department integrates a broad range of technical specialists into three rescue companies that specialize in different types of rescue.

- Water Rescue Task Force
- Technical Rescue Task Force
- Hazardous Materials Task Force

Concept of Operations

A. SAR missions may occur as the result of a wide-area, natural or man-made disaster in which case, the SAR operation(s) may be one aspect within the whole of an emergency. More frequently however, SAR operations occur as a single, geographic point specific incident. Regardless of the cause or size of the incident, SAR operations are conducted to affect the rescue and/or recovery of overdue, lost, missing, stranded, injured, or trapped persons or overdue, missing, disabled, stranded, or sinking vessels.

B. The Fire and Emergency Services Department is the primary agency during most SAR operations. RPD assists with perimeter security, communications, and personnel resources as necessary.

D. RAA, RPD and DPW, DCPD may assist in structural evaluation of buildings and infrastructure. DPW and GIS may assist with equipment, maps, staff and vehicles.

Organization and Assignment of Responsibilities:

A. The Fire and Emergency Services Department will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Development and maintenance of plans and procedures to implement search and rescue operations in time of emergency.
2. Provide emergency medical treatment and pre-hospital care to the injured.
3. Assist with the warning, evacuation and relocation of citizens during a disaster.
4. Management of search and rescue task force deployment to, employment in, and redeployment from the affected area.
5. Coordinate logistical support for search and rescue during field operations.
6. Development of policies and procedures for effective use and coordination of search and rescue.
7. Provide status reports on search and rescue operations throughout the affected area.

Tab 1 to Emergency Support Function #9
Action Checklist

Routine Operations

- Develop and maintain plans and procedures to implement search and rescue operations in time of emergency.
- Train personnel to quickly coordinate a Search and Rescue mission.

Increased Readiness

- Alert the on-duty personnel.
- Determine availability of special team members.

Response Operations

Mobilization Phase

- Review and update plans and procedures.
- Alert personnel to stand-by status.
- Check rescue and communications equipment.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Follow established procedures in providing rescue services, emergency medical treatment and pre-hospital care to the injured.
- Continue to assist with warning and alerting, evacuation, communications as well as any other emergency response operation, as required.

Recovery Operations

- Continue to provide essential services, as required.
- Continue search and rescue operations, if required.
- Provide resources for recovery operations.
- Assist with the inspection of damaged facilities, if applicable.
- Recover equipment and return it to service, replace where necessary.
- Compile and submit records of incurred disaster related expenses.

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Emergency Support Function #10 - Oil and Hazardous Materials

Introduction

Primary Agency:

- Richmond Fire and Emergency Services Department

Support Agencies and Organizations:

- Richmond City Health District

Purpose:

RFES is the primary agency to respond to oil and hazmat emergencies. Their responsibility is to identify the hazard and take steps to stop the issue and mitigate any further contamination to the environment. Hazardous materials are defined under Virginia Law (Title 44-146.34) as: substances or materials which may pose unreasonable risks to health, safety, property, or the environment when used, transported, stored or disposed of, which may include materials which are solid, liquid, or gas. Hazardous materials may include toxic substances, flammable and ignitable materials, explosives, corrosive materials, and radioactive materials.

Scope:

The Local Emergency Planning Commission (LEPC) develops and maintains the *Hazardous Materials Response Plan* which serves as the basis for all actions taken by Emergency Support Function #10 – Oil and Hazardous Materials Response. ESF #10 provides for coordinated and directed support in response to an actual or potential discharge and/or uncontrolled release of oil or hazardous materials during incidents.

ESF #10 includes the appropriate response and recovery actions to prepare for, prevent, minimize, or mitigate a threat to public health, welfare, or the environment caused by actual or potential oil and hazardous materials incidents. Appropriate response and recovery actions can include efforts to detect, identify, contain, clean-up or dispose of related oil and hazardous materials.

ESF #10 coordinates the division and specification of responsibilities among on-site response organizations, personnel, and resources and state agencies that may be used to support response actions. ESF #10 is applicable to all departments and organizations with responsibilities and assets to support response to actual or potential oil or hazardous materials incidents. ESF #10 may also coordinate with private entities as appropriate.

In addition, ESF #10 may be used to respond to actual or threatened releases of materials not typically considered hazardous under the National Contingency Plan (NCP) but that, as a result of an incident, pose a threat to public health or welfare or to the environment.

Concept of Operations

A. The Local Emergency Planning Commission (LEPC) *Hazardous Materials Response Plan* serves as the basis for all actions taken by ESF #10.

B. All oil and hazardous materials releases will be reported to the Virginia Emergency Operations Center (VEOC).

Organization and Assignment of Responsibilities:

See the LEPC *Hazardous Materials Response Plan.*

Tab 1 to Emergency Support Function #10
Action Checklist

Routine Operations

- Develop and maintain plans and procedures to implement HAZMAT operations in time of emergency.
- Train personnel to quickly coordinate a HAZMAT response.

Increased Readiness

- Alert the on-duty personnel.
- Determine availability of special team members.

Response Operations

Mobilization Phase

- Review and update plans and procedures.
- Alert personnel to stand-by status.
- Check response and communications equipment.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Follow established procedures in providing HAZMAT response.
- Continue to assist with warning and alerting, evacuation, communications as well as any other emergency response operation, as required.

Recovery Operations

- Continue to provide essential services, as required.
- Provide resources for recovery operations.
- Assist with the inspection of damaged facilities and/or infrastructure, if applicable.
- Recover equipment and return it to service, replace where necessary.
- Compile and submit records of incurred disaster related expenses.

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Emergency Support Function #12 - Energy

Introduction

Primary Agency:

- Department of Public Utilities

Support Agencies and Organizations:

- Dominion Virginia Power

Purpose:

Emergency Support Function (ESF) #12 – Energy supports restoration of damaged energy systems and components, to include natural gas and street lights, during a potential or actual incident.

Scope:

ESF #12 collects, evaluates, and shares information on energy system damage and estimations on the impact of energy system outages within affected areas. Additionally, ESF #12 provides information concerning the energy restoration process such as projected schedules, percent completion of restoration, geographic information on the restoration, and other information as appropriate.

The incident may impact the community only or it may be part of a larger incident that impacts the locality or the region. In the latter cases, the City of Richmond will follow its plans, policies and procedures, but ensure that regional and state plans are also followed.

Concept of Operations

A. The Department of Public Utilities maintains a list of critical facilities and continuously monitors those resources to identify vulnerabilities.

B. Restoration of power for normal operations at critical facilities will be a priority.

C. The supply of electric power to customers may be cut off due to either generation capacity shortages and/or transmission/distribution limitations.

D. Other energy shortages, such as interruptions in the supply of natural gas or other petroleum products for transportation and industrial uses, may result from extreme weather, strikes, international embargoes, disruption of pipeline systems, or terrorism.

E. The suddenness and devastation of a catastrophic disaster or other significant event can sever key energy lifelines, constraining supply in impacted areas, or in areas with supply links to impacted areas, and can also affect transportation, communications, and other lifelines needed for public health and safety. There may be widespread and prolonged electric power failures. Without electric power, communications will be interrupted, traffic signals and street lights will not operate, and surface movement will become grid-locked. Such outages may impact public health and safety services. Thus, a major, prolonged energy systems failure could be very costly and disruptive.

F. In the wake of such a major disaster, available state-level assets will be used to assist with emergency efforts to provide fuel and power and other essential resources as needed.

G. While restoration of normal operations at energy facilities is the primary responsibility of the owners of those facilities; ESF #12 provides the appropriate supplemental assistance and resources to enable restoration in a timely manner. Collectively, the primary and support agencies that comprise ESF #12:

- Serve as the focal point within the City for receipt of information on actual or potential damage to energy supply and distribution systems and requirements for system design and operations, and on procedures for preparedness, prevention, recovery, and restoration.
- Advise authorities on priorities for energy restoration, assistance, and supply.
- Assist with requests for emergency response actions as they pertain to energy supplies.
- Assist by locating fuel for transportation, communications, and emergency operations.
- Recommend actions to conserve fuel and electric power.

Organization and Assignment of Responsibilities

The Department of Public Utilities will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Provide for the health and safety of individuals affected by the event.
2. Comply with local and state actions to conserve fuel, if needed.
3. Coordinate with ESF #15 to provide energy emergency information, education, and conservation guidance to the public.
4. Coordinate with local, state, and federal officials and energy suppliers about available energy supply recovery assistance.
5. Relay information from Dominion Virginia Power regarding customers without power and restoration timelines to ESF #5.
6. Send requests through ESF #5 to the state EOC for fuel and power assistance, based on current policy.
7. Coordinate regionally if the power outage affects an area beyond the City of Richmond.

Tab 1 to Emergency Support Function #12
Action Checklist

Routine Operations

- Plan for emergency operations.
- Train personnel to quickly coordinate the repair of damages to DPU’s system.
- Participate in mitigation and preparation activities.

Increased Readiness

- Start documenting all actions.
- Identify key personnel for assignment to response and assessment duties.
- Provide technical advice as requested for the protection of the energy systems.
- Review emergency response plans.

Response Operations

Mobilization Phase

- Place personnel on emergency shifts.
- Check equipment and supplies.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Respond to utility calls.
- Bring damaged DPU facilities back on line as soon as possible.
- Assist with clean-up operations when possible.

Recovery Operations

- As needed, plan for long-term recovery and restoration of services to pre-disaster levels.
- Continue to provide technical support in the recovery of facilities and services.
- Fully document all recovery actions.

Tab 2 to Emergency Support Function #12

Utility Providers

Utility Provider	Address	Contact Person	Phone Number(s) & 24-Hour Contact
Dominion	701 E. Cary St. Richmond VA 23219	Jennifer Kostyniuk	Office-804-755-5591 Cell-804-310-4776 Report outages 866-356-4357
Dominion	Regional Operations Center		1-800-826-1027
City of Richmond Natural Gas & Streetlights	400 Jefferson Davis Highway Richmond, VA 23224	Al Scott	Office-804-646-8307 Cell-804-690-5167

Emergency Support Function #13 - Public Safety and Security

Introduction

Primary Agencies:

- Richmond Police Department
- Richmond Sherriff's Office

Support Agencies and Organizations:

- Division of Capital Police
- Federal Law Enforcement Agencies
- J. Sergeant Reynolds Police Department
- University of Richmond Police Department
- Virginia Commonwealth University Police Department
- Virginia State Police
- Virginia Union University Police Department

Purpose:

Emergency Support Function (ESF) #13 – Public Safety and Security – Provides public safety and security capabilities as well as necessary resources to support the full range of incident management associated with potential or actual events.

Scope:

ESF #13 coordinates and provides law enforcement, public safety and security support capabilities and resources during potential or actual events. ESF #13 supports incident management requirements including personnel and critical infrastructure protection, security planning and technical assistance and public safety in pre and post event situations. This support includes but is not limited to the following actions:

- Maintaining law and order
- Coordinating public warning
- Providing security of community facilities
- Controlling traffic when necessary
- Providing security of unsafe areas or potential crime scenes
- Assisting with evacuation of buildings or the City
- Providing security at City managed shelters

Concept of Operations

A. Through ESF #13, state or other law enforcement resources – when requested or required – are integrated into the incident command structure using National Incident Management System (NIMS) principles and protocols.

B. In the event of an emergency or disaster, the RPD will follow the procedures outlined in the *Richmond Police Department Emergency Plan,* published separately.

C. There is sufficient latitude to allow the on-site supervisor to tailor the emergency operational plan to a specific operation. If needed, other law enforcement agencies will supplement manpower and resources. RPD personnel operating in a disaster situation will utilize the Department's supplies and equipment.

D. Mutual Aid Agreements will be recognized and utilized to the utmost of their capabilities.

E. Law enforcement responsibilities for Search and Rescue are addressed in ESF #9.

F. The Office of Emergency Management is the point of contact for the receipt of all warnings and notifications of actual or impending emergencies or disasters.

G. ESF #13 uses several existing procedures, in the form of department directives, which provide the basis of response:

- General Order 07-13, Active Shootings, Active Threats, Hostage and/or Barricaded Subject Situations
- General Order 206-2, Reporting Acts of Terrorism & Hate Crimes
- General Order 502-7, Radioactive/Hazardous Materials
- General Order, 901-1A, Police Communications – Radio Operations
- General Order 1101-1, Emergency Plan and Responses

Organization and Assignment of Responsibilities

The Richmond Police Department, in collaboration with the Sherriff's Office, will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Maintain police intelligence capability to alert government agencies and the public to potential threats.
2. Develop strategies to effectively address special emergency situations that may require distinct law enforcement procedures, such as civil disorders, hostage taking, weapons of mass destruction, terrorist situations, and bomb treats/detonations.
3. Test primary communications systems and arrange for alternate systems, if necessary.
4. Assist with the implementation of the evacuation procedures for the threatened areas, if necessary.
5. Provide traffic and crowd control as required.

6. Provide security and law enforcement to critical facilities and supplies as well as the Emergency Operations Center, evacuated areas and shelters.
7. Implement existing mutual aid agreements with other jurisdictions, if necessary.
8. Document expenses.
9. Evacuation and access control of threatened areas.
10. Assist with identification of the dead.
11. Maintain communication with RPD ECC if operational.

Tab 1 to Emergency Support Function #13
Action Checklist

Routine Operations

- Develop and maintain plans to provide for effective law enforcement, prompt warning and evacuation, traffic and crowd control, search and rescue and the security of vital facilities and supplies.
- Identify essential facilities and develop procedures to provide for their security and continued operation in time of emergency.
- Develop procedures for promptly warning the public of an emergency, using any means necessary and available.
- Develop procedures for warning and evacuating residents with special needs.
- Identify potential evacuation routes in the event of a major emergency situation.
- Develop strategies to effectively address special emergency situations that may require distance law enforcement procedures.
- Review and update plans and procedures.

Increased Readiness

- Assign emergency duties and provide specialized training as needed.
- Delineate the specific areas which may need to be evacuated and designate evacuation routes.
- Alert personnel to standby status.

Response Operations

Mobilization Phase

- Alert all personnel and special facilities, as required.
- Test primary communications systems and arrange for alternate systems, if necessary.
- Implement evacuation procedures for the threatened areas, if necessary.
- Provide traffic and crowd control, as required.
- Implement necessary security.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Dispatch teams to the disaster area as needed and as requested by the EOC. Maintain communications and operational control.
- Secure the site.
- Assist with search and rescue operations, as needed.
- Implement mutual aid agreements, if necessary.
- Provide traffic and crowd control.
- Assist with providing protective action guidance.

Recovery Operations

- Complete necessary post-event investigations.
- Support clean up and recovery operations, as required.
- Assist with identification of the dead, if necessary.
- Complete disaster related expense records for services provided.

Tab 2 to Emergency Support Function #13

ENTRY PERMIT TO ENTER RESTRICTED AREAS

1. Reason for entry (if scientific research, specify objectives, location, length of time needed for study, methodology, qualifications, sponsoring party, NSF grant number and date on separate page). If contractor/agent--include name of contractual resident party, attach evidence of right of interest in destination. Resident: Purpose.

   ____

   ____

2. Name, address, and telephone of applicant, organization, university, sponsor, or media group. Also contact person if questions should arise.

   ____

   ____

3. Travel (fill out applicable sections; if variable call information to dispatcher for each entry)

   Method of Travel (vehicle, aircraft) ____

   Description of Vehicle/Aircraft Registration ______________________________________

   Route of Travel if by Vehicle ____

   Destination by legal location or landmark/E911 address ____________________________

   ____

   Alternate escape route if different from above _____________________________________

   ____

4. Type of 2-way radio system to be used and your base station telephone number we can contact in emergency (a CB radio or radio telephone will not be accepted). Resident: cellular or home number. _

   ____

   Entry granted into hazard area.

   Authorizing Signature ________________________________Date _____________

The conditions for entry are attached to and made a part of this permit. Any violation of the attached conditions for entry can result in revocation of this permit.

The Waiver of Liability is made a part of and attached to this permit. All persons entering the closed area under this permit must sign the Waiver of Liability before entry.

Tab 3 to Emergency Support Function #13

WAIVER OF LIABILITY

(TO BE SIGNED AND RETURNED WITH APPLICATION FORM)

I, the undersigned, hereby understand and agree to the requirements stated in the application form and in the safety regulations and do further understand that I am entering a (high) hazard area with full knowledge that I do so at my own risk and I do hereby release and discharge the federal government, the Commonwealth of Virginia and all its political subdivisions, their officers, agents and employees from all liability for any damages or losses incurred while within the Closed Area.

I understand that the entry permit is conditioned upon this waiver. I understand that no public agency shall have any duty to attempt any search and rescue efforts on my behalf while I am in the Closed or Restricted Area.

Signatures of applicant and members of his field party Date

Print full name first, then sign.

____

I have read and understand the above waiver of liability.

____

I have read and understand the above waiver of liability.

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Emergency Support Function #14 – Long Term Recovery

Introduction

Primary Agencies:

- Department of Economic Development
- Department of Planning and Development Review

Support Agencies and Organizations:

- Office of Emergency Management
- Department of Social Services
- Richmond Fire and Emergency Services
- Department of Public Works
- Department of Public Utilities
- Virginia – Voluntary Organizations Active In Disasters (VVOAD)

Purpose:

Emergency Support Function (ESF) #14 - Long Term Recovery - provides a framework to facilitate both short term and long term recovery from a disaster. The recovery process begins with an impact analysis of the incident and support for available programs and resources then expands to the coordination of programs that assist with the comprehensive economic, social, and physical recovery and reconstruction of the City. Both short term and long term efforts focus on recovery, but also on reducing or eliminating risks and losses from future incidents.

Scope:

ESF #14 support will vary depending on the magnitude and type of incident and the potential for long-term and severe consequences.

Concept of Operations

A. The Mayor and CAO, in collaboration with the Coordinator of Emergency Management, will direct recovery efforts for the City.

B. ESF #14 will begin the recovery process for any disaster with the implementation of short term disaster relief programs by non-governmental organizations.

C. The strategy for long term recovery should encompass, but not be limited to, land use, public safety, housing, public services, transportation services, education, business and industry, employment, health care, natural and cultural resources, non-government service providers and financial continuity and accountability.

D. Long-term recovery and mitigation efforts are forward-looking and market-based, focusing on permanent restoration of infrastructure, housing, and the local economy, with attention to mitigation of future impacts of a similar nature, when feasible.

E. Partnership with federal agencies will be based on the type, extent, and duration of the event and long-term recovery period, and on the availability of federal resources.

F. Federal agencies may be requested to continue to provide recovery assistance under independent authorities to the state and local governments; the private sector; and individuals, while coordinating activities and assessments of need for additional assistance.

Organization and Assignment of Responsibilities

The Department of Economic Development, in collaboration with the Department of Planning and Development Review, will provide the following construction related services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Assess the social, economic and environmental consequences in the impacted area and coordinate state and Federal efforts to address long-term community recovery issues.
2. Partner with disaster assistance agencies to implement short term recovery programs for private individuals and businesses as well as public services authorities and certain non-profit organizations.
3. Advise on the long-term recovery implications of response activities and coordinate the transition from response to recovery in field operations.
4. Work with non-governmental organizations (NGOs) and private-sector organizations to conduct comprehensive market disruption and loss analysis and develop a market-based comprehensive long term recovery plan.
5. Identify appropriate programs and agencies to support implementation of the long-term recovery plan, ensure coordination, and identify gaps in available resources.
6. Avoid duplication of assistance, coordinate to the extent possible program application processes and planning requirements to streamline assistance, and identify and coordinate resolution of policy and program issues.
7. Determine and identify responsibilities for recovery activities, including emergency permitting.
8. Provide a method to maintain continuity in program delivery among all support agencies, and other involved parties, to ensure follow through of recovery and hazard mitigation efforts.

Tab 1 to Emergency Support Function #14
Action Checklist

Routine Operations

- Participate in related training and exercises to assist in the development and maintenance of disaster response capabilities.

Increased Readiness

- Alert key personnel.
- Anticipate initial requirements based on hazard analysis, historical data and forecasted intelligence.
- Begin notification to damage assessment personnel

Response Operations

Mobilization Phase

- Transition to the Emergency Operations Center (EOC) for ESF #14 Operations.
- Expedite administrative procedures to allow rapid deployment of personnel and resources when needed.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Assign additional staff and resources as needed.

Recovery Operations

- As needed, plan for long-term recovery and restoration of services to pre-disaster levels.
- Fully document all recovery actions.

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Emergency Support Function #15 – External Affairs

Introduction

Primary Agency:

- Office of the Press Secretary

Support Agencies or Organizations:

- Department of Public Utilities
- Richmond Fire and Emergency Services
- Richmond Police Department
- Department of Public Works
- Human Services
- Department of Parks and Recreation
- Richmond City Health District
- Richmond Ambulance Authority
- Amateur Radio Groups

Purpose:

Emergency Support Function (ESF) #15 – External Affairs - provides accurate, coordinated, and timely information to affected audiences, including elected officials, media, the private sector, and the local populace.

Scope:

ESF #15 coordinates actions to provide external affairs support to incident management prior to, during and following an emergency or disaster.

Concept of Operations

A. As the primary agency, the Office of the Press Secretary (OPS) is the lead for External Affairs.

B. During normal operations, the OPS coordinates with the news media and others as needed to promote emergency preparedness.

C. In time of emergency, the OPS will coordinate the release of information on emergencies and disasters. The OPS will coordinate all such information with the Emergency Management Coordinator.

D. When a disaster is impending or occurs, the augmented External Affairs staff will be positioned in the Emergency Operations Center (EOC), which has a designated area equipped for this function. The staff may also be asked to provide PIO support in the field at the disaster site.

E. All agencies and organizations are responsible for providing the OPS with appropriate timely information about the incident and actions needed to save lives and protect property.

F. Joint Information Center (JIC) may be activated, if the situation warrants. The JIC will likely be at an off-site location. Agencies involved will staff telephones and coordinate media activities under the supervision of the OPS.

G. In the event that the OPS is unable to or lacks the capability to perform these responsibilities, the state may coordinate with the City of Richmond to provide vital health and safety information to the affected population.

H. Amateur radio operators will provide the secondary communications means for citywide direction and coordination of emergency/disaster operations.

Organization and Assignment of Responsibilities:

The Office of the Press Secretary will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Develop and conduct public information programs for community/citizen awareness of potential disasters, as well as personal protection measures for each hazard present.
2. Develop Rumor Control Procedures.
3. Preparation of advance copies of emergency information packages for release through the news media during actual emergencies.
4. Briefing of news media personnel and city officials on External Affairs policies, plans, and procedures.
5. Maintenance of current lists of radio stations, television stations, cable companies, websites, and newspapers to be utilized for public information releases.
6. Maintenance of support agreements and liaison arrangements with other agencies and the news media, if needed.
7. Maintenance of arrangements to provide a briefing room for the media in the vicinity of the EOC or at the location of the disaster.
8. Assistance with the preparation/transmission of Emergency Alert System (EAS) messages, if needed.
9. Dissemination of news releases.
10. Dissemination of information to elected officials.
11. Monitor the media, to include social media, ensuring accuracy of information and correcting inaccurate information as quickly as possible.
12. Providing information to the public about available disaster relief assistance and mitigation programs.

Tab 1 to Emergency Support Function #15
Action Checklist

Routine Operations

- Establish a working arrangement with local radio and TV stations and the newspapers.
- Encourage local media to periodically publish general information about the specific hazards which are most likely to occur.
- Prepare and provide general information as appropriate to special needs groups.
- Develop and review pre-scripted emergency alert messages.
- Regularly post emergency preparedness information on the City website.
- Distribute emergency information via the city's Twitter account.

Increased Readiness

- If applicable, monitor national and state level news coverage of the situation.
- Prepare locally unique, supplementary published informational news releases and keep them updated to reflect the current emergency situation.
- Evaluate the situation. Release additional information when it is determined the public has a "need to know."

Response Operations

Mobilization Phase

- Disseminate emergency public information to the local news media.
- Confirm activation of the designated phone number and personnel to handle citizen inquiries.
- Confirm the readiness of generators at local Emergency Alert System (EAS) radio stations.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Develop accurate and complete information regarding incident cause, size, current situation and resources committed.
- Continue to keep the public informed and recommend protective actions.
- Handle rumor control, if necessary.

Recovery Operations

- Keep the public informed about local recovery operations.
- Assist the Health District in disseminating public health notices, if necessary.
- Assist state and federal officials in disseminating information concerning relief assistance.

Tab 2 to Emergency Support Function #15
Available Communication Methods

During emergencies, it is especially important that the public be kept informed of available resources, dangerous conditions, and the city is making to the situation. In order to communication with citizens, the City of Richmond will use a variety of communication methods, to include, but not limited to the following:

Geocast - an external Communication/Notification System

- GIS-based emergency communications software housed in the Division of Emergency Communications (911 Center)
- Accessed via the Internet, Geocast allows the city to quickly alert local homes and business of impending emergency situations
- Can serve as a public outreach tool providing information to specific neighborhoods within the city
- Examples of when Geocast may be used:
    - Due to a recent fire, firefighters will be in the area distributing smoke detectors
    - There have been a string of robberies in the area. Please be sure to lock your doors, stay aware and contact the Police Department if you witness any suspicious activity.
    - Evacuation or shelter in place information

Self Registration Portal (SRP)

- The SRP will allow citizens to register to receive emergency information via text messages to their mobile phone
- Examples of the type of information citizens may receive:
    - Weather Watches and Warnings
    - Information about emergency shelters
- Free service, but citizen's wireless carrier may charge a fee to receive messages
- Once live, citizen's will be able to register online

Local Media Outlets

- Television
- Radio

Social Media

- Facebook
- Twitter

Tab 3 to Emergency Support Function #15

Use of Television During Emergency Situations

In addition to using other media outlets, television should be used to disseminate information as follows:

- Government Access Bulletin Board – The government access city cable channel. Through use of a character generator, messages can be typed onto the screen and broadcast through the cable company’s facility.

Tab 4 to Emergency Support Function #15

Use of Emergency Notification System During Emergency Situations

The City has an Emergency Notification System at its disposal for use during an emergency event. The system is capable of sending an outgoing message to land lines, either to all numbers within the City or to a limited geographic area. The system can also communicate with alternate devices such as cell phones or other wireless devices.

The system is intended for use only in instances of actual, identifiable threat to life or property. Any department wishing to utilize the system must request such use through the Emergency Management Coordinator, who in concert with the OPS and the requesting department(s), do the following:

1. Determine whether the request constitutes an appropriate emergency use of the system.
2. Craft an appropriate message.
3. Determine the appropriate geographic or demographic limitations for distribution.
4. Determine whether supplemental resources from the system vendor should be used to expedite message delivery.
5. Activate the notification.

Emergency Support Function #16 - Animal Care and Control

Introduction

Primary Agency:

- Richmond Animal Care and Control

Support Agencies and Organizations:

- Local Animal Welfare/Rescue Organizations
- Local Veterinarians
- Local Animal Boarding Facilities
- Local Animal Crematoriums
- Virginia Capital Area Voluntary Organizations Active in Disaster (VCAVOAD)
- Virginia Department of Agriculture and Consumer Services

Purpose:

Emergency Support Function (ESF) #16 - Animal Care and Control - coordinates and organizes the capabilities and resources of the City of Richmond to facilitate response to and recovery from an event impacting the health, safety and welfare of animals.

Scope:

ESF #16 provides rapid response to emergencies affecting the health, safety and welfare of animals. Animal care and control activities in emergency preparedness, response, and recovery include, but are not limited to, companion animals, facility usage, displaced pet assistance, animal owner reunification, and carcass disposal.

Concept of Operations

A. As the ESF #16 lead, Richmond Animal Care and Control works with several other ESFs in the EOC structure to assist with the response to and recovery from an emergency involving animals.

B. Richmond Animal Care and Control, in concert with the Office of Emergency Management, is responsible for developing and implementing the necessary management policies and procedures that will facilitate and ensure a safe, sanitary and effective animal care and control effort. These procedures will support and expedite emergency response operations, as well as maximize state and federal assistance. In addition, these plans and procedures define the roles of agencies and support organizations in preparedness for, response to and recovery from an animal emergency. They will provide the basis for more detailed standard operating procedures that may be used in a response.

C. Richmond Animal Care and Control will coordinate with all departments, government entities, and representatives from the private sector who support animal emergency operations. This may involve working with other local jurisdictions that provide mutual aid, state and federal governments, private contractors, local retailers, volunteer organizations, etc. and assuring that all involved have current Memorandums of Agreement with the City of Richmond regarding their agreed support.

D. Basic administrative and accountability procedures for any animal emergency will be followed as required by City of Richmond, state and federal regulations. As with any disaster or incident response, the ICS/NIMS will be used to organize and coordinate response activity.

Organization and Assignment of Responsibilities:

Richmond Animal Care and Control will provide the following services as appropriate. They will perform tasks as requested by the EOC and under their own initiative and authorities as applicable:

1. Maintain current listings of emergency contacts and resources necessary for response to an animal emergency.
2. Produce and maintain plans, policies and procedures for overarching animal care and control activities, animal recovery, and household pet sheltering.
3. Oversee all activities (mitigation, planning, response and recovery) in regards to emergency animal care and control.
4. Assign a representative to the EOC in order to coordinate the animal care and control response.

Tab 1 to Emergency Support Function #16
Action Checklist

Routine Operations

- Encourage any group, facility or organization that houses animals to develop emergency procedures and evacuation plans for the animals in the care and custody.
- Develop procedures for public information and education on animal disaster preparedness to include encouraging citizens to develop household emergency plans that include their pets in all aspects of response, i.e. evacuation and sheltering.
- Develop, maintain, and disseminate animal care and control plans, policies and procedures to ensure the safe, sanitary and efficient response to and recovery from an emergency involving animals, as well as support and maximize claims of financial assistance from local, state and federal governments, and facilitate audits following the disaster.
- Provide training to agencies and staff on task-appropriate plans, policies and procedures.
- Provide adequate support for animal preparedness and planning.
- Develop the necessary logistical support to carry out emergency tasking for the department. Instruct all departments to maintain an inventory of supplies on hand.
- Develop the necessary mutual aid agreements, sample contracts, and listing of potential resource providers to expedite the procurement of anticipated resource needs for emergency operations.

Increased Readiness

- Alert on-duty personnel.
- Monitor the situation and be prepared to mobilize, if required.
- Request stand-by of all partners and volunteers.

Response Operations

Mobilization Phase

- Implement animal care and control plans, policies and procedures.
- Provide on-the-spot training as necessary on task-appropriate plans, policies and procedures.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Provide adequate support in a timely manner for animal response. Report any shortfalls and request needed assistance or supplies.
- Implement mutual aid agreements, contracts, and the listing of potential resource providers to fill resource needs for emergency operations.
- Maintain effective communications with Emergency Operations Center, other shelters and field personnel.

- Ensure appropriate recordkeeping such that federal or state disaster assistance can be sought for reimbursement of disaster related expenditures.
- Initiate search, rescue and transport animals to shelters.
- Receive and care for animals.
- Provide documentation of injuries and deaths of animals.
- Provide food, water and waste disposal at the shelter(s).

Recovery Operations

- Reunite animals with owners.
- Deactivate emergency shelter(s).
- Provide referrals regarding long-term shelter of animals for owners who have lost their homes.
- Report disaster related expenses.
- Review animal care and control plans, policies and procedures in respect to the recent emergency response. Update as necessary and disseminate.
- Identify, control and, if necessary, destroy animals that pose hazards to the wellbeing and safety of citizens.

Tab 2 to Emergency Support Function #16
Household Pet Sheltering and Animal Recovery Plan

Introduction

Coordinating Agency

- Richmond Animal Care and Control

Support Agencies and Organizations

- Richmond City Health District
- Department of Social Services
- Richmond Sheriff's Office
- Local Animal Welfare/Rescue Organizations
- Local Veterinarians
- Local Animal Boarding Facilities
- Virginia Capital Area Voluntary Organizations Active in Disaster (VCAVOAD)
- Virginia Department of Agriculture and Consumer Services

Purpose:

The Household Pet Sheltering and Animal Recovery Plan provides basic guidance for all participants in animal related emergency evacuation and shelter management activities as well as animal search, rescue, recovery and reunification. Although, the care and control of animals is the responsibility of owners, Richmond Animal Care and Control is the lead agency on animal issues and is responsible for situation assessment and determination of resource needs.

Pet-Friendly shelters are being established in an effort to assist evacuated residents with the sheltering of companion animals during a declared evacuation. In some situations, owners will not be able to evacuate their animals, and due to the impacts of the event, they may not be able to re-enter the area to recover or care for their animals. It is the goal of this plan to control and support both the humane care and treatment of companion animals during an emergency situation by providing safe shelters for people and their pets and the animal search, rescue, recovery and reunification process during or after an emergency situation. In addition, the plan intends to ensure the continued care of those animals that are unable to be relocated outside of the disaster area.

Scope:

This annex is applicable to departments that participate and respond, with assistance or relief, to an emergency requiring the sheltering of people and their household pets and search, rescue, recovery or reunification of animals with their owners, as coordinated by Richmond Animal Care and Control.

Situation:

Within the City of Richmond, there is an estimated:

- 48,093 dogs
- 52,540 cats
- 4,089 pocket pets (rodents, ferrets, etc.)

Assumptions:

1. Any emergency resulting in evacuation of residents to a shelter will result in household pet issues.
2. The protection of household pets is ultimately the responsibility of their owner. However, during times of emergency or disaster, owners may need assistance in the care and control of their animals.
3. Many household pet owners will not evacuate to safety if their pets must stay behind. Pet owners will frequently live in the streets rather than abandon their animals so that they may enter evacuation shelters. This type of behavior puts animals, their owners and emergency responders at risk.
4. People that do evacuate will try to reenter an area to retrieve animals before an all clear is given.
5. Pet-friendly shelters will only shelter those animals defined as household pets.
6. No dogs with a known bite history or previously classified by Animal Control as "Dangerous" or "Potentially Dangerous" will be accepted into a pet-friendly shelter.
7. No dog that shows signs of aggression during initial check-in will be accepted.
8. A quarantine zone will be set up for animals that do not have proof of current vaccinations, a current rabies tag and City license.
9. No feral cats or wild-trapped cats will be accepted.
10. Animals should be brought to the Pet-Friendly shelter in a suitable cage or on a leash provided by the owner.
11. Birds must be brought in the owner's cage. Bird breeders with large numbers of birds will need to seek sanctuary elsewhere.
12. Pocket pets (hamsters, gerbils, hedgehogs, sugar gliders, etc.) must be brought to shelter in owner's cage. The cage must be of good material to prevent escape.
13. No reptiles will be accepted.
14. Those animals that become homeless, lost or stray as a result of a disaster will be protected by the City of Richmond. Volunteer organizations will assist in this effort.
15. Those animals that are rescued and not identified by their owners within 11 days after the social services shelters close will be considered property of the City of Richmond and normal animal care and control policies and procedures will be followed in regards to euthanasia, adoption, and/or release to rescue organizations.

Concept of Operations

A. Richmond Animal Care and Control will be the lead in all pet-friendly sheltering functions as well as animal search, rescue, recovery and reunification. In response to an emergency requiring sheltering and/or animal recovery, ESF #16 will work together with other ESFs including ESF #6, Mass Care, Housing and Human Services. Other agencies/ESFs may need to be utilized to fulfill other needs as determined.

B. Richmond Animal Care and Control is responsible for developing and implementing the necessary management policies and procedures that will facilitate and ensure a safe, sanitary and effective animal care and control effort for day-to-day operations and emergency response. The plans and procedures establish the concepts and policies under which organizations will operate during emergency activities. They will provide the basis for more detailed standard operating procedures that may be used in a response.

C. Richmond Animal Care and Control will coordinate with all departments, government entities, and representatives from the private sector who support pet-friendly sheltering operations and animal search, rescue, recovery and reunification activities. This may involve working with other local jurisdictions that provide mutual aid, state and federal governments, private contractors, local retailers, volunteer organizations, etc.

Organization and Assignment of Responsibilities

Office of Emergency Management

- Prepare and coordinate pre-incident training and exercise of pet-friendly shelter incident management teams to included NIMS, ICS, EOC Operations, and reimbursement procedures for eligible costs under state and federal public assistance programs.
- Act as liaison for City departments and public/private partners that may not be traditionally involved in animal care to assist with collaboration and coordination of shelter issues in a City emergency shelter location (i.e. Department of Social Services, American Red Cross, etc.).

Richmond Animal Care and Control

- Create and maintain all household pet sheltering and animal recovery policies, plans and procedures.
- Maintain current listing of emergency contacts and resources necessary for response and recovery.
- Coordinate and ensure rapid response to pet-friendly sheltering needs and animal recovery.
- Coordinate incident management activities for the overall operation of the pet-friendly shelters and animal recovery with the EOC and volunteer organizations that are staffing and providing support to shelter operations.
- Maintain situational awareness of pet-friendly shelter operations as well as animal recovery and provide situation/status reports/updates to the EOC.
- Process requests for assistance or additional resources to support response and recovery efforts through the EOC.
- Facilitate the reunification of pets to owners during the transition from response to recovery.
- Provide shelter occupancy data to facilitate the movement of traffic along the evacuation routes.
- Use media to assist with outreach efforts to citizens on evacuation education pre-event and notification during an event regarding routing to be used.

- Monitor, coordinate and manage pet-friendly shelter and animal recovery activation and sequencing.
- Provide subject matter expertise, as needed.

Department of Social Services
- Coordinate the relationship between the human and household animal sheltering functions.
- Ensure general population sheltering staff is aware of the presence of pet-friendly resources pre-event and at the shelter site itself.
- Work with both Richmond Animal Care and Control and the Office of the Press Secretary to create public information releases regarding sheltering.

Richmond City Health District
- Ensure that human health will not be impacted in conjunction with the operation of pet-friendly shelters.

Richmond Police Department/Richmond Sherriff's Office
- Assure the safety and security of household pet sheltering and animal recovery personnel;
- Enforce movement restrictions and establish perimeters for pet-friendly sheltering and animal recovery and reunification areas.

Plan Development and Maintenance

It is the responsibility of Richmond Animal Care and Control to review this plan annually for any needed updates, revisions, or additions. This plan should also be reviewed after every incident in which it is activated to reflect any needed updates, revisions or additions that were found during the response and recovery effort.

Tab 3 to Emergency Support Function #16
Household Pet Sheltering and Animal Recovery Plan
Action Checklist

Mitigation/Prevention:

- Encouraged citizens to develop emergency and evacuation plans as well as go-kits for the animals in their care.

Preparedness:

- Establish an organizational structure, chain of command and outline of duties and responsibilities, required for any household pets sheltering and animal search, rescue, recovery and reunification response.
- Develop, maintain, and disseminate household pet sheltering and animal recovery plans, policies and procedures to ensure the safe, sanitary and efficient response to and recovery from an animal emergency, as well as support and maximize claims of financial assistance from state and federal governments, and facilitate audits following the disaster.
- Identify local veterinarians, humane societies, local household pet sheltering volunteers and animal control personnel in standard operating procedures and ensure that contact information is maintained.
- Provide training to agencies, staff and volunteers on task-appropriate plans, policies and procedures.
- Provide adequate support for animal preparedness and planning.
- Develop the necessary logistical support to carry out emergency tasking. Instruct all departments to maintain an inventory of supplies on hand.
- Develop the necessary mutual aid agreements, sample contracts, and listing of potential resource providers to expedite the procurement of anticipated resource needs for emergency operations.

Response:

- Implement household pet sheltering and animal recovery plans, policies and procedures to ensure the safe, sanitary and efficient response to an animal emergency, as well as support and maximize claims of financial assistance from state and federal governments, and facilitate audits following the disaster;
- Secure supplies, equipment, personnel and technical assistance from support agencies, organizations and other resources to carry out the plan.
- Provide on-the-spot training on task-appropriate plans, policies and procedures, as necessary.
- Provide adequate and timely support for household pet sheltering and animal search, rescue, recovery and reunification activities. Report any shortfalls and request needed assistance or supplies. Request additional assistance as needed.
- Implement mutual aid agreements, contracts, and the listing of potential resource providers to fill resource needs for emergency operations.

- Ensure appropriate recordkeeping such that federal or state disaster assistance can be sought for reimbursement of disaster related expenditures.

Recovery:

- Complete an event review with all responding parties;
- Review plans, policies and procedures in respect to the recent emergency response. Update as necessary and disseminate.
- Review and update the necessary logistical support to carry out emergency tasking. Instruct all departments to replenish their on-hand inventory of supplies.
- Review mutual aid agreements, sample contracts, and listing of potential resource providers in respect to recent emergency response. Update as necessary and disseminate.

Tab 4 to Emergency Support Function #16

Pet-Friendly Shelter Set-Up and Break-Down Procedures

Set-Up Procedures

A. Authority for opening the Emergency Animal Shelter rests with the Emergency Operations Center. That decision will be communicated directly to the Animal Care and Control Liaison in the EOC.

B. Facility Preparation
1. Designate K-9, feline, isolation; and other animal housing areas.
2. Walk the site to identify any existing damage to the site.
3. Apply protective plastic covering, if necessary.
4. Set up crates.

C. Registration and Intake Area
1. Provide a table for owner registration and immediately take a photo of the animal with its owner and attach it to the registration record.
2. Pet owners must be officially registered at a shelter in order to have their pet in the Emergency Animal Shelter.
3. Designate a space for staff to fill out the animal intake forms and do a health assessment on animals.
4. Assign the animal to an appropriately sized crate or kennel and ensure water, towels or bedding is provided. Immediately collar or microchip the animal and label the crate with the owner's name and the pet's name as well as any special needs.
5. If the owner brings their own crate, make sure it is clearly labeled with their name, note that on the intake form, and place the crate in the appropriate area.
6. Keep all leashes, collars, food bowls, toys or bedding that the owner provides with the animal, either inside the crate or directly on top of it.
7. Web-based shelter management system will be activated.

D. Operations

1. Signage
    a. Clearly mark the Emergency Animal Shelter.
    b. Clearly mark an area for "Animal Intake."
    c. Post policies and procedures for pet care and feeding.
    d. Designate and clearly post a "dog walk" area.

2. Animal Areas
    a. Triage area: Should be near the Registration table where the Animal Intake form and assessment are completed; animals are identified, photographed, examined and assigned to the appropriate area.
    b. No animal will be outside its crate/kennel without a leash and identification tag. Only staff or animal owners will be allowed to remove any animal from its crate/kennel.

c. Species should be separated (dogs/cats/pocket animals) as well as those animals with special needs or that are sick or under stress.

E. Animal Care, Set-Up, and Registration

1. Dogs
   a. If space permits, crates or kennels should be twelve (12) inches or more apart.
   b. If able, crates will be oriented to keep animals facing away from each other.
   c. Provide food and water bowls, identification tag, leash, and bedding for each crate.
   d. For dogs sensitive to noise, activity or other dogs, provide a sheet to keep the sides of the crate covered.
   e. The dog area will be close to an exit door to facilitate reaching dog walk areas; provide all owners with plastic bags for clean-up each time they walk their dog and place waste receptacles in an exterior area.
   f. If necessary because of weather or dangerous conditions, a dog walk area can be created indoors in a separate room.
   g. Provide additional separate areas for dogs that are sick and for those without proof of vaccination.
   h. Admittance may be refused to any animal that appears uncontrollable or dangerously aggressive.
   i. Isolate dogs that are in heat.

2. Cats
   a. Cats will be kept in a separate area from dogs, in the quietest part of the facility, preferably away from doors and other activity.
   b. Cats that are sick or without proof of vaccination will be isolated.
   c. Provide food and water bowls, identification tag, and bedding for each crate.
   d. Provide litter boxes in an area where owners can take their cats out of the crate for exercise and/ or feeding, or provide a litter box inside the crate. Litter boxes will be cleaned regularly.
   e. Isolate cats that are in heat.

3. Birds
   a. Designate an area for birds away from drafts and temperate extremes.
   b. All birds must be in cages, fully ventilated. Provide food, water, identification tag, and newspaper for all cages.
   c. Cages may accommodate up to three (3) birds if the birds are socialized, free of disease, and ample mobility is allowed for each.
   d. Provide a sheet to cover the birdcage to deter noise, and cover at night.

4. Ferrets
   a. Ferrets must be current in rabies vaccinations.
   b. Cages may house up to three (3) ferrets if they are socialized, free of disease, and ample mobility is allowed for each.

c. Provide food, water, identification tag, and bedding for each cage.
d. Cages must be of sturdy construction, chew-proof, and deep enough to allow for appropriate bedding.
e. Change bedding regularly and dispose of it in a sealed plastic bag.

5. Small Mammals
   a. All Small mammals are to be kept caged at all times.
   b. Provide food, water, identification tag, and bedding for each cage.
   c. Cages must provide ample mobility and be well ventilated.
   d. Cages or containers must be chew-proof.
   e. Provide odor-inhibiting bedding material such as wood chips or shredded paper.
   f. Change bedding regularly and dispose of it in a sealed plastic bag.

Breakdown Procedures

A. Authority for closing the Emergency Animal Shelter rests with the Emergency Operations Center. That decision will be communicated directly to the Emergency Animal Shelter Supervisor. Once the decision has been made to close the Emergency Animal Shelter, break down can be initiated.

B. Once owners have checked out all the animals housed in the Emergency Animal Shelter all crates, kennels and cages will be broken down and removed from the facility. Cleaning and disinfecting of crates and kennels after breakdown can occur off-site.

C. All crates, materials and supplies will be removed from the facility and, if used, plastic sheeting will be taken up.

D. Clean Up
   1. All floors will be cleaned and disinfected. Any furniture, tables or shelves used for holding crates and animals will be wiped down with disinfectant wipes. Handrails, water fountains and doorknobs will be wiped down with disinfectant wipes.
   2. Trash receptacles will be emptied and bagged trash placed in designated dumpsters.
   3. Cages, crates and kennels will be cleaned and disinfected with detergent and bleach after being used. All towels, sheets and bedding will be laundered before storing in watertight containers
   4. The site will be inspected by personnel to document any new damage to the area.

E. Report Writing
   1. The Emergency Animal Shelter Supervisor will submit a written report to the Coordinator of Emergency Management. This report will be based on the Incident log kept at the Emergency Animal Shelter and the log kept by the Richmond Animal Care and Control Liaison in the EOC. It will include the

number and types of animals housed, an assessment of operations and staffing, descriptions of problems or “incidents within the incident” and how they were handled, and identify any gaps in skills, staffing or logistics. The report will include a section on lessons learned during the incident.

F. Documentation

1. Documentation of the incident will include all registration and animal intake forms, photographs of pets and owners and incident logs kept by the Emergency Animal Shelter Supervisor. This documentation will form the basis of the report submitted to the Coordinator of Emergency Management.

G. Close-Out Meeting

1. The Emergency Animal Shelter Supervisor will attend the EOC close out meeting to help assess management of the incident and identify any problems.

Tab 5 to Emergency Support Function #16

Pet-Friendly Shelter Pet Registration/Discharge Form

Owner Information			
Full Name:		**Driver's License Number:**	
Street Address:			
City, State, Zip			
Phone Numbers:	Home:	Alternate:	
Emergency Contact:	Name:	Phone:	

Pet Information		
Description of Animal: ☐ Dog ☐ Cat ☐ Other ________	**Pet's Name:**	**Crate Assigned:**
MALE ☐ Intact ☐ Neutered	**FEMALE** ☐ Intact ☐ Spayed ☐ In Heat	
Breed:	**Color:**	**Age:**
Distinctive Markings:		
Microchip: ☐ Yes ☐ No **If yes, number:**	**Expected Reclaim Date:**	
Veterinarian Name:	**Phone Number:**	

Pet Medications - List any medications below that you pet is currently taking and note if available

Name of Medication	Dosage	Y/N	Purpose

TO BE COMPLETED BY SHELTER		
Arrival Date:	**Departure Date:**	
Did the owner provide proof of the following:	**Yes**	**No**
• Written proof of vaccinations during the past 12 months		
• Proper ID collar and up to date rabies tag. If yes, record Tag #_________________________		
• Proper ID on all belongings		
• Leash		
• Ample food supply		
• Water/food bowls		
• Necessary medication(s) (ensure medications are listed above)		
• Owner provided cage has owner's name, address, pet name & other pertinent information labeled clearly & securely		

Registration Agreement

I understand that I must pick up my pet(s) when leaving the designated shelter or at the closing of the shelter, whichever comes first, or may pet(s) will become property of the local animal control facility and treated as stray(s).

I, the animal owner signed below, certify that I am the legal owner and request the emergency housing of the pet(s) listed on this form. I hereby release the person or entity receiving the pet(s) from any and all liability regarding the care and housing of the animal during and following this emergency. I acknowledge if emergency conditions pose a threat to the safety of these animals, additional relocation may be necessary, and this release is intended to extend to such relocation.

I acknowledge that the risk of injury or death to my pet(s) during an emergency cannot be eliminated and agree to be responsible for any additional veterinary expenses which may be incurred in the treatment of my pet(s) outside of the shelter triage. **I also understand that it is the owner or his/her agent's responsibility for the care, feeding, and maintenance of my pet(s). Signing in and out upon entering and leaving area. Check-out is required when departing from the shelter.**

I have read and understand this agreement and certify that I am the owner/agent of the above listed animal(s).

SIGNATURE	
Owner's Signature	Shelter Intake personnel

Tab 6 to Emergency Support Function #16

Pet-Friendly Shelter Sites

Name	Address	Type	Pet Capacity
Richmond Animal Care and Control	1600 Chamberlayne Avenue Richmond, Virginia	Shelter	60

Tab 7 to Emergency Support Function #16
Lost Animal Report

Today's Date	Information Received By		
Owner Information			
Name	Address		
Temporary Address	Phone Number		
Date/Location Where Animal Was Last Seen			
Date Last Seen	Location		
Do You Have A Picture Of The Animal?	Is The Animal Friendly?		
Does The Animal Have A History Of Running Away?			
Animal Description			
Type Of Animal	If A Litter, Number In Litter		
Breed	Size (Small/Medium/Large)	Animal's Name	
Male/Female/Fixed	Tail (Short/Long/Curly/Straight)	Distinguishing Marks	
Fur Length/Coat Type	Colors	Ears (Floppy/Erect)	
Is Animal Wearing A Collar?	Does The Animal Have An ID Tag?	Info On Tag?	Microchip number:
Rabies License Number?	Indoor/Outdoor Animal	Cat – Declawed?	
Veterinarian Used			
Name	Phone		
Address	Are Shots Current?		
Animal On Any Medication?	Frequency		
When Was Medication Last Given?			
Contacts			
Who Else Have You Notified That The Animal Is Missing?			
Office Use Only			
Lost Animal Matched With Animal ID #	Date Owner Contacted		
Date Animal Reclaimed	Released to Owner Print & Sign Name		
Owner's Drivers License #	State	Phone Number	
Status Of Animal			
Owner Located	Matched At Shelter	Deceased	Unknown After 30 Days

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Introduction

Coordinating Agency

- Dam Owner - St. Michael's Episcopal School

Cooperating Agencies

- Office of Emergency Management

Purpose

The Dam Safety Support Annex provides the mechanism to facilitate the evacuation of downstream residents or notification of the public in the event of an imminent or impending dam failure at the Winston Lake Dam.

Scope

This annex is applicable to agencies and organizations that will participate and respond with assistance to a dam failure impacting the City of Richmond.

Authorities

In addition to those listed in the Plan:

A. The Virginia Dam Safety Act, Article 2, Chapter 6, Title 10.1 (10.1-604 et seq) of the Code of Virginia.
B. Virginia Soil and Water Conservation Board, Chapter 20 – Impounding Structure Regulations. 4VAC50-20-10 through 4VAC50-20-400 of the Virginia Administrative Code.

Concept of Operations

A. As the dam owner, St. Michael's will report abnormal conditions at the dam to the Emergency Communications Center (911 Center) and the Coordinator of Emergency Management and recommend evacuation of the public below the dam if it appears necessary.

B. Standards have been established for "Dam Classifications" and "Emergency Stages," see Tab 2. The affected public will be routinely notified of conditions at the dam during Stage I.

C. If conditions escalate to Stage II, emergency services personnel will immediately notify the public affected to be on alert for possible evacuation of the areas that would be flooded.

D. If conditions deteriorate and overtopping or failure of a dam has occurred or is imminent, as in Stage III, the Director of Emergency Management or his designee will order evacuation from the affected area and declare a local emergency.

Organization and Assignment of Responsibilities

St. Michael's Episcopal School, the dam owner, will provide the following:

1. Proper design, construction, operation, maintenance, and safety of the Winston Lake Dam.
2. Develop and maintain an Emergency Action Plan, to include a method of notifying and warning persons downstream and of notifying local authorities in the event of impending failure of the dam, as required by the Virginia Department of Conservation and Recreation prior to the issuance of an Operation and Maintenance Certificate.

The Office of Emergency Management will provide the following services as necessary:

1. Maintain a copy of the Winston Lake Dam Emergency Action Plan on file.
2. Coordinate an evacuation of the affected public, if necessary.

Tab 1 to Dam Safety Support Annex
Action Checklist

Routine Operations

- Develop an Emergency Action Plan (EAP) for warning and evacuating the public in event of dam failure.
- Obtain an Operations and Maintenance Certificate from the Virginia Department of Conservation and Recreation.
- Operate and maintain the dam to assure the continued integrity of the structure.
- Exercise and test dam EAP to ensure that it meets current codes and regulations.

Increased Readiness

Stage I Conditions

- Alert on-duty emergency response personnel.

Stage II Conditions

- Notify the public of possible dam failure.
- Place off-duty emergency response personnel on alert.

Response Operations

Mobilization Phase – Latter Part of Stage II or Stage III

- Activate the EOC.
- Notify the Virginia Emergency Operations Center.
- Alert emergency response personnel to stand-by status.
- Begin record keeping of all incurred expenses.

Emergency Phase – Stage III

- Order immediate evacuation of residents in expected inundation areas.
- Warn individuals to evacuate immediately out of the area or to high ground in area for later rescue.
- Call in emergency response personnel necessary to save lives and property.
- Follow all established procedures within designated functional areas specified in the City of Richmond EOP

.

Recovery Operations

- Provide assistance to impacted residents.
- Review dam safety plans, policies and procedures in respect to the recent emergency response. Update as necessary and disseminate.
- Determine what mitigation measures, if any, should be initiated.

Tab 2 to Dam Safety Support Annex
Dam Classifications and Emergency Stages

Dam Classifications

Dams are classified, as the degree of hazard potential they impose should the structure fail completely. This hazard classification has no correlation to the structural integrity or probability of failure.

Dams which exceed 25 feet in height **and** impound more that 50 acre feet in volume, or 100 acre feet if for agricultural purposes, are required to obtain an Operation and Maintenance Certificate which includes the development of an emergency action plan administered by the Department of Conservation and Recreation.

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. Special criteria: This classification includes dams that upon failure would cause damage only to property of the dam owner.

Emergency Stages

When abnormal conditions impact on a dam, such as flooding or minor damage to the dam, the dam owner should initiate specific actions that will result in increased readiness to respond to a potential dam failure. The following stages identify actions and response times which may be appropriate.

> **Stage I** - Slowly developing conditions; five days or more may be available for response. Owner should increase frequency of observations and take appropriate readiness actions.
>
> **Stage II** - Rapidly developing conditions; overtopping is possible. One to five days may be available for response. Increase readiness measures. Notify local Coordinator of conditions and keep him informed.
>
> **Stage III** - Failure has occurred, is imminent, or already in flood condition; overtopping is probable. Only minutes may be available for response. Evacuation recommended.

Support Annex – Damage Assessment

Introduction

Coordinating Agency:

- Office of Emergency Management

Support Agencies and Organizations:

- Richmond Fire and Emergency Services
- Department of Public Works
- Department of Planning and Development Review
- Department of Public Utilities
- Department of Parks, Recreation and Community Facilities
- Richmond Police Department
- Richmond Public Schools System
- Richmond Sheriff's Office
- CERT Volunteers

Purpose

The Damage Assessment Support Annex describes the coordinating process used by the City of Richmond to assess the overall damage to public and private property in a timely and accurate manner, thereby providing a basis for an emergency declaration and/or disaster assistance. The completion of specific information using designated forms is required in order to be eligible for post-disaster assistance.

Scope

This annex covers a broad scope of responsibilities, assignments and standard forms to be used in the overall damage assessment process; it is applicable to agencies and organizations that assist with the post-event damage assessment as coordinated by the Office of Emergency Management. This document will address general situations with no consideration given for incident specific scenarios.

Definitions:

<u>Initial Damage Assessment (IDA)</u>: Independent City of Richmond review and documentation of the impact and magnitude of a disaster on individuals, families, businesses, and public property. This report is due into the Virginia Emergency Operations Center in the required format (see Tab 4) within 72 hours of disaster impact. The Governor will use this information to determine if a Preliminary Damage Assessment needs to be requested from FEMA in response to outstanding needs.

Preliminary Damage Assessment (PDA): A joint venture between FEMA, State and local government to document the impact and magnitude of the disaster on individuals, families, businesses, and public property. The Governor will use the information gathered during the PDA process to determine whether Federal assistance should be requested.

Situation:

During the recovery phase of a disaster, the City of Richmond will conduct a systematic analysis of the nature of the damage to public and private property, which estimates the extent of damage based upon actual observation and inspection. Damage assessment will be performed in a timely basis to provide an initial estimate of damage. A damage estimate of public and private property is required for the City to determine necessary actions the allocation of resources, and what, if any, outside assistance will be required.

Based upon the local damage assessment reports, the Governor may request a Presidential declaration of a “major disaster”, “major emergency”, or a specific federal agency disaster declaration (Small Business Administration, Department of Agriculture, Corps of Engineers, etc.) to augment state, local and private disaster relief efforts. The President, under a “major emergency” declaration may authorize the utilization of any federal equipment, personnel and other resources. The President under a “major disaster” declaration may authorize two basic types of disaster relief assistance:

1. Individual Assistance (IA) which may include:
    a. Temporary housing;
    b. Individual and family grants (IFG);
    c. Disaster unemployment assistance;
    d. Disaster loans to individuals, businesses and farmers;
    e. Agricultural assistance;
    f. Legal services to low-income families and individuals;
    g. Consumer counseling and assistance in obtaining insurance benefits;
    h. Social security assistance;
    i. Veteran’s assistance; and
    j. Casualty loss tax assistance.

2. Public Assistance (PA) which may include:
    a. Debris removal;
    b. Emergency protective measures; and
    c. Permanent work to repair, restore or replace road systems, water control facilities, public buildings and equipment, public utilities, public recreational facilities, etc.

Assumptions:

1. Fast and accurate damage assessments are vital to effective disaster response.
2. Damage will be assessed by pre-arranged teams.
3. If promptly implemented, this plan can expedite relief and assistance for those adversely affected.

4. A catastrophic emergency will require the expenditure of large sums of local funds. Financial operations will be carried out under compressed schedules and intense political pressures, which will require expeditious responses that meet sound financial management and accountability requirements.
5. Damage to utility system and to the communications systems will hamper the recovery process.

Concept of Operations

A. Three types of reports are available for use in reporting the emergency to the Virginia Emergency Operations Center (VEOC). (1) A Situation Report based on the essential elements of information, (2) a Needs Assessment Report based on the Emergency Support Functions, and (3) an Initial Damage Assessment (IDA) Report and Worksheet to facilitate the state in asking for federal and state assistance.

B. Initial Damage Assessment Reports will be compiled and submitted following any disaster or emergency which causes damage to public or private property, of a magnitude which requires expenditure of City of Richmond funds, or which might be eligible for, or require, a request for State or Federal assistance. Part I should be submitted by fax to the Virginia EOC within 24 hours. An updated Part I and Part II should be completed and forwarded within 72 hours. See Tab 3.

C. Designated teams will assess damage within the limits of their capability. See Tab 2.

D. Damage to State-owned roads and bridges will be assessed by VDOT. If the nature of the emergency is such that City of Richmond resources are incapable of assessing the damage, then State assistance will be requested by the Coordinator of Emergency Management to the VEOC.

Organization and Assignment of Responsibilities

The Office of Emergency Management is responsible for damage assessments, the collection of the data and preparation of necessary reports. The damage assessment teams will be supported by multiple agencies from the City of Richmond. If the nature of the incident is such that city resources are incapable of assessing the damage, state assistance will be requested through normal resource request procedures to the VEOC.

Additionally, the Office of Emergency Management will provide the following:

1. Overall direction and control of damage assessment for the City of Richmond.
2. Assemble the appropriate team and develop damage assessment plans, policies and procedures.
3. Coordinate damage assessment training programs for the teams.
4. Collect and compile incoming damage reports from teams in the field, from other operations directors, and outside agencies, systems and companies.
5. Report of damages to the Virginia EOC within 72 of the incident in the appropriate Initial Damage Assessment format.
6. Appropriate and adequate public information and education regarding the damage assessment process.

The Department of Public Works will provide the following services as appropriate:

1. Designate representatives to serve as members of damage assessment teams.
2. Participate in damage assessment training.
3. Collect and compile damage data and provide to the EOC.
4. Participate as requested in Initial Damage Assessment field reviews and escorting for State and Local damage assessments.

The Department of Public Utilities will provide the following services as appropriate:

1. Designate representatives to serve as members of damage assessment teams;
2. Participate in damage assessment training.
3. Collect and compile damage data and provide to the EOC.
4. Participate as requested in Initial Damage Assessment field reviews and escorting for State and Local damage assessments.

The Department of Community Development and Review will provide the following services as appropriate:

1. Maintain a list of critical facilities that will require immediate repair if damaged.
2. Appoint a representative to be located within the EOC to direct damage assessment operations to include operation of the teams, collecting data, and developing accurate and appropriate reports for the Emergency Management Coordinator.
3. Using existing policies and procedures, determine the state of damaged buildings and place notification/placards as needed.
4. Using existing policies and procedures, facilitate the issuance of building permits and for the review and inspection of the site-related and construction plans submitted for the rebuilding/restoration of buildings.
5. Assist in the establishment of the sequence of repairs and priorities for the restoration of affected areas.

The Department of Parks and Recreation will provide the following services as appropriate:

1. Designate representatives to serve as members of damage assessment teams;
2. Participate in damage assessment training.
3. Collect and compile damage data and provide to the EOC.
4. Participate as requested in Initial Damage Assessment field reviews and escorting for State and Local damage assessments.

Richmond Police Department will provide the following services as appropriate;

1. Provide security for ingress and egress of the damaged area(s) post-event.
2. Provide access and security for damage assessment activities with the City.

Richmond Fire and Emergency Services Department will provide the following services as appropriate:

1. Designate representatives to serve as members of damage assessment teams.
2. Participate in damage assessment training.
3. Collect and compile damage data and provide to the EOC.
4. Participate as requested in Initial Damage Assessment field reviews and escorting for State and Local damage assessments.

Richmond Public Schools System will provide the following services as appropriate:

1. Designate representatives to serve as members of damage assessment teams.
2. Participate in damage assessment training.
3. Collect and compile damage data and provide to the EOC.

Tab 1 to Damage Assessment Support Annex
Action Checklist

Routine Operations

- Develop and communicate plans and procedures.
- Review forms.

Increased Readiness

- Damage Assessment Team meets and task assignments are made.

Response Operations

Mobilization Phase

- Prepare to make an Initial Damage Assessment (IDA).
- Alert Teams to stand-by status.

Emergency Phase

- Submit a Situation Report within 24 hours of the onset of the event.
- Submit additional Situation Reports at least once every 24 hours during the event.
- Complete and submit an official Initial Damage Assessment Report (compiled jointly by the Coordinator and the Damage Assessment Team) within 72 hours.
- Continue to provide damage assessment and assist with record keeping, as required.

Recovery Operations

- Continue to assist with damage assessment(s) and requests for post-disaster assistance as required.

Tab 2 to Damage Assessment Support Annex

Damage Assessment Teams

Damage Assessment Teams will be assembled and instructions provided relative to the emergency. Team Leaders will be designated to compile information for situation and damage assessment reports. Team assignments are based on the categories listed on the Damage Assessment Form.

PRIVATE PROPERTY

Category A – Residential/Personal Property - Houses, manufactured homes, apartments, duplexes (identify number of families and units affected) – Include estimate for structures, private bridges, fencing and vehicles/boats.

Category B – Business and Industry - Industrial plants and businesses (facilities, equipment, materials, commercial vehicles).

PUBLIC PROPERTY

Category A – Debris Clearance - Debris on roads and streets, on public property, on private property and structure demolition.

Category B – Protective Measures

1. Life and safety (all public safety report costs)

2. Barricading, sandbagging, stream drainage channels, health (rodents/insect control)

Category C – Road Systems - Damage to roads and streets, bridges, culverts, sidewalks, traffic control systems.

Category D – Water Control Facilities - Damage to dams and drainage systems.

Category E – Public Buildings and Equipment - Damage to buildings, inventory, vehicles and equipment.

Category F – Public Utility Systems - Damage to water plants, dams, sanitary/sewage systems and storm drainage systems.

Category G – Recreational Facilities - Damage to parks, shelters, lighting and equipment.

DAMAGE ASSESSMENT – TELEPHONE REPORT

1. CALLER NAME			**2. PROPERTY ADDRESS (include apt. no; zip code)**	
3. TELEPHONE NUMBER			**4. TYPE OF PROPERTY**	**5. OWNERSHIP**
Home	**Work**	**Cell**	☐ Single Family ☐ Multi-Family (usually Apts.) ☐ Business ☐ Check here if residence is a vacation home—not a primary residence	☐ Own ☐ Rent ☐ Lease (business only)
Best time to call	**Best number to use**			

6. CONSTRUCTION TYPE

☐ **Masonry** ☐ **Wood Frame** ☐ **Mobile Home** ☐ **Manufactured** ☐ **Other**

7. TYPE OF INSURANCE

☐ **Property** ☐ **Sewer Back-up** ☐ **Flood (Structure)** ☐ **Flood (Contents)** ☐ **Wind/Hurricane** ☐ **None**

8. DAMAGES (Check all that apply)

HVAC ☐ Yes ☐ No **Water Heater** ☐ Yes ☐ No **Electricity** ☐ On ☐ Off **Natural Gas** ☐ On ☐ Off

Roof Intact ☐ Yes ☐ No **Foundation** ☐ Yes ☐ No **Windows** ☐ Yes ☐ No **Sewer** ☐ OK ☐ Not OK

Major Appliances ☐ Yes ☐ No **Basement Flooding** ☐ Yes - Depth___Feet **Furnace** ☐ Yes ☐ No

9. SOURCE OF DAMAGES

☐ **Sewer back-up** ☐ **Primarily Flood** ☐ **Wind/Wind driven rain** ☐ **Tornado** **Other** ☐______________

10. Based on the damages reported, the property is ☐ **Habitable** ☐ **Uninhabitable**

11. CALLER'S ESTIMATE OF DAMAGES

REPAIRS	**CONTENTS**	**TOTAL**
$	**$**	**$**

12. COMMENTS

12. CALL TAKER **13. DATE & TIME REPORT TAKEN**

Tab 4 to Damage Assessment Support Annex
Cumulative Initial Damage Assessment Report

PRIMARY: Input into WebEOC
SECONDARY: VDEM VEOC Phone Number (804) 674-2400 Fax Number (804) 674-2419

Jurisdiction:	
Date/Time Report Prepared:	
Prepared By:	
Call back number:	
Fax Number:	
Email Address:	

Part I: Private Property CUMULATIVE DAMAGES

Type Property	**# Destroyed**	**# Major Damage**	**# Minor Damage**	**# Affected**	**Dollar Loss**	**% Flood Insured**	**% Property Insured**	**% Owned**	**% Secondary**
Single Dwelling Houses (inc. condo units)									
Multi-Family Residences (count each unit)									
Manufactured Residences (Mobile)									
Business/Industry									
Non-Profit Organization Buildings									
Agricultural Facilities									

Part II: Public Property (Includes eligible non-profit Facilities) CUMULATIVE DAMAGES

Type of Property	**Estimated Dollar Loss**	**% Insured**
Category A (Debris Removal)		
Category B (Emergency Protective Measures)		
Category C (Roads and Bridges)		
Category D (Water Control Facilities)		
Category E (Public Buildings and Equipment		
Category F (Public Utilities)		
Category G (Parks and Recreation Facilities)		
TOTAL	$0.00	

Additional Comments:

Tab 5 to Damage Assessment Support Annex

Public Assistance Damage Assessment Guidelines

Category	Purpose	Eligible Activities
A: Debris Removal	**Clearance of trees and woody debris; building wreckage; sand, mud, silt, and gravel; vehicles; and other disaster-related material deposited on public and, in very limited cases, private property**	• **Debris removal from a street or highway to allow the safe passage of emergency vehicles** • **Debris removal from public property to eliminate health and safety hazards**
B: Emergency Protective Measures	**Measures taken before, during, and after a disaster to save lives, protect public health and safety, and protect improved public and private property**	• **Emergency Operations Center activation** • **Warning devices (barricades, signs, and announcements)** • **Search and rescue** • **Security forces (police and guards)** • **Construction of temporary levees** • **Provision of shelters or emergency care** • **Sandbagging • Bracing/shoring damaged structures** • **Provision of food, water, ice and other essential needs** • **Emergency repairs • Emergency demolition** • **Removal of health and safety hazards**
C: Roads and Bridges	**Repair of roads, bridges, and associated features, such as shoulders, ditches, culverts, lighting and signs**	• **Eligible work includes: repair to surfaces, bases, shoulders, ditches, culverts, low water crossings, and other features, such as guardrails.**
D: Water Control Facilities	**Repair of irrigation systems, drainage channels, and pumping facilities. Repair of levees, dams, and flood control channels fall under Category D, but the eligibility of these facilities is restricted**	• **Channel alignment • Recreation** • **Navigation • Land reclamation** • **Fish and wildlife habitat** • **Interior drainage • Irrigation** • **Erosion prevention • Flood control**
E: Buildings and Equipment	**Repair or replacement of buildings, including their contents and systems; heavy equipment; and vehicles**	• **Buildings, including contents such as furnishings and interior systems such as electrical work.** • **Replacement of pre-disaster quantities of consumable supplies and inventory. Replacement of library books and publications.** • **Removal of mud, silt, or other accumulated debris is eligible, along with any cleaning and painting necessary to restore the building.** • **All types of equipment, including vehicles, may be eligible for repair or replacement when damaged as a result of the declared event.**
F: Utilities	**Repair of water treatment and delivery systems; power generation facilities and distribution lines; and sewage collection and treatment facilities**	• **Restoration of damaged utilities.** • **Temporary as well as permanent repair costs can be reimbursed.**
G: Parks, Recreational Facilities, and Other Items	**Repair and restoration of parks, playgrounds, pools, cemeteries, and beaches. This category also is used for any work or facility that cannot be characterized adequately by Categories A-F**	• **Roads, buildings, and utilities within those areas and other features, such as playground equipment, ball fields, swimming pools, tennis courts, boat docks and ramps, piers, and golf courses.** • **Grass and sod are eligible only when necessary to stabilize slopes and minimize sediment runoff.** • **Repairs to maintained public beaches may be eligible in limited circumstances.**

Only states, local government agencies and authorities, public utilities, and certain non-profit organizations may be eligible for Public Assistance grants.
Eligibility Criteria: Locality population per latest US Census x annual local multiplier for local eligibility.

Tab 6 to Damage Assessment Support Annex

Public Assistance Damage Assessment Field Form

JURISDICTION: **INSPECTOR:** **DATE:** **PAGE__of**

Key for Damage Categories (Use appropriate letters in the 'category' blocks below)		
A. Debris Clearance B. Emergency Protective Measures C. Roads & Bridges	D. Water Control Facilities E. Public Buildings & Equipment F. Public Utility System	G. Parks, Recreation Facilities & Other

SITE #	WORK CATEGORY:	NAME of FACILITY and LOCATION:					
		GPS (in decimal deg.):					
DAMAGE DESCRIPTION:							
EMERGENCY FOLLOW-UP NEEDED?	Y	N	TOTAL ESTIMATED DAMAGES: $				
FLOOD INSURANCE	Y	N	PROPERTY INSURANCE	Y	N	NO DATA AVAILABLE (check box)	

SITE #	WORK CATEGORY:	NAME of FACILITY and LOCATION:					
		GPS (in decimal deg.):					
DAMAGE DESCRIPTION:							
EMERGENCY FOLLOW-UP NEEDED?	Y	N	TOTAL ESTIMATED DAMAGES: $				
FLOOD INSURANCE	Y	N	PROPERTY INSURANCE	Y	N	NO DATA AVAILABLE (check box)	

SITE #	WORK CATEGORY:	NAME of FACILITY and LOCATION:					
		GPS (in decimal deg.):					
DAMAGE DESCRIPTION:							
EMERGENCY FOLLOW-UP NEEDED?	Y	N	TOTAL ESTIMATED DAMAGES: $				
FLOOD INSURANCE	Y	N	PROPERTY INSURANCE	Y	N	NO DATA AVAILABLE (check box)	

Tab 7 to Damage Assessment Support Annex

Individual Assistance Damage Assessment Level Guidelines

Damage Definitions	General Description	Things to Look For	Water Levels
DESTROYED	**DESTROYED**	**DESTROYED**	**DESTROYED**
Structure is a total loss. ***<u>Not economically feasible to rebuild.</u>***	Structure leveled above the foundation, or second floor is gone. Foundation or basement is significantly damaged.	Structure leveled or has major shifting off its foundation or only the foundation remains. Roof is gone, with noticeable distortion to walls.	More than 4 feet in first floor. More than 2 feet in ***mobile home.***
MAJOR	**MAJOR**	**MAJOR**	**MAJOR**
Structure is currently uninhabitable. Extensive repairs are necessary to make habitable. ***<u>Will take more than 30 days to repair.</u>***	Walls collapsed. Exterior frame damaged. Roof off or collapsed. Major damage to utilities: furnace, water heater, well, septic system.	Portions of the roof and decking are missing. Twisted, bowed, cracked, or collapsed walls. Structure penetrated by large foreign object, such as a tree. Damaged foundation.	2 to 4 feet in first floor without basement. 1 foot or more in first floor with basement. 6 inches to 2 feet in ***mobile home*** with **plywood** floors. 1 inch in ***mobile home*** with **particle board** floors.
MINOR	**MINOR**	**MINOR**	**MINOR**
Structure is damaged and uninhabitable. Minor repairs are necessary to make habitable. ***<u>Will take less than 30 days to repair.</u>***	Interior flooring / exterior walls with minor damage. Tree(s) fallen on structure. Smoke damage. Shingles / roof tiles moved or missing.	Many missing shingles, broken windows and doors. Loose or missing siding. Minor shifting or settling of foundation. Minor damage to septic system.	2 inches to 2 feet in first floor without basement. 1 foot or more in basement. <u>Crawlspace</u> – reached insulation. <u>Sewage</u> - in basement. ***Mobile home,*** "Belly Board" to 6 inches.
AFFECTED HABITABLE	**AFFECTED HABITABLE**	**AFFECTED HABITABLE**	**AFFECTED HABITABLE**
Structure has received minimal damage and is ***<u>habitable without repairs.</u>***	Chimney or porch damaged. Carpet on first floor soaked. Broken windows.	Few missing shingles, some broken windows. Damage to air conditioning units / etc. Some minor basement flooding.	Less than 2 inches in first floor. Minor basement flooding. ***Mobile home***, no water in "Belly Board".

<u>IDA Tips: Estimating Water Depths</u>

Brick - 2 1/2 inches per course **Lap or aluminum siding - 4 inches or 8 inches per course** **Stair risers - 7 inches**

Concrete or cinder block - 8 inches per course **Door knobs - 36 inches above floor** **Standard doors - 6 feet 8 inches**

LOCALITY INDIVIDUAL DAMAGE ASSESSMENT FIELD FORM

Incident Type		Sector	Place Name	IDA Date		
Georgraphic Area Description				Page #	Of Total Pages	
IDA Team						

		SINGLE FAMILY	MULTI - FAMILY	MOBILE HOME	Total Surveyed	% Owner	% FL Ins.	% HO Ins.	% Low Income	Number Inaccessible
AFFECTED	OWNER									
	RENTER									
	Secondary									
MINOR	OWNER									
	RENTER									
	Secondary									
MAJOR	OWNER									
	RENTER									
	Secondary									
DESTROYED	OWNER									
	RENTER									
	Secondary									
TOTAL PRIMARY										
TOTAL SECONDARY										
TOTAL (Incl. Secondary)										

ROADS / BRIDGES	Number of Roads / Bridges Damaged		Number of Households Impacted	
UTILITIES	Number of Households Without Utilities		Estimated Date for Utilities Restoration	
Comments				

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Support Annex – Evacuation

Introduction

Coordinating Agency

- Department of Public Works (Traffic Engineer)
- Greater Richmond Transit Company (GRTC)

Cooperating Agencies

- Richmond Police Department
- Richmond Sheriff's Office
- Department of Social Services
- Richmond City Health District
- Richmond Animal Care and Control
- Richmond Public School System

Purpose:

The Evacuation Support Annex establishes the organizational basis for operations in the City of Richmond to effectively respond to and recover from disasters and/or emergency situations which involve an evacuation. Additionally, the plan outlines details of an evacuation process for events occurring without warning, and the transportation components necessary to address the operations of assembly areas that may be used during a declaration of emergency.

Scope:

This annex is applicable to agencies and organizations that will participate and respond with assistance to an evacuation as coordinated by the Coordinator of Emergency Management. This document will address wide-ranging scenarios with no consideration for special incident(s) at this time.

There are four basic scenarios in which a planned evacuation or evacuation without warning may be required:

1. <u>Catastrophic event with warning</u> – An event where citizens may need to evacuate or shelter in place then seek evacuation; citizens will not be able to return home in a reasonable period of time. Examples may include major hurricanes and severe river flooding.
2. <u>Disruptive event with warning</u> – An event where citizens may need to evacuate; citizens will be able to return home in a reasonable period of time. Examples may include hurricanes, minor to moderate flooding events, or hazardous materials events.
3. <u>Catastrophic event without warning</u> – An event where citizens need to take immediate action to protect themselves which may or may not involve evacuation efforts after the event. Citizens will not be able to return home in a reasonable period of time. Examples may include terrorism events, severe tornadoes and hazardous material events.

4. Disruptive event without warning – An event where citizens need to take immediate action to protect themselves which may or may not involve evacuation after an event. Citizens will be able to return home within a reasonable period of time. Examples may include severe weather, flash flooding and transportation accidents.

Definitions:

Assembly Area: Site where mass transit resources collect as directed by the EOC to assist in the transporting of populations out of the risk area.

Evacuation Route **-** Road or highway designated as a primary route for motorists evacuating from the threat.

Evacuee: A person moving out of the risk area of a potential or occurring hazard. Evacuees are categorized either as transit dependent or as "self-evacuating". Transit dependent evacuees may require public transportation for immediate life safety, and it is assumed that this population will require public sheltering. The self-evacuating population can be further categorized into two groups: evacuees with end-point destinations (i.e. hotel, family or friends' home) and evacuees without end point destinations. It is possible that the self-evacuating population without end-point destinations will require public sheltering.

Pick-up Point: Site that is used to pick up transit dependent evacuees to move them to the assembly area(s) to be transported out of the risk area.

Refuge of Last Resort: A facility that may be identified that can provide temporary relief from the risk. A refuge of last resort is not intended to be designated as a "shelter" and may not be able to provide basic services such as food, accommodations for sleeping or first aid, but security is provided. It should be considered only as a probable safe haven for evacuees who are unable to clear the area until the risk passes. In many cases these sites can be pre-identified.

Shelter **–** A facility where evacuees with no end destination point can be processed evaluated and provided disaster services from government agencies and/or pre-established voluntary organizations. This facility is generally designed for stays less than 3 days. Supplies available are meals and water for 3 days, basic first aid, pet sheltering (if applicable,) sleeping quarters, hygienic support and basic disaster services (counseling, financial assistance and referral, etc.)

Assumptions:

1. A decision to implement a voluntary or mandatory evacuation may require interaction and coordination between local, state, federal and certain private sector entities.
2. Warning time, in the case of a hurricane or river flood, will normally be available to evacuate the threatened population. A local evacuation might be needed because of a hazardous materials incident, major fire, terrorist incident or other incident. Additional regional evacuations may be necessary in the event of a larger incident such as an impending hurricane.
3. Given warning of an event, a portion of the population will voluntarily evacuate before an evacuation has been recommended or directed. Most people who leave their homes will seek shelter with relatives, friends or in hotels.

4. Evacuation of people at risk for emergency situations that occur with little or no warning will be implemented as determined necessary to protect life and property. Evacuation instructions should be based on known or assumed health or safety risks associated with the hazard. The individual responsible for implementing it should be the Incident Commander at the scene of the emergency, with support from the EOC as necessary.
5. The timing of an evacuation directive will be determined by the circumstances of the event.
6. During events without warning, there might be limited to no time prior to the event to implement more formalized evacuation processes.
7. Emergency evacuations might require evacuation of all or part of the City of Richmond. Evacuation from a designated risk area might affect adjacent and outlying areas within and outside of the City of Richmond. Traffic control resources must be in place prior to issuance of an evacuation order.
8. Evacuation will require a greater lead-time to implement than that of in-place sheltering. A delayed evacuation order could endanger lives.
9. There are on-going efforts to proactively reach out and educate citizens about family preparedness, evacuation procedures, and where to go for additional information on these subjects.
10. Evacuation procedures, to include notification and routing, will be made available to the public by all available means.
11. The primary means of evacuation from any event will be private vehicles.
12. Residents who are ill or disabled may require vehicles with special transportation capabilities.
13. Stranded motorists could present significant problems during an evacuation situation.
14. Evacuation or protective action guidance must be communicated in a clear, concise and timely manner in order to ensure the effective implementation of the strategy recommended. A variety of communication pathways may have to be used in order to effectively communicate the hazard, level or risk and the recommended evacuation or protection action to the public.
15. Some owners of companion animals might refuse to evacuate unless arrangements have been made to care for their animals.
16. Despite the comprehensive effort implemented to communicate evacuation or protective action guidance, some segments of the population might not receive or follow the instructions given.
17. Every hospital, long-term care facility and home health agency is to have plans in place to shelter in place, evacuate patients in their care, transport them to safe and secure alternate facilities and support their medical needs.

Policies:

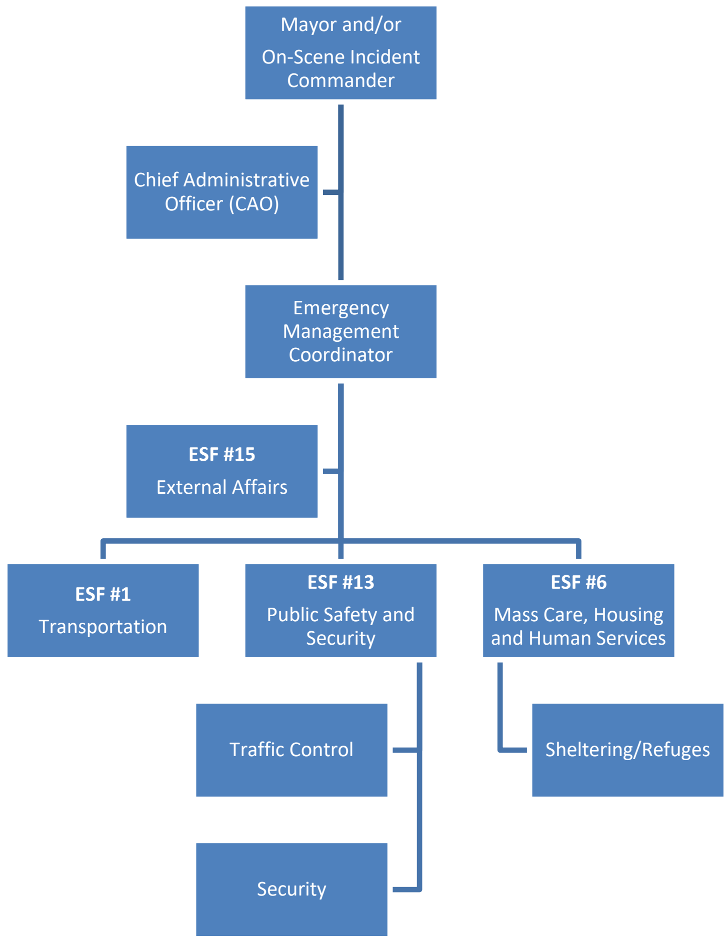
Under the provisions of Section 44-146.17 of the Commonwealth of Virginia Emergency Services and Disaster Law, the Governor may direct and compel evacuation of all or part of the populace from any stricken or threatened area if this action is deemed necessary for the preservation of life or other emergency mitigation, response or recovery; prescribe routes, modes of transportation and destination in connection with evacuation; and control ingress and egress at the emergency area, the movement of persons within the area and the occupancy of premises therein provided resources are in place to support such an operation.

Concept of Operations

A. Evacuation of the City will be directed by the Mayor or his designee.

B. In small-scale incidents or incidents requiring immediate evacuation, the on-scene incident commander will have the authority to determine and implement evacuation orders.

C. Additional ESFs may need to be used to enhance the results of the evacuation. The primary ESFs, as listed, will use their ESF specific annex and any supporting departments and/or organizations to implement their portion of the evacuation.



Organization and Assignment of Responsibilities

The Office of Emergency Management will provide the following services as necessary:

1. Develop, review and test City of Richmond evacuation plans, policies and procedures.

2. Recommend policies, procedures and projects necessary for the implementation of evacuation plans.
3. Facilitate training to departments and other organizations regarding evacuation plans.
4. Publish approved policy guidance including performance measures.
5. Coordinate evacuation efforts with external agencies including, federal, state and other localities.
6. Work with the Office of the Press Secretary to coordinate and disseminate public information through all media types regarding evacuation efforts pre-event, during the event and post-event.

The Department of Public Works will provide the following services as necessary:

1. Assist with traffic control in accordance with Highway Laws of Virginia and the policies of the State Highway Commission and any local laws and ordinances.
2. Assist in moving motorists to refuges of last resort as an event with warning approaches.
3. Assist with the development, review and testing of the City of Richmond evacuation plans, policies and procedures.

The Richmond Police Department, in coordination with the Sherriff's Office, will provide the following services as necessary:

1. Coordinate traffic control in the event of an emergency requiring evacuation in accordance with Highway Laws of Virginia and the policies of the State Highway Commission and any local laws and ordinances.
2. Coordinate resources and information with state and adjacent jurisdiction law enforcement.
3. Assist in directing motorists to refuges of last resort as an event with warning approaches.
4. Provide security for ingress and egress of the evacuated area(s) and for shelters and refuges of last resort.
5. Assist with the development, review and testing of the City of Richmond evacuation plans, policies and procedures.

The Department of Social Services will provide the following services as necessary:

1. Assist in selection of and initiation of sites to serve as refuges of last resort and shelters.
2. Fulfill sheltering plan as required in response to an evacuation.
3. Assist with outreach efforts to citizens on evacuation education pre-event and notification during an event regarding personal evacuation and sheltering planning.
4. Assist with the development, review and testing of the City of Richmond evacuation plans, policies and procedures.

Tab 1 to Evacuation Support Annex
Action Checklist

Routine Operations

- Encourage special facilities to develop emergency procedures and evacuation plans for those charged to their care and custody and provide them to the Office of Emergency Management for comment and review.
- Encourage citizens to develop household emergency plans that include their pets and any other dependents in all aspects of response including evacuation and sheltering.
- Develop, review and test City of Richmond evacuation plans, policies and procedures.
- Provide training to departments and staff on task-appropriate plans, policies and procedures.
- Select, prepare plans for and initiate sites to serve as refuges of last resort and/or shelters.

Increased Readiness

- Develop the necessary logistical support to carry out emergency tasking. Instruct all departments to maintain an inventory of supplies on hand.
- Coordinate information dissemination internally and externally;

Response Operations

Mobilization Phase

- Provide on-the-spot training as necessary on task-appropriate plans, policies and procedures.
- Report any anticipated shortfalls and request needed assistance or supplies.
- Continue to coordinate information dissemination internally and externally.
- Ensure appropriate recordkeeping such that federal or state disaster assistance can be sought for reimbursement of disaster related expenditures.

Emergency Phase

- Implement evacuation plans, policies and procedures.
- Implement mutual aid agreements, contracts, and the listing of potential resource providers to fill resource needs.
- Continue to provide record keeping, as required.

Recovery Operations

- Review evacuation plans, policies and procedures in respect to the recent emergency response. Update as necessary and disseminate.
- Assist with requests for post-disaster assistance as required.

Support Annex – Functional Needs

Introduction

Coordinating Agency

- Department of Social Services
- Human Services
- Office of Emergency Management
- Richmond Behavioral Health Authority
- Richmond City Health District
- Richmond Redevelopment and Housing Authority

Cooperating Agencies

- Office of the Press Secretary
- Richmond Sheriff's Office
- Virginia Voluntary Organizations Active in Disaster

Purpose:

The Functional Needs Support Annex describes the processes the City of Richmond will incorporate to assist persons with functional needs during an emergency or disaster.

The term "functional needs" population describes populations that under usual circumstances are able to function on their own or with support systems. Consistent with the definition of "special needs populations" as it appears in the National Response Framework (NRF), the City of Richmond definition reflects the capabilities of individuals, not the condition or label. Individuals in need of additional response assistance may include those who have disabilities; who live in institutionalized setting; who are elderly; who are children; who are from diverse cultures; who have limited English proficiency; or who are non-English speaking; or who are transportation disadvantaged. Persons with functional needs may include individuals who are hospitalized, homebound, homeless, transient, tourists or visitors; people who have mental disorders, visual impairments, and hearing impairments; those persons living in long-term and residential care facilities; and people with limited English proficiency or literacy.

The definition focuses on the following function-based aspects:

Maintaining Independence – Individuals requiring support to be independent in daily activities may lose this support during an emergency or a disaster. Such support may include consumable medical supplies (diapers, formula, bandages, ostomy supplies, etc.), durable medical equipment (wheelchairs, walkers, scooters, etc.), service animals, and/or attendants or caregivers. Supplying needed support to these individuals will enable them to maintain their pre-disaster level of independence.

Communication – Individuals who have limitations that interfere with the receipt of, and response to, information will need that information provided in methods they can understand and use. They may not be able to hear verbal announcements, see directional signs, or understand how to get assistance due to hearing, vision, speech, cognitive, or intellectual limitations, and/or limited English proficiency.

Transportation – Individuals who cannot drive or who do not have a vehicle may require transportation support for successful evacuation. This support may include accessible vehicles (e.g., lift-equipped or vehicles suitable for transporting individuals who use oxygen) or information about how and where to access mass transportation during an evacuation.

Supervision – Before, during, and after an emergency, individuals may lose the support of caregivers, family, or friends or may be unable to cope in a new environment (particularly if they have dementia, Alzheimer‘s or psychiatric conditions such as schizophrenia or intense anxiety). If separated from their caregivers, young children may be unable to identify themselves; and when in danger, they may lack the cognitive ability to assess the situation and react appropriately.

Medical Care – Individuals who are not self-sufficient or who do not have adequate support from caregivers, family, or friends may need assistance with: managing unstable, terminal, or contagious conditions that require observation and ongoing treatment; managing intravenous therapy, tube feeding, and vital signs; receiving dialysis, oxygen, and suction administration; managing wounds; and operating power dependent equipment to sustain life. These individuals require support of trained medical professionals.

Scope:

This document provides a general framework within which the various care giving entities shall function in a disaster situation, while promoting flexible and creative strategies and solutions that are consistent with the resources currently available to the City of Richmond.

Situation:

The City of Richmond is vulnerable to many disasters that could endanger large numbers of citizens. Among these are people with functional needs. During an emergency, people with functional needs may require additional assistance with medical services, shelter and transportation, communication equipment, and support and adaptive equipment. Adequate preparation and empowerment of individuals with functional needs and their families can improve response capacities and effectiveness during emergencies and disaster events.

The responsibility of assisting persons with functional needs generally begins with their families or caregivers; however, city departments involved in emergency response need to design specific awareness, prevention, preparedness, response, and recovery operations to accommodate those requiring additional assistance. Activities and preparedness designed to accommodate individuals with functional needs can also benefit the general population and improve response to the entire community.

Assumptions:

1. The City of Richmond has ultimate responsibility to protect the health and well being of populations with functional needs. If a disaster or emergency does occur, injuries can be lessened and lives can be saved with proper pre-event planning that addresses those persons with functional needs.
2. Citizens with functional needs will first be assisted at the family or care giver level.
3. Individuals with functional needs will require assistance after exhausting their usual resources and support network. Since this level of support varies among individuals, proper pre-event planning will improve the effectiveness of the city's emergency response.
4. Designated emergency shelters within the city provide sufficient resources to assist people with functional needs.
5. Departments have identified and designated individuals with special skills available to assist the population with functional needs.
6. Departments have coordinated with private sector vendors to provide essential adaptive equipment and supplies to assist individuals with functional needs.
7. Departments provide emergency services that recognize and accommodate persons with functional needs and expedite access to needed services until routine assistance is re - established.
8. Departments develop and maintain emergency planning and response capabilities that accommodate the diverse and functional needs represented in the city. Allowances include but are not limited to interpreter and translation services, adaptive equipment and services, access and referral to medical and specialized support services in shelter and feeding environments, transportation, crisis counseling, and culturally sensitive accommodations.
9. The capability exists to disseminate information and instructions to the populations with functional needs via radio, television, and other available media as necessary. Information to be communicated includes immediate actions people should take and other pertinent information.
10. Health care and social service providers are accustomed to addressing individuals with functional needs. They will continue to support the needs of individuals in the event of an emergency, as outlined in the City of Richmond Emergency Operations Plan.
11. Failure to consider and incorporate planning and preparedness for persons with functional needs into facility emergency operation plans will contribute to adverse outcomes for those persons and shortcomings in response and recovery operations.

Concept of Operations

A. Each care-giving entity within the city is responsible for using all its resources to form a comprehensive emergency response program that addresses citizens with functional needs who either have been or might be affected by an emergency or major disaster.

B. Family and care givers provide the first and most important level of response in a disaster. Until routine assistance is re-established, providing emergency services that recognize and accommodate those persons with functional needs will be required.

C. Private industry and service organizations are key partners for city departments in responding to emergencies affecting persons with functional needs. Volunteer organizations with specific training and experience supporting persons with Functional needs, such as the American Red Cross, The Salvation Army, and church groups are uniquely suited to assist when emergencies happen. Including these organizations in the city's planning process is critical to the success of the subsequent response efforts.

D. People with functional needs, and agencies and organizations that provide support to these individuals are valuable resources in the city. Individuals with functional needs have firsthand experience regarding the assistance they require. Including people with functional needs at all levels of emergency response planning is critical to the development of a comprehensive response plan.

Organization and Assignments of Responsibilities

All departments are responsible for conducting their routine and emergency services in ways that promote assistance to persons with functional needs.

The Office of Emergency Management, in partnership with Human Services and the Department of Social Services will provide the following, as necessary:

1. Identification of emergency response barriers affecting the functional needs population.
2. Facilitate the delivery of specialized training regarding persons with functional needs.
3. Preparation and dissemination of appropriate emergency public information to include specialized materials tailored to specific populations with functional needs.
4. Coordinate the distribution of essential resources, supplies or services during an emergency.

Tab 1 to Functional Needs Support Annex
Action Checklist

Routine Operations

- Develop plans and procedures that address the requirements of citizens with functional needs.
- Review and update plans and procedures.

Increased Readiness

- Confirm task assignments and alert key personnel to stand-by status.
- Anticipate and resolve special problems.
- Begin record keeping of disaster related expenses and continue for the duration of the event.

Response Operations

Mobilization Phase

- Activate the shelter or activate agreements for other lodging, as required.
- Provide mass transportation, as required.
- Receive and care for evacuees/displaced persons with functional needs. Register and maintain accurate records on their status. Provide mass feeding, as required.
- Provide status reports to the EOC.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Continue to receive and care for displaced persons with functional needs until reentry to the impacted area(s) is granted. Provide mass feeding, as required.

Recovery Operations

- Provide long-term housing and care, as needed.
- Consolidate and report disaster-related expenses.

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Support Annex – Shelter Management

Introduction

Coordinating Agency

- Department of Social Services

Cooperating Agencies

- American Red Cross
- Department of Parks, Recreation and Community Facilities
- Human Services
- Office of Emergency Management
- Office of the Press Secretary
- Richmond Behavioral Health Authority
- Richmond Animal Care and Control
- Richmond City Health District
- Richmond Public School System
- Richmond Redevelopment and Housing Authority
- Richmond Sheriff's Office
- Virginia Voluntary Organizations Active in Disaster

Purpose:

The Shelter Management Support Annex describes the coordinating processes used to direct shelter operations in the City.

Scope:

This annex assigns broad responsibilities to city departments and support organizations for sheltering preparedness, operations, and response. It is supported by documents that address specificities relevant to the process of shelter operations.

Situation:

The City of Richmond is vulnerable to a variety of hazards such as flash flooding, river flooding, hurricanes, winter storms, tornadoes and hazardous materials incidents. Many of these hazards could result in the need to shelter residents. To respond effectively to any emergency of a size or complexity beyond routine response systems, it is critical that public officials, departments, non-governmental emergency organizations and the public understand their roles and responsibilities. These non-routine responsibilities begin as the incident is recognized and preparation or response ensues, and become particularly important as command organizes beyond the initial reactive phase of first responders.

Assumptions:

1. The development and execution of effective shelter management takes into consideration the character and associated needs of the impacted community by an evacuation and/or sheltering operation, and includes an assessment of the resources and capabilities required to implement the various actions that may be employed in a timely manner.
2. Plans and procedures for identified shelter sites will be available pre-event to ensure that shelter sites are prepared, trained, and staffed.
3. Sufficient warning time may not be available, pre- or post-event, to ensure that shelters are opened in time to provide shelter and other services for the people that have been evacuated from an area.
4. There are ongoing efforts to proactively reach out and educate citizens on all sheltering procedures to include when to shelter-in-place, where to go for information on sheltering options, and what to bring to a public shelter to assist in self-sustainment.
5. All hospitals, nursing homes, and group residential facilities operated by private or public agencies based upon licensing requirements will have pre-determined evacuation and/or refuge plans.
6. Departments will work together to allow for adequate shelter management staff at the designated shelter sites.
7. A variety of communication pathways will be used in order to effectively communicate not only the location of shelters, but also what materials citizens will need to have in hand to increase comfort at available shelter sites. Additionally, these pathways will need to disseminate information on what not to bring to shelters and how to assist with certain special consideration populations (i.e., pets, medically fragile, etc.).
8. Despite the comprehensive effort implemented to communicate shelter locations, some segments of the population might not receive or follow the instructions given.
9. A method for registering and tracking evacuees will be established and maintained.
10. Richmond Animal Care and Control, as the lead department for ESF #16, produces and maintains plans, policies and procedures for overarching animal care and control activities, animal recovery and household pet sheltering.
11. Should the City of Richmond, opt to provide ice and care packages to residents impacted by an emergency, the resources will be distributed using the existing shelters as distribution points.

Concept of Operations

A. The Shelter Management Support Annex is the core plan for managing sheltering procedures with an all-hazards approach. Other supplemental department and interdepartmental plans provide details on authorities, response protocols, and technical guidance for responding to and managing specific incidents (such as hazardous materials spills, hurricanes, etc.).

B. At the onset of any of these events, plans that are in place, to include shelter site plans, would be set into motion to assist with the sheltering needs of any given area that would be affected by these events.

C. Sheltering operations will vary from situation to situation, especially when consideration is given to incidents involving the need for decontamination of evacuees prior to entry into a shelter environment. This document will address general situations with no consideration given for special incident scenarios. For more information on special incident scenarios, consult the appropriate City of Richmond Emergency Operations Plan annex for additional guidance.

D. The Shelter Management Support Annex may be used in conjunction with other City of Richmond incident management and EOPs developed under these and other authorities as well as memoranda of understanding (MOUs) among various local, State, and Federal agencies.

Organization and Assignment of Responsibilities

The emergency situation will determine the scope of evacuation and the number of evacuees. Determination of a need for shelter operations will be accomplished by a coordinated effort between the Department of Social Services and Office of Emergency Management. Departments with operational responsibilities include, but are not limited to the following.

The Department of Social Services will provide the following, as necessary:

1. Coordinate the effort to identify shelter sites.
2. Maintain site specific plans and procedures.
3. Exercise the functionality of those plans and procedures.
4. Oversee the operation of shelters in caring for people evacuated from their homes, as well as homeless and transient citizens.
5. Request and coordinate the assistance provided by non-governmental and volunteer relief organizations.
6. Facilitate the transition of evacuees through the human service system from response to recovery.
7. Provide shelter occupancy data to the Emergency Operations Center.
8. Use 3-1-1 and/or other communications channels to assist with outreach efforts to citizens on evacuation education pre-event, notification during an event and reunification post-event.
9. Monitor, coordinate and manage shelter activation.
10. Coordinate long-term housing and care as needed.
11. Subject matter expertise to other city departments, as needed.

The Office of Emergency Management will provide the following, as necessary:

1. Recommend policies, procedures and projects necessary for the implementation of sheltering for the City of Richmond.
2. Facilitate training across departments regarding sheltering plans.
3. Publish approved policy guidance including performance measures.
4. Coordinate city sheltering efforts with external agencies to include state and federal partners.
5. Coordinate efforts for reimbursement to departments and partners participating in sheltering efforts.

The Richmond Sherriff's Office will provide the following, as necessary:

1. Law enforcement staffing and security at shelters.

2. Subject matter expertise to other city departments, as needed.

Richmond Behavioral Health will provide the following, as necessary:

1. Subject matter expertise in matters relating to the needs of citizens with mental health, intellectual disability, and/or substance abuse issues.
2. Guidance in developing assistance for citizens with mental health, intellectual disability, and/or substance abuse issues that may come to a shelter.
3. Assurance that the local facilities and community services boards are aware of their responsibilities in the event of a major disaster involving sheltering operations and have in place necessary procedures and plans for responding to major disasters.
4. Direction to the local facilities, in the event of a major disaster, to establish liaison with local and State emergency services offices and to make their facilities available for relief assistance.
5. Crisis intervention services at shelters.
6. Any additional assistance as required by the Office of Emergency Management, within the capability of the Department; this includes on-site visits to assess service needs and provision of needed technical assistance.

Richmond City Health District will provide the following, as necessary:

1. Plan and prepare to assist evacuees with special medical needs at shelters.
2. Assist with the media outreach efforts of shelter education pre-event targeting potential medically fragile evacuees.
3. Subject matter expertise in matters relating to the people with special medical needs in shelter.
4. Subject matter expertise on other topics to other city departments, as needed.

Richmond Public School Systems will provide the following, as necessary:

1. Coordinate with the Department of Social Services regarding available facilities for use as shelters.
2. Additional means of transportation for evacuation of impacted citizens.
3. Subject matter expertise to other city departments, as needed.

Department of Parks, Recreation and Community Facilities will provide the following, as necessary:

1. Coordinate with the Department of Social Services regarding available facilities for use as shelters.
2. Subject matter expertise to other city departments, as needed.

American Red Cross will provide the following, as necessary:

1. Assistance, as outlined in Memorandum of Understanding and in concert with VAVOAD, to support feeding, supplies and food provisions at shelter locations as needed.

Virginia Voluntary Organizations Active in Disaster (VAVOAD) will provide the following, as necessary:

1. Feeding capability and food provisions at shelter locations.

Tab 1 to Shelter Management Support Annex
Action Checklist

Routine Operations

- Develop plans and procedures to receive and care for evacuees.
- Designate shelter center(s). Determine maximum capacities for each.
- Designate shelter manager(s) and other key personnel.
- Review and update plans and procedures.

Increased Readiness

- Confirm task assignments and alert key personnel to stand-by status.
- Prepare the necessary forms.
- Anticipate and resolve special problems, such as receiving nursing home patients, closing of schools, etc.
- Begin record keeping of disaster related expenses and continue for the duration of the event.

Response Operations

Mobilization Phase

- Activate the shelter or activate agreements for other lodging, as required.
- Provide mass transportation, as required.
- Receive and care for evacuees/displaced persons. Register and maintain accurate records on their status. Provide mass feeding, as required.
- Provide status reports to the EOC.
- Using WebEOC, begin tracking all disaster-related actions and expenditures and continue to do so for the duration of the event.

Emergency Phase

- Continue to receive and care for displaced persons until reentry to the impacted area(s) is granted. Provide mass feeding, as required.

Recovery Operations

- Provide long-term housing and care, as needed.
- Consolidate and report disaster-related expenses.

Tab 2 to Shelter Management Support Annex
Designated Shelters

Facility	Capacity
Arthur Ashe Center 3001 N. Boulevard Richmond, VA 23230	1920
Linwood Holton Elementary 1600 W. Laburnum Ave 23227	358
Thomas Henderson Middle School 4319 Old Brook Road 23227	312
James Blackwell Elementary 1600 Everett Street 23224	358
Miles Jones Elementary 200 Beaufont Hill Drive 23225	358
Boushall Middle School 3400 Hopkins Road 23234	290

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Incident Annex – Hazmat

Introduction

Purpose

The Hazardous Materials (Hazmat) support annex provides the organizational framework and defines the roles and responsibilities City departments will use when responding to a hazardous materials incident. It emphasizes the relationship between the regulatory, law enforcement, emergency management and private sector components of the program, to more effectively support prevention and preparedness initiatives, as well as enhance the capabilities and capacities of response and recovery organizations involved in protecting the health, safety, and property of the citizens of the City of Richmond. Additionally, it is designed to adapt to and meet the challenges of these types of incidents by adopting NIMS.

Situation

Accidents or emergencies involving the broad spectrum of hazmat can and do occur anywhere within the City. The vulnerability to hazardous materials incidents is continually increasing due to the growth in the use, storage, processing and transportation of hazardous materials to support the needs of the industrial, technological, medical, and energy sectors of the economy. As such, local, regional, state and federal response organizations must develop the tactical capability and acquire the necessary tools to assist in promptly identifying the hazard(s) with which they are confronted and develop an effective incident action plan with the necessary resources to support it.

Assumptions

A. It may not be initially evident that the emergency or disaster event is accidental or naturally occurring in nature, or precipitated by criminal acts or terrorist actions.

B. The complexities of hazmat incidents and the associated consequences may exceed the capabilities of the City and require specialized assistance and support from a variety of regional, state, federal and military organizations.

C. Site restoration and rehabilitation will be conducted to the extent that it is technically feasible, economically practical and prudent from a health, environmental and public safety perspective.

D. Site remediation will be overseen and monitored by the appropriate agencies that have jurisdiction under the law and possess the necessary technical knowledge and expertise to restore the impacted area to a level that is considered clean, safe and capable of supporting the same or similar type pre-event use.

E. Other departments not specifically tasked in this plan may be assigned tasks as required under the authority of the City of Richmond EOP.

Concept of Operations

A. If the shipper, manufacturer, or other responsible party is unable to report the incident in a timely manner, the spiller is unknown, unwilling, or unable to find an appropriate response to alleviate the situation, the City, within its capability, must act to prevent or minimize injuries and property damage and report the incident in accordance with state and federal regulations. Once informed of actual or potential events, the Richmond Fire Department Hazmat Officer is responsible for notifying the VEOC of the incident whether or not assistance is required.

B. When notified of a hazmat incident, the VEOC will contact the Region I Hazardous Materials Officer (RHMO). The RHMO will assess the situation and respond on scene, if warranted, or if requested by the City, to provide advice and coordinate requests for further assistance through the VEOC. The VEOC will also notify the appropriate Local Support Services Division Region I Coordinator.

C. Richmond Fire Department will establish an Incident Command, assess the situation and take steps necessary to provide public warning, initiate protective actions and isolate the general area affected.

D. If the situation exceeds local capabilities, the RHMO activates the regional HAZMAT team that services the City of Richmond. The determination to activate the team can be made based on discussions with the Incident Commander by telephone or after arriving on-scene and assessing the situation.

E. A field command post will be established at the scene of incidents that require on-scene coordination. On-scene coordination of the response will be accomplished within the framework of NIMS using the ICS. The unified command will develop a response strategy after conducting an assessment of the situation that will include but not be limited to the following: the nature, amount, and locations of real or potential releases of hazmat; pathways to human and environmental exposure; probable direction and time of travel of the materials; potential impact on human health, welfare, safety, the environment, and property; identification of the types, location, and availability of response resources and technical support required; and establishment of priorities.

F. ESF 10 will be established, if necessary, to coordinate resources in support of field operations. ESF #8 will provide technical assistance and support to ESF 10 as required.

G. The Emergency Alert System (EAS) will be activated as necessary to alert the public of an imminent or actual hazardous materials event that may pose a threat to life and/or property and require the immediate implementation of protective actions (evacuation/in-place sheltering). The National Weather Service also has the capability through NOAA Weather Radio (NWR) to send a Civil Emergency Message (CEM) to the public.

H. All costs associated with response and recovery operations will be tracked and documented to support reimbursement from the responsible party or from the appropriate state and federal funds that may be applicable to the event.

Organization and Assignment of Responsibilities

The organizational response framework to events involving hazmat necessitate the coordination and interface of a variety of local, state and federal agencies that have certain authorities, responsibilities and jurisdiction by statute, executive order or presidential directive. These authorities may vary by the type of incident, the categorization of the incident, geographic area involved and may transition by operational stage during an event. The planning and response frameworks established at the local, state and federal levels are briefly summarized below.

1. The Richmond Local Emergency Planning Committees (LEPCs) and the Virginia Emergency Response Council (VERC) are organizational structures that were established under the Superfund Amendments and Reauthorization Act (SARA Title III), also referred to as the Emergency Planning and Community Right to Know Act (EPCRA). This legislation requires industry to share information with the community to enhance hazmat preparedness.

2. The VERC was established to carry out the provisions of EPCRA at the state level. The duties of the Council include designating emergency planning districts, appointing Local Emergency Planning Committees, providing guidance and technical assistance to LEPCs and the regulated community, and establishing procedures for receiving and processing requests from the public for information.

The general assignment of responsibilities is detailed in the City of Richmond EOP and more specifically within the ESF Annexes. Responsibilities specific to a hazmat incident are provided below:

Richmond Fire and Emergency Services Department

1. Develop and maintain plans and procedures to address the full spectrum of technological hazards.
2. Develop and maintain a hazmat emergency response program to protect human health and the environment from the effects of hazmat incidents.
3. Establish standard and comprehensive procedures to ensure the safety of emergency responders while responding to hazmat incidents.
4. Coordinate the preparation and dissemination of public information releases with the appropriate local, state, and federal agencies.

Richmond Police Department and Sheriff's Office

1. Assist in dissemination of warning.
2. Assist in evacuating areas at risk in coordination with state and federal law enforcement authorities, as well as other emergency support functions.
3. Implement traffic control actions in and around site, as required.
4. Establish the necessary security and accessibility policies around site and evacuated areas in coordination with state and federal law enforcement.

5. Coordinate the development and preservation of evidence to support criminal litigation during the response and recovery phases of an incident with other emergency support functions.

Richmond City Health District

1. Develop plans and procedures to coordinate emergency medical and health operations for the control of chemical and biological contamination. Coordinate response and recovery actions for public health hazards resulting from such contamination.
2. Coordinate the activation and deployment of follow-on medical resources needed to stabilize extended incidents.
3. Assist in incident evaluation and assessment.
4. Conduct environmental/health monitoring as required.
5. Recommend the necessary protective actions for responders, essential facilities comprising the medical care system, and the general population.
6. Provide technical advice, as requested, to medical facilities in developing and maintaining a capability to receive, treat, and care for contaminated patients.
7. Identify medical facilities capable of receiving, decontaminating, and treating contaminated patients, along with the number of patients each facility can accept.
8. Develop criteria for reentry into structures and evacuated areas, and advise the City when the health and medical criteria have been met.

Tab 1 to Hazmat Incident Annex
Action Checklist

Routine Operations

- Develop, review and test City of Richmond hazardous materials plans, policies and procedures.
- Provide training to departments and staff on task-appropriate plans, policies and procedures.

Increased Readiness

- Determine availability of special team members.
- Coordinate information dissemination internally and externally

Response Operations

Mobilization Phase

- Report any anticipated shortfalls and request needed assistance or supplies.
- Alert personnel to stand-by status.
- Continue to coordinate information dissemination internally and externally.
- Ensure appropriate recordkeeping such that federal or state disaster assistance can be sought for reimbursement of disaster related expenditures.

Emergency Phase

- Follow established procedures in providing HAZMAT response.
- Continue to coordinate information dissemination internally and externally.
- Implement evacuation or shelter in place plans, policies and procedures, as necessary.
- Continue to provide record keeping, as required.

Recovery Operations

- Review plans, policies and procedures in respect to the recent emergency response. Update as necessary and disseminate.
- Assist with requests for post-disaster assistance as required.
- Recover equipment and return it to service, replace where necessary.
- Compile and submit records of incurred disaster related expenses.

Tab 2 to Hazmat Incident Annex
Authorities

Local

1. The Local Emergency Planning Commission (LEPC) *Hazardous Materials Response Plan.*

State

1. Commonwealth of Virginia Emergency Services and Disaster Law.
2. Commonwealth of Virginia Emergency Operations Plan.
3. Commonwealth of Virginia Radiological Emergency Response Plan, 2006.
4. Commonwealth of Virginia, Department of Environmental Quality Hazardous Waste Management Regulations, as amended.
5. Code of Virginia, Title 62 (Water Control Law), as amended.
6. Commonwealth of Virginia Hazardous Materials Transportation Regulations (VR672-30-1), as amended.
7. Virginia Waste Management Act, Section 10.1-1400 of the Code of Virginia (1950), as amended.
8. Code of Virginia, Fire Protection, Section 27-15.1, as amended.

Federal

1. National Response Framework, January 2008.
2. Public Law 96-510, December 1980, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as "Superfund."
3. Public Law 99-499, October 17, 1986, Superfund Amendments and Reauthorization Act, Title III, Emergency Planning and Community Right-to- Know, commonly known as SARA Title III.
4. Public Law 92-500, Federal Water Pollution Control Act, commonly known as the Clean Water Act (CWA), as amended.
5. Public Law 93-288, The Robert T. Stafford Disaster Relief and Emergency Assistance Act.
6. Public Law 101-380, The Oil Pollution Act of 1990, commonly known as OPA-90.
7. National Hazardous Substance Contingency Plan, 40 CFR, Part 300, November 1985, U. S. Environmental Protection Agency.
8. Federal Region III Oil and Hazardous Substance Pollution Contingency Plan, November 1988.
9. Virginia Coastal Area Contingency Plan, U.S. Coast Guard, October 2006.
10. Virginia Inland Area Contingency Plan, Environmental Protection Agency, December 1996.
11. 29 CFR 1910, Occupational Safety and Health Standards for General Industry

Incident Annex – Hurricane

Introduction

Purpose

The Hurricane Incident Annex is a hazard-specific incident plan to the City of Richmond Emergency Operations Plan. This plan establishes, within the general guidance of the City of Richmond EOP, the hurricane-specific concepts and policies under which all elements of city government will operate. It was developed to provide for the safety and welfare of citizens by minimizing the loss of life and property and expediting the restoration of essential services following a tropical storm or hurricane.

Situation

The City of Richmond is susceptible to impacts from a tropical storm or hurricane. Tropical systems can produce high winds, localized heavy rains and/or flooding. These secondary tropical system effects are less predictable than the storm surge and hurricane force winds that can impact the coastal communities of Virginia.

Reporting, warning, notification and communications are included in the City of Richmond EOP. In addition there are several hurricane-specific requirements, which must be considered.

- There will be an immediate and continuous demand for information needed in the decision-making process.
- There may be delays in acquiring and assimilating the information.
- Communications problems, damage, weather, flooding and other environmental factors may restrict situation assessment operations.

Richmond is located near two summer tourist areas, Virginia Beach and the Outer Banks of North Carolina. Tourists and residents may travel through Richmond if those areas are evacuated. The City of Richmond will coordinate with the VEOC and neighboring jurisdictions to address traffic conditions and an influx of citizens in need of sheltering.

Assumptions

A. Pre-disaster warning time will vary; however, the National Weather Service will detect and track a hurricane in time for effective action to be taken in accordance with the provisions of this plan.

B. A declaration of emergency will be considered in advance of actual hurricane conditions.

C. When a hurricane strikes, help may not be immediately available from the state or federal government. The City of Richmond is prepared to bear the initial responsibility for hurricane response and relief as well as preparation for the arrival of a hurricane.

D. The EOC will continue to be operable despite the effects of a hurricane.

Concept of Operations

A. An effective response to a tropical storm or hurricane emergency is dependent on the development of plans, programs, and procedures, which will provide for rapid mobilization and effective use of the resources, capabilities and support from other localities through Statewide Mutual Aid *(SMA)*.

B. The City's response to the event will be under the direction of the Emergency Management Coordinator, who reports directly to the Mayor, or his designee.

C. The Office of Emergency Management will monitor the situation, disseminate appropriate weather information on a continuous basis and augment the Emergency Operations Center accordingly. The EOC will be staffed to collect information, review status of pre- and post-landfall protective actions, produce the required reports and coordinate requests for assistance.

D. Each department should designate an individual to develop and maintain their appropriate disaster preparedness, response, and recovery program in accordance with emergency duties and responsibilities as assigned in the City of Richmond Emergency Operations Plan and this annex.

E. Non-tasked departments may be called upon to provide assistance where needed.

Organization and Assignment of Responsibilities

General organization and assignment of responsibilities are detailed in the City of Richmond EOP and more specifically within the ESF Annexes. Responsibilities specific to a tropical storm or hurricane are provided below:

1. The Office of Emergency Management will participate in VDEM sponsored conference calls with National Weather Services and localities within the region.
2. As necessary, the Office of Emergency Management will conduct conference calls with National Weather Service and city departments to discuss storm arrival, potential impact and operational issues to include evacuation and sheltering.
3. The Office of Emergency Management will maintain storm assessment capability, utilizing the storm tracking computer program "HURREVAC."
4. If the City of Richmond is impacted by a tropical system, the Emergency Management Coordinator will submit situation reports, as needed, to the VEOC.
5. The decision, timing and interval of when to permit residents and property/business owners to return to the risk area, post landfall, will be made cooperatively between the City of Richmond and VEOC.
6. The Mayor may initiate a curfew as a crime prevention measure depending on the intensity of the disaster and the level of damage sustained.

Tab 1 to Hurricane Incident Annex
Action Checklist

The Readiness Conditions listed below aligned with the Commonwealth of Virginia Emergency Operations Plan (COVEOP) and Center (VEOC)

Routine Operations – *Readiness Condition 5 - (June 1st through November 30th)*

- Monitor weather systems for possible development of tropical systems.
- Maintain plans, conduct training and exercises, test emergency communications periodically.

Increased Readiness – *Readiness Condition 4 - A tropical weather system has developed which has the potential to impact the City within 144-96 hours (D-6 to D-4 days).*

- Begin preparatory actions by identifying stocks of materials, pre-warning emergency services personnel, etc.
- Continue to track the weather system and maintain situational awareness.
- Advise the public on emergency preparedness actions.

Response Operations

Mobilization Phase

Readiness Condition 3 - Tropical storm force winds from a tropical weather system may impact the City within 96-48 hours (D-4 to D-2 days).

- All appropriate departments and organizations should continue to be informed of the situation. Continue to track the weather system and maintain situational awareness.
- Augment Emergency Operations Center.
- Fuel vehicles and generators.
- Provide evacuation and shelter recommendations to the Mayor or his designee.
- Begin pre-positioning of evacuation personnel and resources.
- Advise ESF #6 and #16 of potential shelter operation requirements.

Readiness Condition 2 - Tropical storm force winds may impact the City within 48-24 hours (D-2 to D-1 days).

- **48 hours** prior to the forecast arrival of tropical storm force winds, the National Hurricane Center *(NHC)* will issue a Hurricane Watch for the projected impact areas.
- **36 hours** prior to the forecast arrival of tropical storm force winds, the National Hurricane Center *(NHC)* will issue a Hurricane Warning for the projected impact areas.
- Monitor status of public sheltering conditions.
- Accelerate all preparedness actions for emergency and vital affected services.
- Maintain knowledge of storm track, size, probabilities, and decision point times.

- Recommend departments take necessary actions in order to prepare for the threat from the approaching storm.
- Continue to track the weather system and maintain situational awareness.

Readiness Condition 1 - Tropical storm force winds may impact the City within 24 hours (D-1 day).

- Evacuations should be completed prior to the arrival of tropical storm force winds.
- Continue to monitor evacuation and sheltering activities and track availability and locations of local Refuges of Last Resort.
- Condition 1 should be maintained through the storm event and until the threat has receded as appropriate.

Emergency Phase

Landfall - Period between the arrival and final departure of tropical storm force winds.

- Report shelter status and needs to EOC as communications systems allow.
- Gather information about where damage has been observed.
- Shut down non life safety operations when sustained winds are above 40 mph.
- Shut down life safety operations when sustained winds are above 50 mph.

Emergency Relief Phase - Life-saving operations and the restoration of essential services. Usually ends when it is safe to allow residents to return to their homes.

- Coordinate the distribution of supplies and resources.
- EOC provides status reports to department heads and CAO.

Following the storm event, response and recovery operations should be undertaken as outlined in the City of Richmond EOP.

Recovery Operations

- Damage assessment teams complete assigned tasks and reports.
- Monitor progress of re-entry and shelter populations.
- Develop long-term sheltering capacity, if needed.

Tab 2 to Hurricane Incident Annex
Saffir-Simpson Hurricane Scale

Non-Hurricane Classifications		
	Wind - Knots	**Wind - MPH**
Tropical Storm	35-63	39-73
Tropical Depression	< 34	< 39

Category	Winds Knots	Winds MPH	Pressure Millibars	Pressure Inches	Anticipated Damage
1	64 - 82	74 - 95	>980	28.94	Very Dangerous Winds – Will Produce Some Damage
2	83 - 95	96 - 110	965 - 979	28.50 - 28.91	Extremely Dangerous Winds – Will Cause Extensive Damage
3	96 - 113	111 - 130	945 -964	27.91 – 28.47	Extremely Dangerous Winds – Devastating Damage Will Occur
4	114 – 135	131 – 155	920 – 944	27.17 – 27.88	Extremely Dangerous Winds – Catastrophic Damage Will Occur
5	> 135	> 155	< 919	< 27.16	Extremely Dangerous Winds – Catastrophic Damage Will Occur

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Incident Annex – Terrorism

Introduction

Purpose

The Terrorism Incident Annex is a hazard-specific incident annex to the City of Richmond Emergency Operations Plan. It was developed to provide for the safety and welfare of citizens by minimizing the loss of life and property and expediting the restoration of essential services following an act of terror.

Situation

The City of Richmond is the state capital. Because of its location, in the middle of the eastern seaboard, it is within 750 miles of two-thirds of the nation's population and less than 100 miles from the nation's capital. The City is intersected by Interstates 95, 64 and 295, two major freight lines and Amtrak passenger service. The City is within 50 miles of both the Surry and North Anna Power Stations. Additionally, Richmond is home to the Fifth District Federal Reserve Bank and the Fourth Circuit U.S. Court of Appeals.

Assumptions

A. It may not be initially evident that the event is accidental or precipitated by criminal acts or terrorist actions.

B. A declaration of emergency will be declared at both the local and state level.

C. The EOC will continue to be operable despite the effects of a terrorist event.

E. The Federal Bureau of Investigation, Department of Homeland Security *(DHS)*, FEMA and other federal agencies may, in accordance with the National Response Framework, provide an immediate response and recovery assistance.

Concept of Operations

A. Depending on the type of incident, the Richmond Police Department (bomb, civil disorder), Department of Information Technology (cyber), Richmond City Health District (biomedical) or Richmond Fire and Emergency Services Department (hazmat, fire or MCI) will provide and coordinate the response to an incident until it is identified as a possible terrorism event.

B. Should an incident be identified as a possible terrorism event, the Virginia Emergency Operations Center will be notified.

C. Unified Command will be established.

Organization and Assignment of Responsibilities

Presidential Directive 39, states the Federal Bureau of Investigation is the designated lead federal agency for any terrorism event.

General organization and assignment of responsibilities for City departments are detailed in the City of Richmond EOP and more specifically within the ESF Annexes. Responsibilities specific to an act of terror are provided below:

1. The Office of Emergency Management will coordinate consequence management with VDEM.
2. Richmond Police Department and Sheriff's Office will coordinate crisis management with the Virginia State Police as well as provide traffic and crowd control, as needed.
3. Richmond City Health District will provide mass immunization and/or administer medication, as needed.
4. Richmond Fire and Emergency Services will provide technical rescue and search and rescue support, as needed.

Tab 1 to Terrorism Incident Annex
Action Checklist

Routine Operations

- Develop, review and test City of Richmond terrorism response plans, policies and procedures.
- Provide training to departments and staff on task-appropriate plans, policies and procedures.

Increased Readiness

If warning of an event occurs:
- Determine availability of special team members.
- Coordinate information dissemination internally and externally.

Response Operations

Mobilization Phase

- Alert personnel to stand-by status.
- Continue to coordinate information dissemination internally and externally.
- Ensure appropriate recordkeeping such that federal or state disaster assistance can be sought for reimbursement of disaster related expenditures.
- Activate Emergency Operations Center, if appropriate.

Emergency Phase

- Follow established procedures.
- Continue to coordinate information dissemination internally and externally.
- Implement hazmat, search and rescue and other plans, policies and procedures, as necessary.
- Continue to provide record keeping, as required.

Recovery Operations

- Review plans, policies and procedures in respect to the recent emergency response. Update as necessary and disseminate.
- Assist with requests for post-disaster assistance as required.
- Compile and submit records of incurred disaster related expenses.

Incident Annex – Earthquake

Introduction

Purpose

To enable coordinated, multi-department, multi-jurisdictional response to an earthquake. It applies to all City Departments and provides information to all partners that support or depend on the City response.

Scope

This Annex addresses the challenges posed by the following hazards:

- Earthquake and associated aftershocks
- Severe earthquake that causes large numbers of causalities, widespread damage, and catastrophic impacts.

Assumptions

A detailed common operating picture may not be achievable for 24 to 48 hours, or longer, after the earthquake, response operations may have to begin without a complete or detailed situation and critical needs assessment.

Staffing varies in many City departments depending on the time of day, should an earthquake strike at the time of lowest levels of staffing the response will be significantly impaired until personnel can respond.

There are not enough City public safety resources to immediately address all, or even a majority of the life safety needs expected after a severe earthquake.

Fires are the leading danger immediately following an earthquake due to the expected number fires, damage to fire suppression systems, damage to water pipelines, difficulty in accessing fire incidents and limited resources.

The number of expected deaths could exceed the capacity of the Medical Examiner's Office, as well as any local mutual aid that office might call upon, which may require the mobilization of federal resources, establishment of temporary morgues, and instructions to the public on fatality management.

The 911 phone system, if operating, may be overloaded.

During the initial response, the amount of radio use by responders could overload the 800 MHz radio system.

The limited capacity in the region for charging portable radio batteries and the expected high tempo of operations will make it difficult to keep City 800 MHz portable radios charged.

Damage to City owned buildings may impact the ability of City employees to effectively respond.

Traffic congestion may be significant due to possible roadway damage which can impact operations such as the establishment of shelters.

The City does not stockpile food or water for the general public.

The level of personal preparedness by the public is insufficient to significantly decrease the need for public services

Hospitals may not have sufficient capacity to meet the surge in patient demand.

Damage to water utility infrastructure may impair firefighting.

Numerous initial, separate fires may combine to create extremely large fires.

Spontaneous shelters will likely be established by private entities not in coordination with government.

The number of individuals seeking shelter will exceed the City's emergency shelter capacity.

Unreinforced masonry buildings may be at risk of significant damage or collapse.

Social media will be an important source of information for the general public; however, the accuracy of social media reports may cause confusion.

The private sector will volunteer assistance to the response effort and provide contract services, which will require coordination with the public response.

Many individuals will volunteer to assist with the response; while this represents a potential resource it will also present significant operational and logistical challenges.

Donated goods, solicited and unsolicited, may present a significant challenge to manage

Departments should expect to receive no logistical support from the City Emergency Operations Center for 72 hours.

Neighboring jurisdictions will also be impacted, limiting the availability of mutual aid, and making it important to coordinate regional response operations through the Virginia Emergency Operations Center (VEOC).

Concept of Operations

Even in an earthquake with catastrophic impacts, the City will retain jurisdiction and authority over the response and recovery efforts. This will be accomplished by maintaining a line of succession throughout the City government, clearly defining areas of operations and responsibility, establishing alternate command centers, augmenting command and general staff using Mutual Aid resources and delegating authority where needed.

On duty personnel will be responsible for the first hours of the response. The initial common operating picture will be imperfect due to the many challenges that will follow an earthquake. It will be based primarily on windshield surveys conducted by the Police and Fire Department and possibly some early media reports.

The initial response to an earthquake consists of supporting and coordinating life safety efforts; controlling fires, addressing hazardous materials releases, providing emergency medical care, ensuring access to hospitals, conducting rescues and evacuations and maintaining public order. Damage to dams, water storage facilities or large pipelines may require immediate response operations to address hazards.

Responders may have to make difficult choices regarding where to assign the limited resources available. Close coordination and unity of effort between all responders will be especially critical.

Repair of roads and bridges and water service to support life safety response operations will have priority over other repair missions.

Inspecting city own buildings to include bridges will have priority.

To support the response, the first public message will be broadcast within the first hour following the earthquake. The first message will include instructions to limit travel on roadways and use of the phone system.

Concurrent with these early response operations, command center will be activated, the mobile command center will be deployed, damage or impacts to infrastructure, facilities and systems determined, a more comprehensive command operating picture developed. City objects and priorities established, resources obtained, a local emergency declared if necessary.

Efforts will begin as soon as possible to establish shelter operations. The strategy for sheltering will be determined during the first operational period in the Emergency Operations Center.

As immediate life safety issues are addressed and stabilized, the number of shelters established and their capacity may increased as rapidly as available resources permit. To the degree practical, shelters will be established nearest to the community in need. Residents will be encouraged to remain in their homes if at all possible. Points of Distribution for fold and water may be established for this purpose.

Communications and coordination with neighboring jurisdictions and the State will be established as early as possible. The plans and logistics necessary to address the best use of private sector and State resources will be coordinated from a strategic level through the City Emergency Operations Center.

Mass fatality management and missing person investigations will be established as early as possible. An effective process for determining the status of missing persons contributes to stabilization and ultimately decreases the demand on law enforcement, medical and rescue resources. The city will advocate for a regional approach to mass fatality management and missing person investigations in order to maximize limited resources provide for a consistent approach and high quality of service. Public Health will lead this mission with close support from ESF 13. Planning for recovery will begin as soon as possible and in parallel to response operations.

Earthquake Response

City departments will err on the side of caution and be proactive when determining what initial actions to take following an earthquake.

Departments

Departments will initiate response operations when an earthquake occurs that may have caused damage or impacts to City facilities systems or services.

Emergency Operations Center

Office of Emergency Management (OEM) staff will automatically respond to activate the Emergency Operations Center (EOC) immediately following an earthquake that may have caused damage or impacts to City facilities systems or services. OEM staff will issue information via the most effective communication method available.

Earthquake Responses Goals

- Saving and protecting the greatest number of people at risk
- Provide for the safety of responders and other city employees
- Saving and protecting as many residential, business and industrial properties as possible
- Saving and protecting as much critical infrastructure as possible
- Stop the spread of environmental damage
- Minimizing human hardship and economic disruption

Response Priorities

- Life Safety
- Incident Stabilization
- Property Conservation
- Environmental Protection

Initial City Objectives for Earthquake Response

Initial City objectives provide a starting point for the response and will be modified as needed.

- Support a City strategy for firefighting, emergency medical service, rescue and hazardous material response
- Assess damage and impacts to community
- Provide sheltering in coordination with regional efforts
- Sustain public confidence and trust in response and recovery efforts
- Ensure life sustaining essentials are available to the public such as food, water, sanitation, medical care and fuel
- Sustain situational awareness for City response and recovery

Common Operating Picture

Departments will exchange information on damage and impacts to systems through the most effective communication method available at the time. Once the EOC is activated, these reports will be consolidated into Situation Reports and Incident Action Plans. The goal is to develop a Common Operating Picture that includes an understanding of the extent of damage and impacts to people, systems and services.

Attachment 1 – Critical Information for the First 24 Hours

The following information should be collected as soon as reasonably possible to protect life and property.

− Number and locations of deaths and injuries.

− Location and extent of secondary events, including aftershocks, fires, landslides, and hazardous materials events.

− Requirements for major evacuations and estimated number of people displaced.

− Location of severely damaged or collapsed structures

− Location and estimated number of people trapped in collapsed structures.

− Status of communication systems, including:

 Public telephone and wireless systems (to include internet)
 Public Safety Answering Points (PSAP) "911 center"
 Radio and televisions (emergency public information access points)

− Damage to critical public buildings and other infrastructure, including:

 Emergency Operation Centers
 Police and fire facilities
 Hospitals, shelters, and skilled nursing facilities
 Bridges and tunnels
 Schools
 Jails
 Public transportation networks.
 Other facilities deemed to be critical infrastructure

− Status of and damage to major utility systems or infrastructure, including:

 Water
 Sewer
 Power / Electrical (to include nuclear facilities)
 Natural gas

− Critical resource shortfalls impacting public health and safety.

Incident Annex – Tornado

Introduction

Purpose

To facilitate a coordinated response and assign responsibilities by city agencies to reduce potential loss of life and to or quickly restored following a tornado. provide the basis for a tornado emergency response in order to protect the lives and property of citizens and visitors to the city of Richmond.

Situation

The city of Richmond is susceptible to impacts from a tornado, often occurring with little or no warning. Many structures may not survive the effects of toradic winds. Persons in vehicles or mobile homes are particularly susceptible to serious injury or death when a tornado strikes.

Reporting, warning, notification and communications are included in the city of Richmond EOP. In addition there are several specific requirements, which must be considered.

- There will be an immediate and continuous demand for information needed in the decision-making process.
- There may be delays in acquiring and assimilating the information.
- Communications problems, damage, weather, down trees and power lines and other environmental factors may restrict situation assessment operations.
- Secondary effects of a tornado must be planned for including hazardous materials, health issues, power failure and others.

Assumptions

A. Citizens will be advised of potential severe weather conditions through a variety of means, including National Oceanic & Atmospheric Administration (NOAA) radio, standard radio announcements, TV announcements, etc.

B. The National Weather Service (NWS) will provide tornado and severe weather warnings. Warning time will vary.

C. When a tornado strikes, help may not be immediately available from the state or federal government. The city of Richmond is prepared to bear the initial responsibility for a tornado response and relief.

Concept of Operations

A. A tornado **watch** means that conditions are favorable for tornadoes to develop.

B. A tornado **warning** means that a tornado has actually been sighted or is developing, as indicated on radar.

C. An effective response to a tornado is dependent on the development of plans, programs, and procedures, which will provide for rapid mobilization and effective use of the resources, capabilities and support from other localities through Statewide Mutual Aid *(SMA).*

D. The city's response to the event will be under the direction of the Emergency Management Coordinator, who reports directly to the Deputy Director Emergency Manager (CAO) or his designee.

E. The Office of Emergency Management will monitor the situation, disseminate appropriate weather information on a continuous basis and augment the Emergency Operations Center (EOC) accordingly. The EOC will be staffed to collect information, review status, produce the required reports and coordinate requests for assistance.

F. The extent of the initial response will depend on warning time, the severity and location of the strike, the number of people and structures affected by the tornado, and the ability to provide assistance.

G. Each department should designate an individual to develop and maintain their appropriate disaster preparedness, response, and recovery program in accordance with the emergency duties and responsibilities as assigned in the city of Richmond Emergency Operations Plan and this annex.

H. Non-tasked departments may be called upon to provide assistance where needed.

I. The Community Emergency Response Team (CERT) Volunteer Program may be called upon to provide assistance where needed.

Organization and Assignment of Responsibilities

1. General organization and assignment of responsibilities are detailed in the city of Richmond EOP and more specifically within the ESF Annexes. Responsibilities specific to a tornado are provide below:

2. As necessary, the Office of Emergency Management will participate in situation awareness conference calls with VDEM and localities within the region.

3. The Office of Emergency Management, Coordinator will submit situation reports, as needed to the Virginia Emergency Operations Center (VEOC)

4. The Mayor may initiate a curfew as a crime prevention measure depending on the intensity of the disaster and the level of damage sustained.

5. Maintain communications with the Deputy Emergency Manager (CAO) or designee, and VDEM and local jurisdictions regarding the status of response and recovery efforts.

6. Establish traffic control on state highways and preserve law and order.

7. Maintain communications and advise dispatch of current conditions in all areas impacted.

8. Administer assistance programs including Individual & Family Grants Program.

9. Plan for and provide mental health services to victims and rescuers.

10. Provide shelters and provisions for stranded people in accordance with internal procedures.

11. Provide assistance to local health facilities in impacted area for public health issues, water quality and hazardous materials issues.

12. Provide assistance by providing barricades, debris removal and road repair as requested.

13. Deploy Damage Assessment teams.

14. ESFs that are likely to be involved in a tornado emergency are: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14 -- agency involvement will vary with the circumstances of each incident.

15. Other agencies will provide support as requested.

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The following information should be collected as soon as reasonably possible to protect life and property.

− Number and locations of deaths and injuries.

− Location and extent of secondary events, including fires, and hazardous materials events.

− Requirements for major evacuations and estimated number of people displaced.

− Location of severely damaged or collapsed structures

− Location and estimated number of people trapped in collapsed structures.

− Status of communication systems, including:

 Public telephone and wireless systems (to include internet)
 Public Safety Answering Points (PSAP) "911 center"
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− Damage to critical public buildings and other infrastructure, including:

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− Status of and damage to major utility systems or infrastructure, including:

 Water
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− Critical resource shortfalls impacting public health and safety.