VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION: 2021 VIRGINIA COMMUNITY FLOOD PREPARDNESS FUND GRANT

Application
Watershed Master Plan Study
City of Norfolk

Department of City Planning
810 Union Street, Suite 508
Norfolk, VA 23510

&

Department of Public Works
Division of Environmental Stormwater Management
2233 McKann Avenue
Norfolk, VA 23505

Contents

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.

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 Norfolk

Category of Grant Being Applied for: Study

NFIP/DCR Community Identification Number (CID): 510104

Name of Authorized Official: Dr. Larry H. Filer II, City Manager

Signature of Authorized Official: _____

DocuSigned by:
C45AA22E7D6047B...

Mailing Address: 810 Union St, Suite 1101

City: Norfolk **State:** VA **Zip:** 23510

Telephone Number: 757-664-4242 **Email Address:** city.manager@norfolk.gov

Contact Person (If different from authorized official): Matt Simons, CFM Floodplain Administrator

Mailing Address: 810 Union Street, Suite 508

City: Norfolk **State:** VA **Zip:** 23510

Telephone Number: 757-664-4750 Cell Phone Number: 757-334-8622

Email Address: matthew.simons@norfolk.gov

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

Appendix C: Scoring Criteria for Studies

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

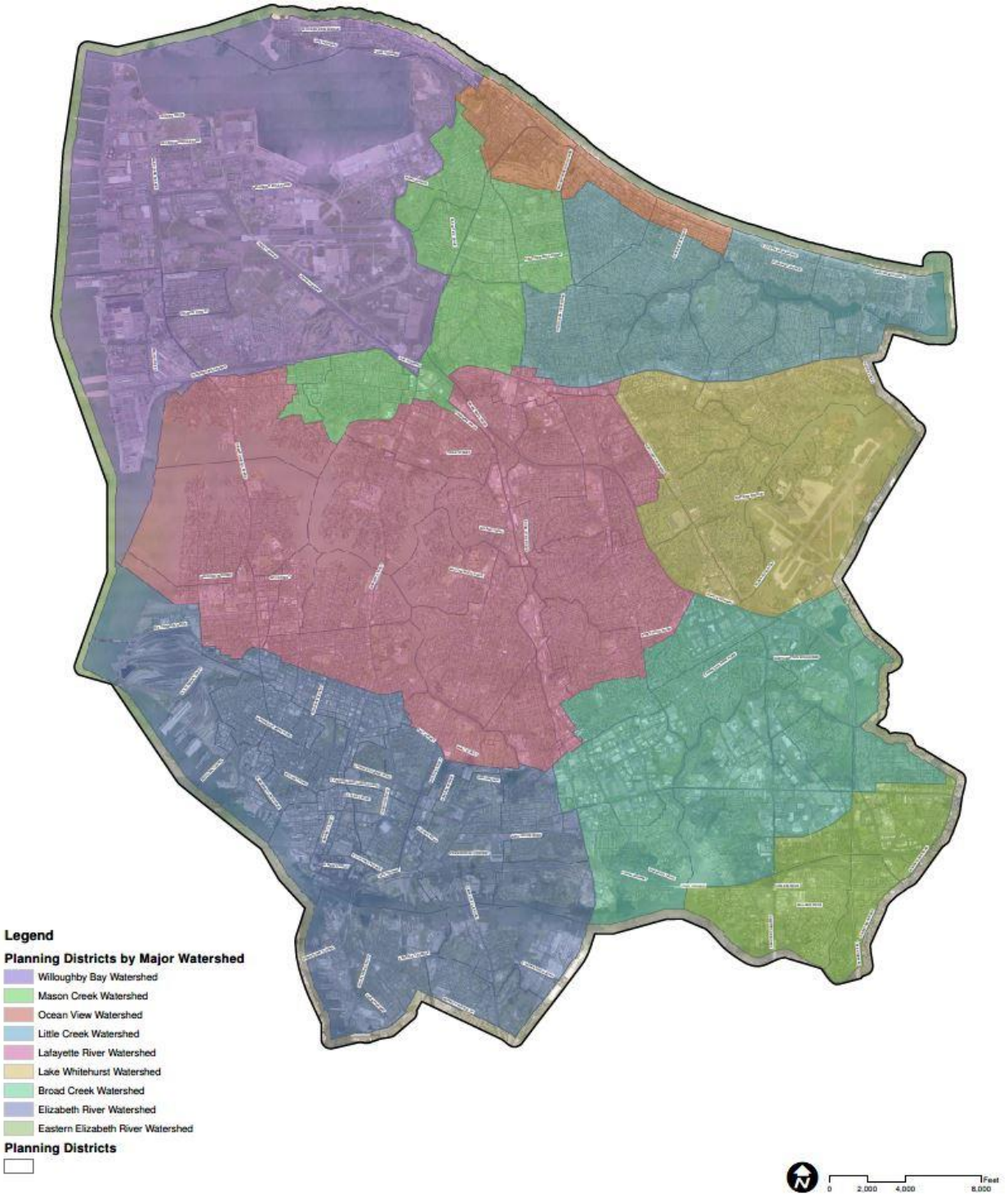
Applicant Name:	City of Norfolk	
Eligibility Information		
Criterion	**Description**	**Check One**
1. **Is the applicant a local government (including counties, cities, towns, municipal corporations, authorities, districts, commissions, or political subdivisions created by the General Assembly or pursuant to the Constitution or laws of the Commonwealth, or any combination of these)?**		
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?**		
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**	X
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**	
No	**Eligible for consideration**	X
5. **Has the applicant provided evidence of an ability to provide the required matching funds?**		
Yes	**Eligible for consideration**	X
No	**Not eligible for consideration**	
N/A	**Match not required**	

Studies Eligible for Consideration		☑ Yes No	
Applicant Name:	City of Norfolk		
Scoring Information			
Criterion		**Point Value**	**Points Awarded**
6. Eligible Studies (Select all that apply)			
Revising 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.		**30**	30 (Stormwater Manual and Floodplain Ordinance updates will follow)
Creating tools or applications to identify, aggregate, or display information on flood risk or creating a crowd-sourced mapping platform that gathers data points about real-time flooding. This could include a locally or regionally based web-based mapping product that allows local residents to better understand their flood risk.		**15**	15 (Includes installation of 20 pluvial flood sensors)
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).		**35**	35
Studies and Data Collection of Statewide and Regional Significance. Funding of studies of statewide and regional significance and proposals will be considered for the following types of studies:			
o **Updating precipitation data and IDF information (rain intensity, duration, frequency estimates) including such data at a sub-state or regional scale on a periodic basis.**		**45**	N/A
o **Regional relative sea level rise projections for use in determining future impacts.**		**45**	N/A

o **Vulnerability analysis either statewide or regionally to state transportation, water supply, water treatment, impounding structures, or other significant and vital infrastructure from flooding.**	**45**	N/A
o **Flash flood studies and modeling in riverine regions of the state.**	**45**	N/A
o **Statewide or regional stream gauge monitoring to include expansion of existing gauge networks.**	**45**	N/A
o **New or updated delineations of areas of recurrent flooding, stormwater flooding, and storm surge vulnerability in coastal areas that include projections for future conditions based on sea level rise, more intense rainfall events, or other relevant flood risk factors.**	**45**	N/A
o **Regional flood studies in riverine communities that may include watershed-scale evaluation, updated estimates of rainfall intensity, or other information.**	**50**	N/A
o **Regional hydrologic and hydraulic studies of floodplains.**	**45**	N/A
o **Studies of potential land use strategies that could be implemented by a local government to reduce or mitigate damage from coastal or riverine flooding.**	**40**	N/A
o **Other proposals that will significantly improve protection from flooding on a statewide or regional basis**	**35**	N/A
7. **Is the study area 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**	8
Low Social Vulnerability (-1.0 to 0.0)	**0**	
Very Low Social Vulnerability (Less than -1.0)	**0**	
1. **Is the proposed study part of an effort to join or remedy the community's probation or suspension from the NFIP?**		
Yes	**10**	
No	**0**	No - 0
2. **Is the proposed study in a low-income geographic area as defined in this manual?**		
Yes	**10**	Yes - 10
No	**0**	

3. **Projects eligible for funding may also reduce nutrient and sediment pollution to local waters and the Chesapeake Bay and assist the Commonwealth in achieving local and/or Chesapeake Bay TMDLs. Does the proposed project include implementation of one or more best management practices with a nitrogen, phosphorus, or sediment reduction efficiency established by the Virginia Department of Environmental Quality or the Chesapeake Bay Program Partnership in support of the Chesapeake Bay TMDL Phase III Watershed Implementation Plan?**		
Yes	**5**	Yes - 5
No	**0**	
Total Points		103

Location of Study Area: Major Watersheds in Norfolk (see map below):



Is Project Located in an NFIP Participating Community? ☑ Yes □ No

Is Project Located in a Special Flood Hazard Area? ☑ Yes □ No

Flood Zone(s) (If Applicable): VE, AE, Shaded X (500 year), X (low to moderate)

Flood Insurance Rate Map Number(s) (If Applicable): 5101040006H, 5101040007H, 5101040004H, 5101040008H, 5101040009H, 51010400028H, 51010400029H, 51010400011H, 51010400012H, 51010400016H, 51010400014H, 51010400017H, 51010400036H, 51010400037H, 51010400041H, 51010400038H, 51010400039H, 51010400043H, 51010400018H, 51010400019H, 51010400052H, 51010400056H, 51010400057H, 51010400076H, 51010400077H, 51010400081H, 51010400058H, 51010400059H, 51010400078H, 51010400079H, 51010400083H

Total Cost of Project: $350,000

Total Amount Requested: $315,000

Scope of Work Narrative
Watershed Master Plan Update for Norfolk

Overview

Located in Southeastern Virginia, the city is a highly urbanized, relatively flat, community with nearly all areas below elevation 15 feet (North American Vertical Datum of 1988). Established in 1682, Norfolk has a long and proud history as a national maritime trading, shipbuilding and military center. Today, a city of approximately 247,000 residents, Norfolk is the commercial center of Hampton Roads which is a region of 1.7 million residents. The City of Norfolk is increasingly at risk from flooding and damage from coastal storms as well as future conditions impacts on pluvial flooding within an urban stormwater conveyance system.

The City of Norfolk requests **$315,000** in grant funding from the Virginia Department of Conservation and Recreation's Community Flood Preparedness Fund to update the City's Watershed Master Plan (*Combined Coastal and Precipitation Flooding Master Plan*) to incorporate the Federal Emergency Management Agency's National Flood Insurance Program Community Rating System (CRS) requirements from Activity 452.b. The objective of watershed master planning under Section 452.b (WMP) is to provide the community with a tool it can use to make decisions that will reduce the increased flooding from development on a watershed-wide basis and address existing flood problems.

Current watershed planning for Norfolk is found within the ***Combined Coastal and Precipitation Flooding Master Plan (2017)***; the "Combined Plan" prepared by the City's Department of Public Works. This Combined Plan is based on a multi-year study effort supported by technical analyses and recommendations from Fugro Atlantic within the ***Norfolk Preliminary City-wide Coastal Flooding Mitigation Concept Evaluation and Master Plan Development*** (the "Fugro report", 2012; Appendix A of the Combined Plan). The Combined Plan is also supported by a thorough analysis and priority ranking technical guide from Timmons Group within the City's drainage conveyance system, ***City-wide Drainage and Watershed Master Plan*** (the "Timmons" report", 2012; Appendix B of the Combined Plan). The Combined Plan was adopted in 2014 and reaffirmed by the Norfolk City Council in 2017.

The Combined Coastal and Precipitation Flooding Master Plan provides the framework for Norfolk to analyze the flood risks from both coastal and precipitation influences within the entire watershed. This framework was underscored by the completion of the 2018 ***USACE Coastal Storm Risk Management (CSRM) Feasibility Study and Environmental Impact Statement*** which presents a recommended array of coastal flood protection projects throughout the entire city, based on the technical analysis provided in the Combined Coastal and Precipitation Flooding Master Plan.

The U.S. Army Corp of Engineers (USACE) will partner with Norfolk to develop each recommended project beyond the initial 10% design that has been provided in the CSRM Feasibility Study. The CSRM projects are intended to protect the City of Norfolk against the threat of tidally and tropically influenced storm surge coastal flooding (hurricanes and nor'easters).

The CSRM projects are not intended to protect Norfolk from the increased flood threats associated with precipitation flooding. Decades of improvements will be needed to the City's existing stormwater drainage and conveyance infrastructure. Modifications to the City's minimum stormwater and floodplain requirements will also be needed.

Given the impacts of sea level rise over time on an existing limited capacity urban stormwater drainage system, the true combined impacts associated with the observed phenomenon of joint occurrence and probabilities of increased tides and rainfall amounts, will cause future 10-year precipitation events to be roughly equivalent to the current 25-year storm (NOAA Atlas 14). As tailwater elevations throughout the conveyance system rise due to increased sea levels, the impacts are exacerbated further up the stormwater pipe.

Proposal

The Combined Coastal and Precipitation Flooding Master Plan must be revised to incorporate updated sea level rise and future conditions impacts to inform drainage system and ordinance recommendations for varying sea level rise and increased precipitation benchmarks, to the year 2100.

The Combined Coastal and Precipitation Flooding Master Plan will be updated to serve as Norfolk's official Watershed Master Plan, providing recommended Actions for Norfolk to implement based on benchmarks and metrics that are grounded in anticipated pluvial tailwater elevations for increased precipitation events.

The Watershed Master Plan will incorporate an equitable Resilience Rubric to prioritize projects for each watershed. The plan will be informed by smart technologies that incorporate real-time storm sensors. The plan will satisfy the Community Rating System (CRS) requirements for a Watershed Master Plan and Norfolk will reach Class 3 within the CRS program.

Project Goals and Objectives

The goals and objectives of the Watershed Master Plan update for Norfolk include the following:

- Development of a Hydrologic and Hydraulic (H&H) model for future conditions planning within Norfolk's coastal, urban, low-lying topography. The H&H model will be based on **best available data** and dynamic to adjust outputs as a result of more accurate assessments of future conditions that may be developed over time.

- Comprehensive H&H model recommendations comprehensive; identifying potential stormwater system improvements (capital improvements), stormwater ordinance revisions, and BMP maintenance strategies to achieve **overall improvements to the system's level or service** (LOS).

- Detailed **system-wide inventory of the stormwater conveyance system** elements necessary to develop the H&H model will be derived from both existing inventories and field verified assessments. This includes the entire pipe network, roadside ditches, nodes and surface storage areas, delineated catchments, detailed LiDAR data, levels of imperviousness, overland flow characteristics, water table characteristics, infiltration and soil conditions, etc.

- **Future conditions assessments** aligned with the Hampton Roads Planning District Commission's Sea Level Rise Planning Policy and Approach and the **Resilient Design Guidelines** for Stormwater Management, as well as the State's **Coastal Resilience Master Plan** (based on NOAA's most recent intermediate-high sea level rise projection for the year 2100). Where deviations are found, the more conservative estimates and assumptions will be applied.

- System-wide recommendations to manage runoff from all storms up to and including the **100-year precipitation event** to ensure that flood flows into the rivers and bay do not increase due to new development.

- Holistic recommendations that analyze each watershed's runoff based on combined quantity assessments (**joint probability events**) at key benchmarks in time – increased ordinance requirements for onsite management, increased uptake/absorption through better tree integration, system wide capacity improvements within the conveyance system, etc.

- Planning level cost estimates and a phasing plan for implementation of the potential array of improvements. This includes **realistic metrics and timeframes** for each watershed to holistically achieve varying levels of system-wide pluvial flood reduction for various storm levels (10-, 25-, 50-, and 100-year storm events):

  > *Based on the recommended array of drainage improvements within this conveyance system and watershed and given the recommended modifications to the stormwater manual and municipal BMP's… this watershed will be able to provide a ___ percent reduction in pluvial flooding within the conveyance system during the ___-year rainfall event given the sea level rise impacts to tailwater conditions by year ____.*

- **Innovative solutions and stormwater technologies** such as outfall check values, low impact development technologies, underground rain harvesting systems, pipe upsizing or daylighting, constructed wetlands, increased use of trees to offset stormwater conveyance needs, etc.

- **Storm sensor technologies** throughout the City's stormwater drainage conveyance system in order to properly establish and validate tailwater elevation impacts within the drainage system over time. Inundation sensors will be able to **provide real-time tracking of tidal and precipitation tailwater conditions** within a cloud-based continuous-simulation model.

- **Equitable Resilience Rubric Tool** to rank and prioritize recommended projects in a manner that builds upon the existing scoring system developed in the existing Citywide Drainage Master Plan by Timmons Group (2012) and incorporating the equitable Resilience Rubric project evaluation tool recently established by the City's Office of Resilience. The rubric **prioritizes social equity** and equality in considering City projects. Included variables of the rubric are infrastructure considerations, community impact, economic impact, property and asset mitigation, and risk mitigation. The Resilience Rubric will align with and incorporate the evaluation factors, criteria and metrics from the Virginia Coastal Resilience Master Plan's Project Prioritization Approach.

- Align watershed actions with the array of planning recommendations from Norfolk's DCR-approved Resilience Plan, to incorporate **natural and nature-based adaptations** to each watershed's conveyance system; establishing and promoting the open space corridors and critical floodplain habitats outlined in Norfolk's adopted Green Infrastructure Plan.

- Satisfy the criteria of a **Community Rating System (CRS) Watershed Master Plan**. By meeting the CRS requirements for a Watershed Master Plan, this update will allow Norfolk to meet the CRS Class 4 prerequisite and with the expected increase in points (315 pts.) will allow Norfolk to build upon its recent two-Class improvement (Class 7 to 5) with another two-Class improvement to **CRS Class 3**.

The Watershed Management Plan update will NOT perform any analyses nor replicate the recommended projects within the Coastal Storm Risk Management Plan (CSRM) from the U.S. Army Corps of Engineers. The focus of the CSRM study was to assess the feasibility for coastal flood protection projects, particularly storm-surge flooding events. The Watershed Master Plan is greatly impacted by future conditions associated with sea level rise and increased precipitation. Therefore, pluvial flooding impacts within the various watersheds of Norfolk will continue to evolve and worsen even as coastal storm-surge protection projects from the CSRM are constructed.

The Watershed Master Plan will acknowledge the impact that the array of recommended CSRM projects will have on the pluvial flooding conditions across Norfolk. In some instances, pluvial flooding conditions may be improved by the construction of some reaches of CSRM storm surge protection projects (e.g. interior drainage improvements associated with new pump stations, etc.). Such improvements will be acknowledged within the Watershed Master Plan, however all

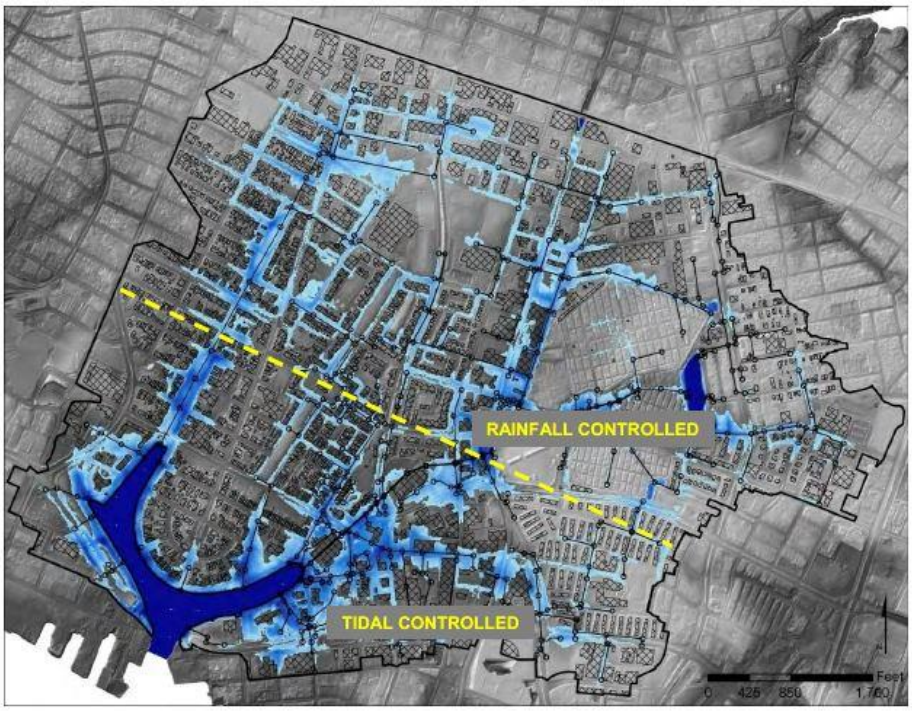
recommended actions of the Watershed Master Plan will be analyzed independent of any CSRM protection projects.

One way to understand this complex relationship – the need to comprehensively address future conditions impacts to pluvial flooding in a Norfolk that will one day be protected from major storm surge events – a watershed may be protected by a surge barrier in the future, but that barrier will not be closed during many low-level surge events or unpredictable rain bomb events.

The Watershed Master Plan will not provide, nor is intended to inform, the interior drainage analysis for any CSRM surge protection structures.

Assessment of Need

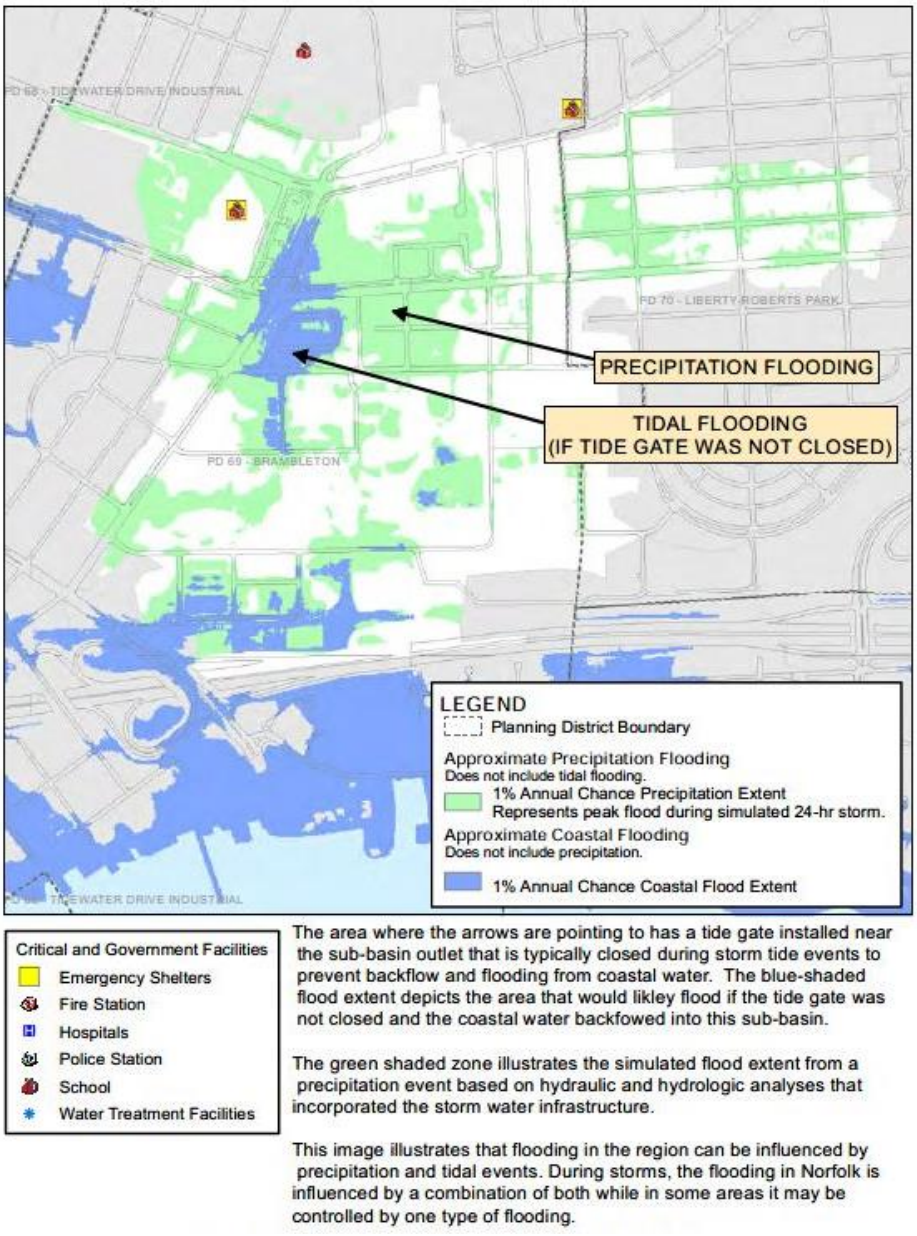
While the primary source of flooding that impacts most of Norfolk is coastal (storm surge), a significant number of properties are at risk of pluvial (surface water flooding). Given that Norfolk is surrounded almost entirely by bodies of water, very few areas of Norfolk have upstream drainage or watershed areas outside of the city limits that contribute to the pluvial flood characteristics of Norfolk. Therefore, Norfolk has considerable control over the factors that influence Norfolk's pluvial flooding conditions.



Tidal and precipitation flooding graphic by Fugro Atlantic, 2012.

The graphic above shows predicted maximum flooding during a 24-hour period where coincident 10-year tidal water level and 10-year precipitation event were simulated. The simulation incorporates a model of the existing stormwater infrastructure (e.g. pipes and inlets). The results

suggest that flooding areas in the lower section of the watershed are tidal controlled and flooding areas in upper areas are rainfall controlled during this simulated event. However, sea level rise and increased precipitation impacts will influence both the location of the line between tidal and rainfall, and the varying depth and flooding characteristics. The Watershed Master Plan update will analyze future conditions impacts to be reflected to inform better pluvial floodplain planning.



Comparison of coastal and precipitation flooding graphic by Fugro Atlantic, 2012

This graphic shows how flooding impacts in a pluvial system can be greatly influenced, or greatly improved, by innovative solutions targeted within certain combined tidal and precipitation parameters. The success of such projects relies on robust models of joint probabilities and occurrence for tidal and precipitation flooding given future conditions

assessments that provide the most accurate tailwater elevations and system conditions for the conveyance system over time. This illustrates the urgent need for a real-time tracking system to inform tidal and precipitation tailwater conditions within a cloud-based continuous-simulation model.

Future conditions H&H modeling, informed by real-time storm sensors, will provide a best practice framework for coastal communities throughout the Commonwealth as communities manage the landward-migrating intersection between coastal and pluvial flooding.

The City of Norfolk has one of the highest concentrations of structures deemed to suffer repetitive and severe repetitive flood loss as represented in the number of claims filed through the National Flood Insurance Program (NFIP). A significant number of these structures are filing flood claims as the result of pluvial flooding. This determination has been made by floodplain management staff reviewing flood insurance claims data provided by the NFIP. Staff have analyzed claims that arose from properties with elevations higher than the surge elevations associated with the storm events, as well as other precipitation events with no associated surge to deduce the need for pluvial flood mitigation.

This analysis has shown that nearly 25% of all NFIP flood claims in Norfolk appear to be the result of pluvial flood characteristics. Furthermore, nearly 15% of the 1,000+ repetitive loss properties located in Norfolk are properties whereby the source of flooding is determined to be pluvial

With the aforementioned information, this will support the City's prioritization of ensuring that recommended improvements are viewed through a lens of social equity. With a median household income of $53,253, Norfolk is defined as a low-income community compared to the rest of Virginia, which has a median household income of $76,448. Within the City's population 13% of the population have a household income of less than $15,000. 8.9% of the City's population has a household income of between $15,000 - $24,999 (see Attachments).

As a result, more than 20% of the City's population is living beneath the Federal Poverty Standard of $26,500. The City is classified as moderately socially vulnerable, with an overall score of 0.59, as identified by ADAPT VA's Social Vulnerability Index (see Attachments). The entire City is routinely impacted by flooding which is precipitated by various occurrences to include coastal flooding, stormwater impacts, and rainfall. With a large part of the city defined as vulnerable populations, it is critical the City prioritizes advancing the City's CRS rating to provide residents with more affordable flood insurance policy costs.

Project Team

This project will be managed through the City of Norfolk's Department of City Planning and Department of Public Works Stormwater Division. Through the City's procurement process, an engineering and planning consultant team would be selected from either existing on-call consultants or via a competitive request for proposal process. Criteria for the chosen consultant

would include: 1) extensive pluvial flooding and stormwater H&H modeling experience, 2) experience assessing future tidal and precipitation impacts, 3) capacity to start working on the project in an expedited manner. In addition to staff and consultants, study team members would include Norfolk staff from the Office of Resilience.

Proposed team members are noted below:

John White, PE	Storm Water Engineer	Public Works
Tammy Halstead, PE	Civil Engineer IV	Public Works
Justin Shafer, CFM	Green Infrastructure Project Manager	Public Works
Kyle Spencer, GISP, CFM	Deputy Resilience Officer	Resilience
Doug Beaver	Chief Resilience Officer	Resilience
Matthew Simons, CFM	Floodplain Administrator	Planning
Tristian Barnes	CRS Coordinator	Planning

Community Rating System

The City of Norfolk has been a CRS Community since its inception in 1991 (Class 5 effective April 1, 2022). Recent improvements within the CRS program have been well received within the community and elected leaders recognize the value associated with programmatic investments that strengthen Norfolk's floodplain management activities while providing increased NFIP premium discounts to policyholders.

The Watershed Master Plan update will meet the following CRS standards:

- WMP1 (90 pts);
    - Evaluates the future conditions, including the impacts of a median projected sea level rise (based on the National Oceanic and Atmospheric Administration's (NOAA's) "intermediate-high" projection for the year 2100) on the local drainage system during multiple rainfall events, including the 100-year rainfall event[1]. The plan must identify the natural drainage system and constructed channels.
    - The plan must address all flooding issues identified for at least the 10-year storm in addition to the 25-year event.

[1] WMP1 guidance provided by CRS Technical Reviewer Dave Carlton on 8/24/2020 via email to Norfolk Floodplain Administrator, Matt Simons. Dave states that coastal communities can meet WMP1 by adopting a "plan for managing the impacts of sea level rise during at least a 25-year rainfall event. Our suggestion is to analyze the current condition of your drainage system during the 10-, 25-, and 100-year rainfall events (what floods, how bad, how long, and for which events), then redo that analysis with a new tailwater that incorporates the projected rise in sea levels. Compare the results and develop a plan to address the increased flooding. The plan may have some triggers in it such as, *once MHHW reaches a certain elevation we need to start doing "X*." These could be general recommendations such as when to install more pumps, increase height of sea walls, abandon some streets, and anything else that might be in your plan… For WMP credit you have to look at the projected sea level in 2100 (intermediate high localized to Norfolk) and its impact on your drainage system, and general flooding, during a 100-year rainfall."

- WMP2 (30 pts);
    - Plan for the necessary actions (CIP improvements, ordinance modifications, etc.) to manage the runoff from all storms up to and including the 100-year event to ensure that flood flows downstream of new development do not increase due to new development.
- WMP3 (55 pts);
    - Plan for the actions (ordinance modifications) that will require onsite management of future peak flows and volumes so that they do not increase over present values.
- WMP4 (35 pts);
    - Plan for the actions (ordinance modifications, model improvements[2], etc.) manages the runoff from all storms up to and including the 5-day event.
- WMP5 (30 pts);
    - Identify existing wetlands or other natural open space areas to be preserved from development so that natural attenuation, retention, or detention of runoff is provided (referenced from Norfolk's Green Infrastructure Plan).
- WMP6 (25 pts);
    - Include recommendation language to prohibiting development, alteration, or modification of existing natural channels.
- WMP7 (25 pts);
    - Include recommendations that channel improvement projects use natural or "soft" approaches rather than gabions, rip rap, concrete, or other "hard" techniques.
- WMP8 (25 pts);
    - Identify the community's funding source dedicated to implementing the plan's recommendations.

Outcomes

Updating Norfolk's Watershed Master Plan is the only activity needed to allow Norfolk to transition to a Class 3 CRS Community. Norfolk NFIP policyholders would be eligible for a 35% reduction on all non-subsidized NFIP premiums. Premium savings resulting from a two-class improvement would result in a **roughly $1M additional premium savings for Norfolk NFIP policyholders**. For context, CRS Class 3 designation would position Norfolk amongst the top five CRS communities on the East and Gulf coasts, top 1% for the entire country of more than 1,500 CRS communities.

More important than the associated CRS improvement, a Watershed Master Plan update for Norfolk will allow Norfolk to incorporate the best available sea level rise[3] science and precipitation models into an action strategy to incorporate stormwater ordinance amendments

[2] WMP4 note: If a community can demonstrate that an event shorter than five days is the locally appropriate "worst-case" runoff event for stormwater management, it may receive this credit if it uses that event for its regulatory standard. In some areas this may require continuous-simulation modeling. If a community, regional, state, or federal agency can demonstrate that, for example, the 72-hour event provides the "worst case" runoff for a watershed, the 72-hour event would be credited for communities in that area.

[3] NOAA's 2017 intermediate-high sea level rise curve to year 2100

and identify stormwater improvements that need to be made as rising tailwater elevations impact the strategic investment needs over time – BMP designs, pump station capacity and retreat strategies – daylighting outfalls, etc.

Budget Narrative – Watershed Master Plan Update for Norfolk

The City of Norfolk is categorized as a low-income community compared to the remainder of the state. As a result, Norfolk is seeking funding support of 90% for the proposed Watershed Master Plan Study for a total grant request of $315,000. The estimated total project cost is $350,000 with a $35,000 match from the City of Norfolk. This includes an estimated $75,000 for the installation and optimization of twenty (20) flood inundation storm sensors to be installed at various locations within the stormwater conveyance system (likely involving subconsultants). The intent is for the storm sensors to be transportable, to allow Stormwater staff to adjust the location of storm sensors within the conveyance system over time as sea levels rise and tailwater elevations increase.

Storm sensor optimization includes the consultants' integration of the real-time flood sensors into a real-time continuous-simulation model that Stormwater, Planning or Resilience staff can maintain post-project completion. The City will provide the server space and technical staff to facilitate a program development framework; program development staff are available for special project development without need for additional budgetary assignment.

For estimates on the work to be completed, please see Table 1 below. The City has designated funding to serve as cash funds available for match in the form of the City's Stormwater Reserve Fund which is an account set aside specifically to support large-scale and long-term resiliency efforts. The City has appropriated $35,000 for the City's 10% match towards the Watershed Master Plan with hopes of being awarded this funding to cover the remaining 90% ($315,000) necessary to complete the project.

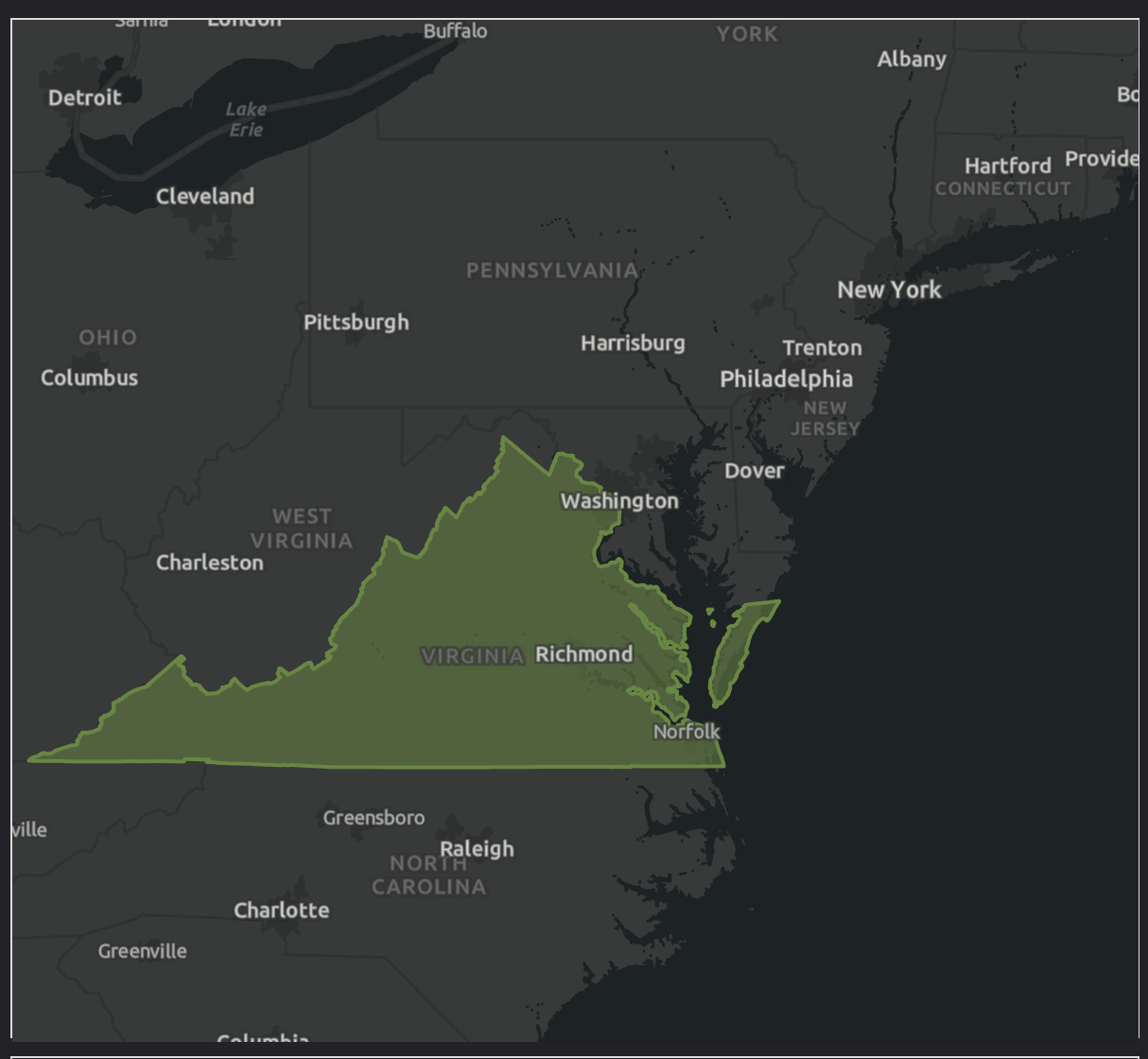
Table 1 below summarizes project costs associated with each element of the scope of work. In addition to the direct funding as included match, Norfolk also commits to managing all aspects of project management and public outreach using existing qualified staff. Funds proposed as match are authorized through existing approved budgets and verified on the attached, signed City Manager Transmittal Form outlining grant and match funds for the Norfolk application for the current Community Flood Preparedness Fund grant cycle. Upon award of grant funds, the City sets up a special revenue account that includes approved match funds and cash funds to cover awarded grant funding until reimbursement is received. This allows Norfolk to move through projects without delays for reimbursement requests.

Table 1- Scope of Work Project Costs

Project Tasks	Grant Funds (90%)	Match Funds (10%)	Total
Task I Project Initiation, Plan Alignment, Data Integration, Model Development	$36,000	$4,000	$40,000
Task II Purchase and Installation of Flood Sensors (20)	$18,000	$2,000	$20,000
Task III Optimization of Flood Sensors within real-time GIS dashboard and H&H model	$49,500	$5,500	$55,000
Task IV Future Conditions H&H Modeling	$103,500	$11,500	$115,000
Task V Resilience Rubric Integration and Scoring - Watershed Action Recommendations	$67,500	$7,500	$75,000
Task VI Action Refinement, Final Report and Project Closeout - DCR-approval for watershed revisions to approved Resilience Plan	$40,500	$4,500	$45,000
Total Project Costs:	**$315,000**	**$35,000**	**$350,000**

Attachments

Virginia



Norfolk city, VA

EDUCATION

10%	23%	27%	40%
No High School Diploma	High School Graduate	Some College	Bachelor's/Grad /Prof Degree

EDUCATION

12%	25%	33%	30%
No High School Diploma	High School Graduate	Some College	Bachelor's/Grad /Prof Degree

INCOME

$76,448	Median Household Income
$41,359	Per Capita Income
$179,845	Median Net Worth

INCOME

$53,253	Median Household Income
$27,724	Per Capita Income
$41,051	Median Net Worth

EMPLOYMENT

White Collar	70%
Blue Collar	18%
Services	11%

5.8% Unemployment Rate

EMPLOYMENT

White Collar	63%
Blue Collar	22%
Services	15%

9.7% Unemployment Rate

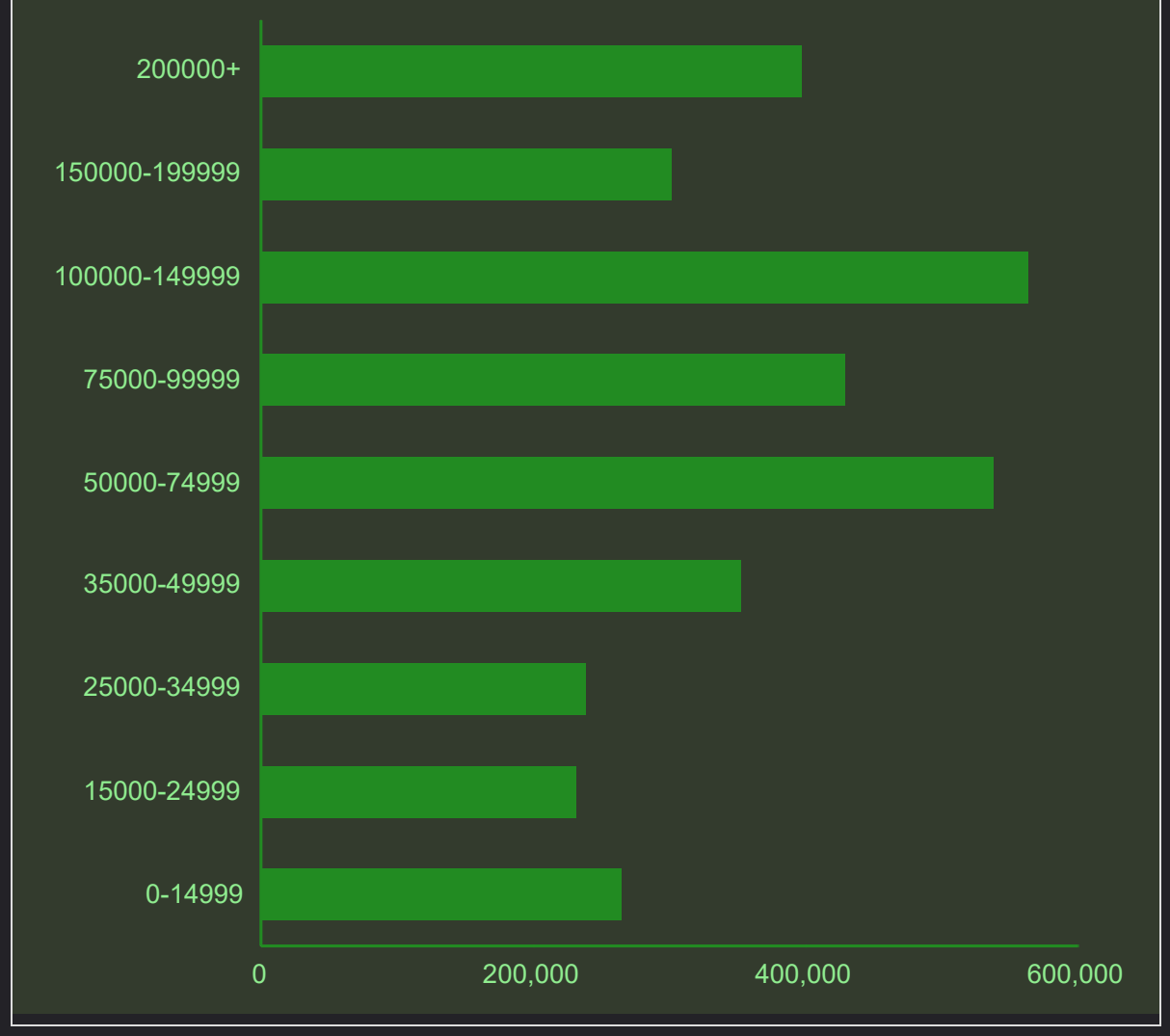
KEY FACTS

8,695,186	39.2
Population	Median Age
3,314,697	$58,392
Households	Median Disposable Income

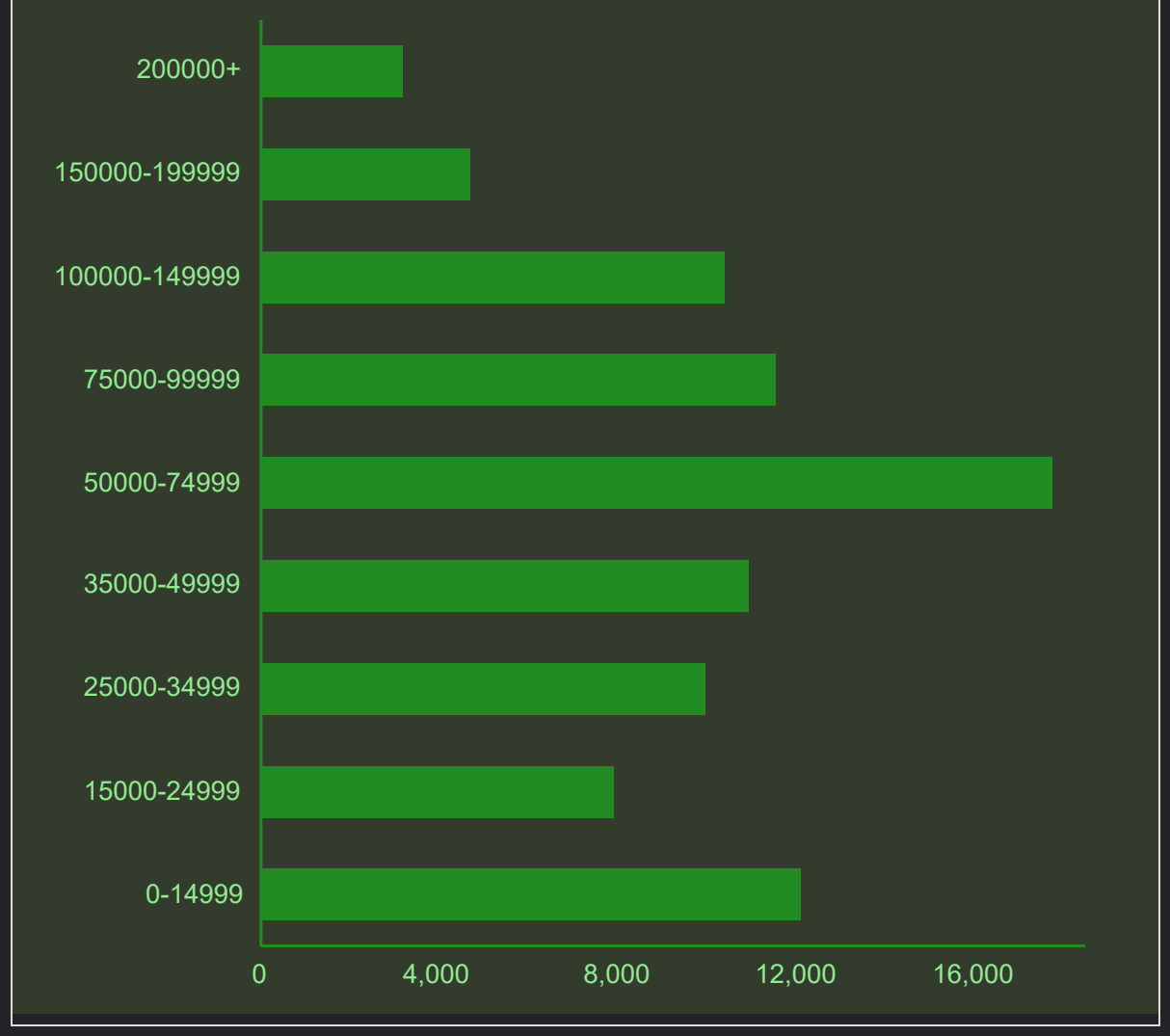
KEY FACTS

247,421	31.3
Population	Median Age
87,998	$42,072
Households	Median Disposable Income

HOUSEHOLD INCOME ($)



HOUSEHOLD INCOME ($)



Hampton Roads Resilient Design Standards
DRAFT

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Table of Contents

Design Tidal Elevations - Methodology

The goal of this effort is to develop design tidal elevations for communities in Hampton Roads that incorporate future sea level rise. These design tidal elevations are intended for use as input tailwater conditions for stormwater management calculations using design storms based on specific recurrence intervals for individual tidal subwatersheds (12-digit Hydrologic Unit Code) throughout Hampton Roads.[1] This analysis builds on two previous studies conducted by the U.S. Army Corps of Engineers: the FEMA Region III Storm Surge Study[2] and the North Atlantic Coast Comprehensive Study.[3] The FEMA Region III Storm Surge Study (FEMA Study) was used in the development of the most recent flood insurance studies and corresponding flood insurance rate maps for coastal Hampton Roads localities. As part of the FEMA Study, the Advanced Circulation Model for Oceanic, Coastal and Estuarine Waters (ADCIRC) model was used to develop a two-dimensional, unstructured grid of storm surge stillwater (not including waves) elevations for six return periods: 10-year, 25-year, 50-year, 100-year, 500-year, and 1000-year (Figure 1). This dataset provided the baseline storm surge values used for the analysis.

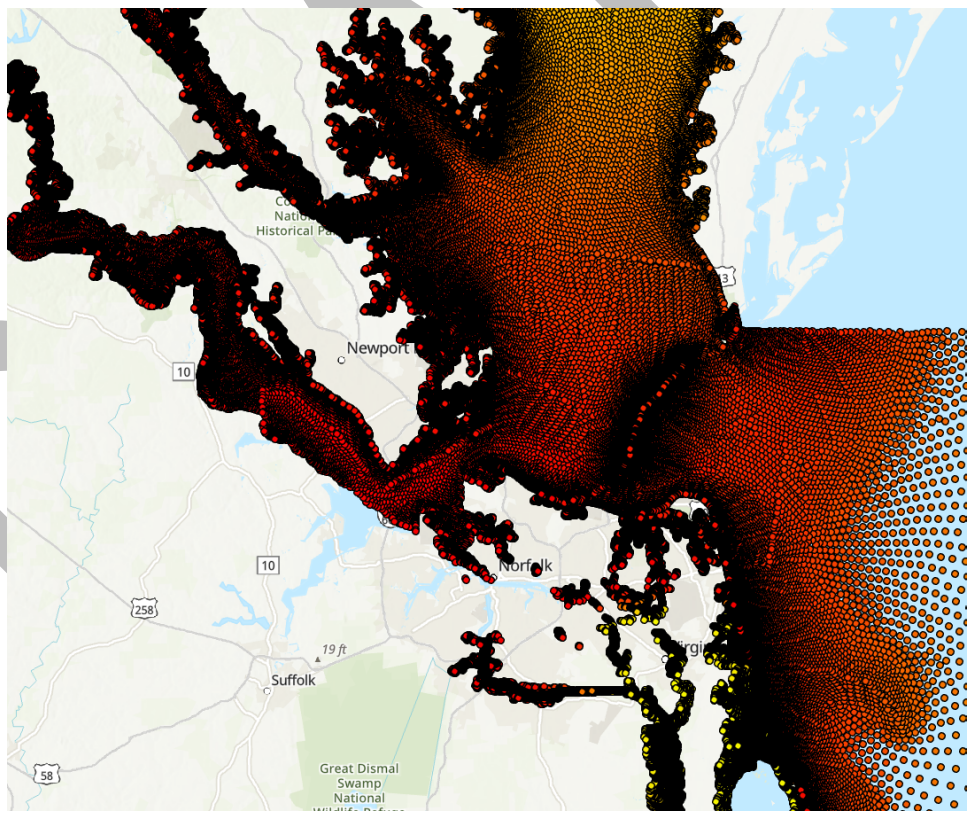


Figure 1: ADCIRC Grid from FEMA Region III Storm Surge Study

[1] Subwatersheds are 12-digit Hydrologic Unit Code (HUC-12) watersheds.

[2] Hanson, Jeffrey L., Michael F. Forte, Brian Blanton, Mark Gravens, and Peter Vickery. FEMA Region III Storm Surge Study Coastal Storm Surge Analysis: Storm Surge Results. US. Army Corps of Engineers Engineer Research and Development Center. November 2013.

[3] U.S. Army Corps of Engineers. North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk. U.S. Army Corps of Engineers. January 2015. https://www.nad.usace.army.mil/CompStudy/

HRPDC staff developed representative tidal elevations for individual watersheds by calculating the 95th-percentile for each HUC-12 geography. A log-linear analysis was run on these values to calculated values for the 1-year, 2-year, 3-year, and 5-year return periods for each watershed. Figure 2 shows an example of this approach. Blue dots represent the 95th-percentile values calculated from the original dataset. Orange dots represent the values calculated using the log-linear analysis.

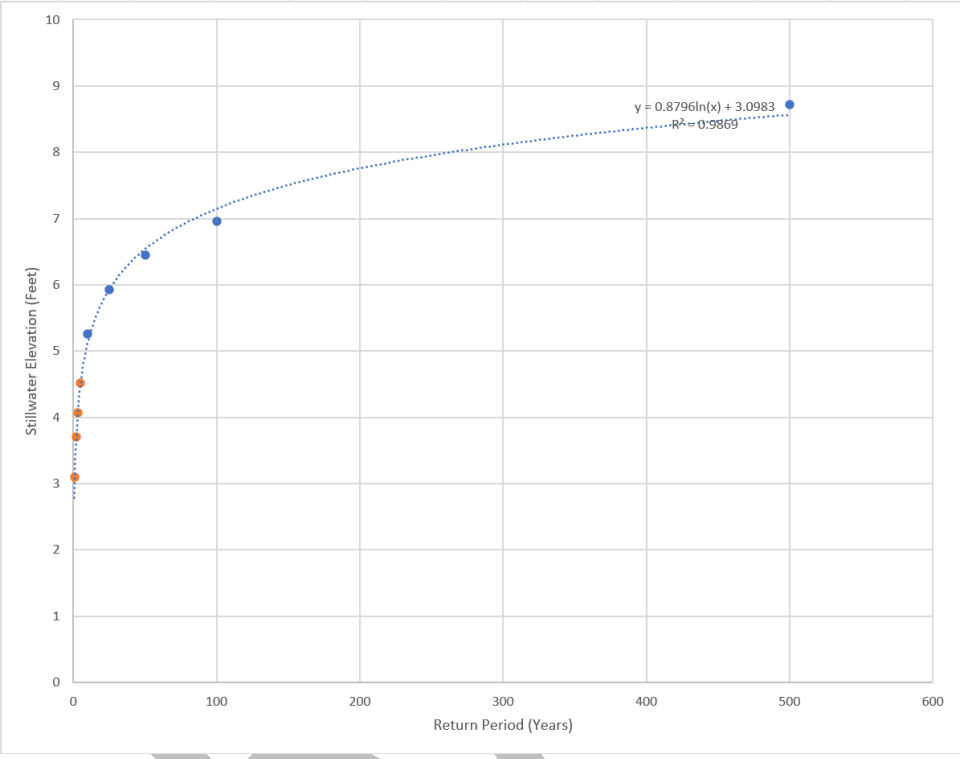


Figure 2: Chart Showing Results of Log-Linear Analysis of 1-, 2-, 3-, and 5-Year Return Periods

Separately, estimates of non-linear effects of sea level rise were calculated by comparing storm surge elevations from the North Atlantic Coast Comprehensive Study (NACCS) with and without sea level rise (Figure 3). This approach described here for calculating non-linearity factors is based on the methodology used by the City of Virginia Beach and Dewberry to develop design tidal elevations for the city's Public Works Design Standards Manual (June 2020). As part of the NACCS, the US. Army Corps of Engineers modeled storm surge under present conditions and with one meter of sea level rise. The results showed that storm surge in many areas was higher than simply adding one meter to the baseline value. This difference can be accounted for by using non-linearity factors, which are multipliers used to convert baseline values to future values.

For this analysis, non-linearity factors for all HUC-10 and HUC-12 watersheds in Hampton Roads were calculated by averaging factors for each NACCS grid point and return period (10-year, 20-year, 50-year, 100-year, and 500-year). HUC-10 watershed values were calculated for use when the NACCS did not include points within a given HUC-10. Design tidal elevations with sea level rise were then calculated by adding the three regional sea level rise scenarios (1.5', 3', and 4.5') to the calculated elevations. The

non-linearity factors derived from the NACCS were then used to develop design tidal elevations for the 3' and 4.5' sea level rise scenarios. The Virginia Beach study found that non-linearity did not occur with 1.5' of sea level rise, so for that scenario the amount of sea level rise was just added to the baseline tidal elevation.

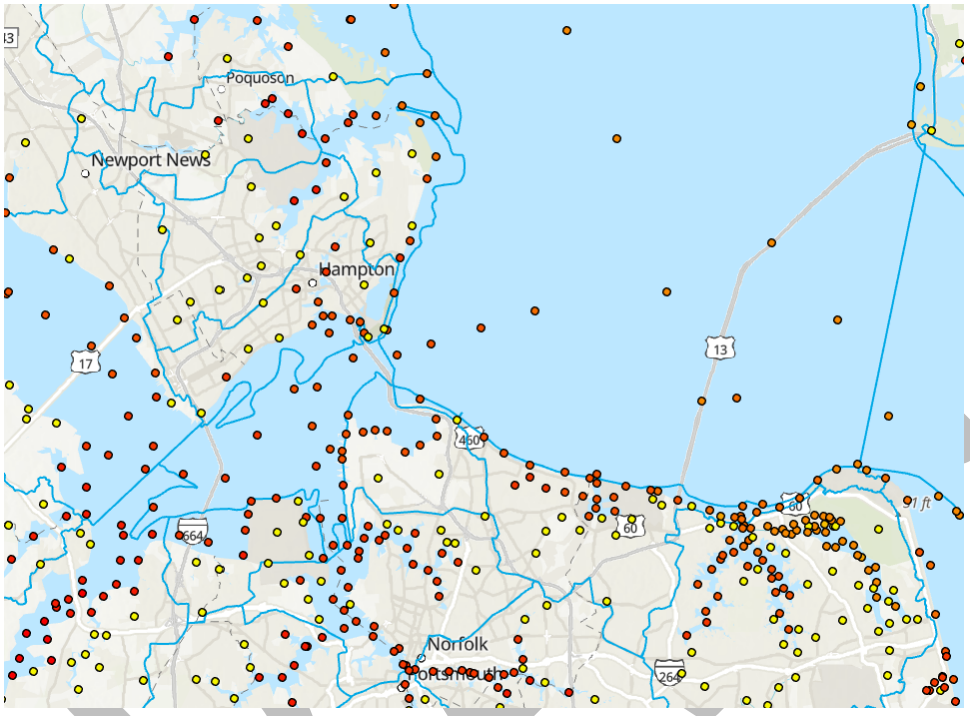


Figure 3: NACCS Storm Surge and Sea Level Rise Analysis Grid Points

Methodology for Design Tidal Elevations:

1. Spatially join Region III Storm Surge points to HUC-12 watersheds (Figure 4)
2. Export spatially joined table and convert to Excel format
3. Calculate 95th-percentile for 10-year, 25-year, 50-year, 100-year, 500-year, and 1000-year return periods for each HUC-12 watershed
4. Calculate SLOPE and INTERCEPT values for each watershed
5. Calculate values for 1-year, 2-year, 3-year, and 5-year return periods using log-linear model
6. (For 1.5' SLR) Add 1.5' to each baseline return period value
7. (For 3' and 4.5' SLR):

$$\textit{Future Design Tidal Elevation} = \textit{(Baseline Tidal Elevation + SLR Scenario) x Non-Linearity Factor}$$

Calculation of Non-Linearity Factors

$$\textit{Non-Linearity Factor} = \frac{\textit{(USACE Modeled Storm Surge Elevation with SLR)}}{\textit{(USACE Baseline Storm Surge Elevation + SLR)}}$$

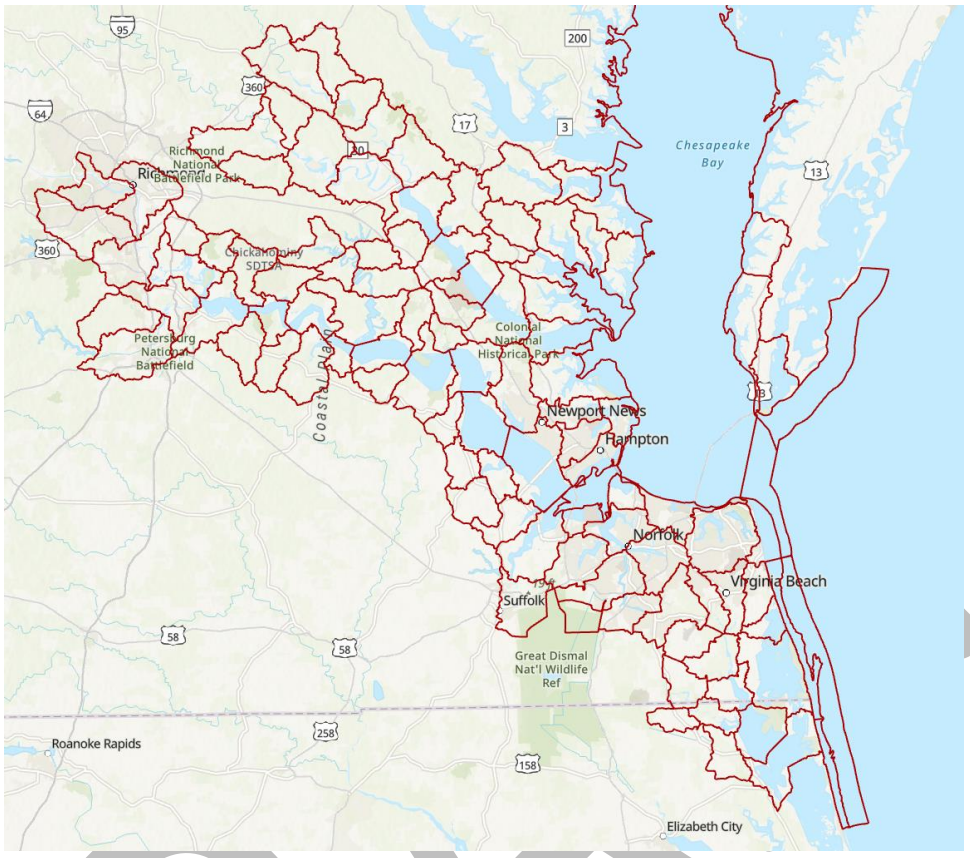


Figure 4: HUC-12 Watersheds Used for Tidal Elevation Analysis

Design Tidal Elevations for Hampton Roads Localities

Notes:

1. Sea level rise scenarios are based on HRPDC Sea Level Rise Planning Policy and Approach (2018).
2. All elevations sourced from statistical analysis of the distribution of water elevations in each watershed from the FEMA Region III Storm Surge Study conducted by the U.S. Army Corps of Engineers Engineer Research and Development Center (2013).
3. Conditions related to the 3-ft and 4.5-ft sea level rise design levels include non-linear increases derived from numerical modeling completed by the U.S. Army Corps of Engineers as part of the North Atlantic Coast Comprehensive Study.
4. Non-linearity factors for HUC-10 watersheds used in cases where HUC-12 watersheds had no data points to calculate non-linearity factors.

Design Tidal Elevations – Chesapeake

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802080201	New Mill Creek-Southern Branch Elizabeth River	Existing Condition	3.9	4.5	4.8	5.2	5.8	6.6	7.2	7.8	9.2
		1.5 ft SLR	5.4	6.0	6.3	6.7	7.3	8.1	8.7	9.3	10.7
		3.0 ft SLR	6.9	7.5	7.8	8.2	8.8	9.6	10.2	10.8	12.2
		4.5 ft SLR	8.4	9.0	9.3	9.7	10.3	11.1	11.7	12.3	13.7
020802080203	Deep Creek-Southern Branch Elizabeth River	Existing Condition	3.4	4.1	4.5	5.1	5.9	6.7	7.3	8.0	10.0
		1.5 ft SLR	4.9	5.6	6.0	6.6	7.4	8.2	8.8	9.5	11.5
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.9	9.7	10.3	11.0	13.0
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	11.8	12.5	14.5
020802080204	Eastern Branch Elizabeth River	Existing Condition	2.9	3.7	4.2	4.8	5.9	6.6	7.3	8.0	10.4
		1.5 ft SLR	4.4	5.2	5.7	6.3	7.4	8.1	8.8	9.5	11.9
		3.0 ft SLR	6.0	6.8	7.3	7.9	9.1	9.8	10.5	11.2	13.6
		4.5 ft SLR	7.5	8.3	8.9	9.5	10.6	11.3	12.0	12.7	15.2
020802080205	Western Branch Elizabeth River	Existing Condition	3.7	4.5	4.9	5.4	6.1	7.0	7.9	8.6	10.3
		1.5 ft SLR	5.2	6.0	6.4	6.9	7.6	8.5	9.4	10.1	11.8
		3.0 ft SLR	6.9	7.7	8.1	8.6	9.3	10.2	11.2	11.9	13.6
		4.5 ft SLR	8.4	9.2	9.6	10.1	10.9	11.8	12.7	13.4	15.2
030102051104	Indian Creek-Northwest River	Existing Condition	0.1	0.5	0.7	1.0	1.4	2.0	2.4	2.8	3.8
		1.5 ft SLR	1.6	2.0	2.2	2.5	2.9	3.5	3.9	4.3	5.3
		3.0 ft SLR	3.2	3.6	3.8	4.2	4.6	5.2	5.6	6.0	7.1
		4.5 ft SLR	4.8	5.2	5.4	5.7	6.1	6.8	7.2	7.6	8.6
030102051201	Chesapeake Canal	Existing Condition	3.0	3.6	4.0	4.4	5.0	5.8	6.4	7.0	8.4
		1.5 ft SLR	4.5	5.1	5.5	5.9	6.5	7.3	7.9	8.5	9.9
		3.0 ft SLR	6.0	6.6	7.0	7.4	8.0	8.8	9.4	10.0	11.4
		4.5 ft SLR	7.5	8.1	8.5	8.9	9.5	10.3	10.9	11.5	12.9
030102051203	Upper North Landing River	Existing Condition	0.4	0.8	1.0	1.3	1.8	2.2	2.5	3.0	4.0
		1.5 ft SLR	1.9	2.3	2.5	2.8	3.3	3.7	4.0	4.5	5.5
		3.0 ft SLR	3.5	3.9	4.1	4.5	5.0	5.4	5.7	6.2	7.3
		4.5 ft SLR	5.1	5.5	5.7	6.0	6.5	7.0	7.3	7.8	8.8

Design Tidal Elevations – Gloucester County

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020801020301	Carvers Creek-Piankatank River	Existing Condition	1.8	2.5	2.9	3.4	4.2	5.0	5.3	5.9	7.8
		1.5 ft SLR	3.3	4.0	4.4	4.9	5.7	6.5	6.8	7.4	9.3
		3.0 ft SLR	4.8	5.5	5.9	6.4	7.2	8.0	8.3	8.9	10.8
		4.5 ft SLR	6.3	7.0	7.4	7.9	8.7	9.5	9.8	10.4	12.3
020801020401	Beaverdam Swamp	Existing Condition	1.2	2.2	2.7	3.4	4.9	5.6	6.1	6.9	10.0
		1.5 ft SLR	2.7	3.7	4.2	4.9	6.4	7.1	7.6	8.4	11.5
		3.0 ft SLR	4.3	5.4	5.9	6.6	8.1	8.9	9.4	10.2	13.4
		4.5 ft SLR	5.9	6.9	7.4	8.1	9.7	10.4	10.9	11.7	14.9
020801020402	Crany Creek-Fox Mill Run	Existing Condition	1.6	2.5	3.0	3.6	4.9	5.6	6.1	6.8	9.6
		1.5 ft SLR	3.1	4.0	4.5	5.1	6.4	7.1	7.6	8.3	11.1
		3.0 ft SLR	4.7	5.6	6.1	6.7	8.0	8.7	9.2	9.9	12.8
		4.5 ft SLR	6.2	7.1	7.6	8.2	9.5	10.2	10.8	11.5	14.3
020801020403	Ware River	Existing Condition	1.8	2.6	3.1	3.7	4.9	5.6	6.0	6.6	9.3
		1.5 ft SLR	3.3	4.1	4.6	5.2	6.4	7.1	7.5	8.1	10.8
		3.0 ft SLR	4.9	5.7	6.2	6.8	8.1	8.8	9.2	9.8	12.5
		4.5 ft SLR	6.4	7.2	7.7	8.4	9.6	10.3	10.7	11.3	14.1
020801020404	North River	Existing Condition	1.5	2.3	2.8	3.5	4.8	5.4	5.9	6.6	9.4
		1.5 ft SLR	3.0	3.8	4.3	5.0	6.3	6.9	7.4	8.1	10.9
		3.0 ft SLR	4.6	5.5	6.0	6.7	8.1	8.7	9.2	9.9	12.8
		4.5 ft SLR	6.2	7.0	7.5	8.3	9.6	10.2	10.7	11.5	14.4
020801020407	Severn River	Existing Condition	2.6	3.2	3.6	4.1	4.9	5.7	6.0	6.5	8.5
		1.5 ft SLR	4.1	4.7	5.1	5.6	6.4	7.2	7.5	8.0	10.0
		3.0 ft SLR	5.7	6.3	6.8	7.3	8.1	8.9	9.2	9.7	11.8
		4.5 ft SLR	7.3	7.9	8.3	8.8	9.6	10.4	10.7	11.3	13.3
020801020408	Monday Creek-Mobjack Bay	Existing Condition	2.6	3.1	3.5	3.9	4.6	5.2	5.6	6.0	7.7
		1.5 ft SLR	4.1	4.6	5.0	5.4	6.1	6.7	7.1	7.5	9.2
		3.0 ft SLR	5.7	6.3	6.7	7.1	7.8	8.4	8.8	9.2	11.0
		4.5 ft SLR	7.3	7.8	8.2	8.6	9.3	10.0	10.4	10.8	12.5
020801050604	Cabin Creek-Mattaponi River	Existing Condition	2.1	3.0	3.5	4.1	5.5	6.2	6.6	7.1	10.1
		1.5 ft SLR	3.6	4.5	5.0	5.6	7.0	7.7	8.1	8.6	11.6
		3.0 ft SLR	5.3	6.2	6.7	7.3	8.8	9.5	9.9	10.5	13.6
		4.5 ft SLR	6.8	7.8	8.3	8.9	10.4	11.1	11.5	12.0	15.1

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
		Existing Condition	2.7	3.4	3.9	4.4	5.4	6.1	6.5	6.9	9.2
		1.5 ft SLR	4.2	4.9	5.4	5.9	6.9	7.6	8.0	8.4	10.7
	Poropotank	3.0 ft SLR	6.2	7.0	7.5	8.0	9.1	9.9	10.3	10.8	13.3
020801070103	River	4.5 ft SLR	7.8	8.6	9.1	9.7	10.8	11.5	12.0	12.4	14.9
		Existing Condition	3.0	3.6	4.0	4.5	5.3	6.1	6.4	6.9	8.8
		1.5 ft SLR	4.5	5.1	5.5	6.0	6.8	7.6	7.9	8.4	10.3
	Skimino Creek-	3.0 ft SLR	6.3	6.9	7.3	7.9	8.7	9.5	9.8	10.4	12.4
020801070104	York River	4.5 ft SLR	7.9	8.5	8.9	9.4	10.3	11.1	11.4	11.9	13.9
		Existing Condition	3.2	3.8	4.1	4.6	5.2	6.0	6.4	6.8	8.5
		1.5 ft SLR	4.7	5.3	5.6	6.1	6.7	7.5	7.9	8.3	10.0
	Jones Creek-	3.0 ft SLR	6.4	7.0	7.3	7.8	8.5	9.3	9.7	10.1	11.9
020801070201	York River	4.5 ft SLR	7.9	8.6	8.9	9.4	10.0	10.8	11.2	11.7	13.4
		Existing Condition	3.1	3.7	4.0	4.5	5.1	5.8	6.3	6.8	8.3
		1.5 ft SLR	4.6	5.2	5.5	6.0	6.6	7.3	7.8	8.3	9.8
	Carter Creek-	3.0 ft SLR	6.3	6.9	7.2	7.7	8.3	9.1	9.6	10.1	11.6
020801070203	York River	4.5 ft SLR	7.8	8.4	8.7	9.3	9.9	10.6	11.1	11.6	13.2
		Existing Condition	3.0	3.6	3.9	4.3	4.9	5.5	6.1	6.6	7.9
		1.5 ft SLR	4.5	5.1	5.4	5.8	6.4	7.0	7.6	8.1	9.4
	Sarah Creek-	3.0 ft SLR	6.1	6.7	7.1	7.5	8.1	8.7	9.3	9.8	11.1
020801070204	York River	4.5 ft SLR	7.7	8.3	8.6	9.0	9.6	10.2	10.8	11.4	12.7

Design Tidal Elevations – Hampton

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020801080102	Northwest Branch Back River	Existing Condition	3.2	3.9	4.3	4.9	5.6	6.4	7.2	7.9	9.6
		1.5 ft SLR	4.7	5.4	5.8	6.4	7.1	7.9	8.7	9.4	11.1
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.8	9.6	10.5	11.2	12.9
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	12.0	12.7	14.5
020801080103	Southwest Branch Back River	Existing Condition	3.3	4.0	4.4	5.0	5.6	6.5	7.4	8.1	9.7
		1.5 ft SLR	4.8	5.5	5.9	6.5	7.1	8.0	8.9	9.6	11.2
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.7	9.6	10.5	11.3	12.9
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.2	11.2	12.1	12.8	14.4
020801080104	Back River-Lower Chesapeake Bay	Existing Condition	3.2	3.9	4.3	4.7	5.4	6.1	6.8	7.5	9.0
		1.5 ft SLR	4.7	5.4	5.8	6.2	6.9	7.6	8.3	9.0	10.5
		3.0 ft SLR	6.4	7.1	7.5	7.9	8.6	9.3	10.1	10.8	12.3
		4.5 ft SLR	7.9	8.6	9.0	9.4	10.2	10.9	11.6	12.3	13.9
020801080202	Little Creek-Lower Chesapeake Bay	Existing Condition	3.2	3.8	4.2	4.7	5.3	6.1	6.8	7.4	8.9
		1.5 ft SLR	4.7	5.3	5.7	6.2	6.8	7.6	8.3	8.9	10.4
		3.0 ft SLR	6.4	7.0	7.4	8.0	8.6	9.4	10.1	10.7	12.3
		4.5 ft SLR	8.0	8.6	9.0	9.5	10.1	10.9	11.7	12.3	13.8
020802060906	Cooper Creek-James River	Existing Condition	3.7	4.4	4.8	5.2	5.8	6.7	7.5	8.1	9.6
		1.5 ft SLR	5.2	5.9	6.3	6.7	7.3	8.2	9.0	9.6	11.1
		3.0 ft SLR	6.9	7.6	8.0	8.4	9.1	10.0	10.8	11.4	13.0
		4.5 ft SLR	8.4	9.2	9.6	10.0	10.6	11.5	12.3	13.0	14.5
020802080303	Hampton River-Hampton Roads	Existing Condition	3.5	4.1	4.4	4.9	5.4	6.2	7.0	7.6	8.9
		1.5 ft SLR	5.0	5.6	5.9	6.4	6.9	7.7	8.5	9.1	10.4
		3.0 ft SLR	6.7	7.3	7.6	8.1	8.6	9.5	10.3	10.9	12.2
		4.5 ft SLR	8.2	8.9	9.2	9.7	10.2	11.0	11.8	12.5	13.8

Design Tidal Elevations – Isle of Wight County

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
		Existing Condition	4.0	4.5	4.8	5.2	5.6	6.4	6.8	7.3	8.4
		1.5 ft SLR	5.5	6.0	6.3	6.7	7.1	7.9	8.3	8.8	9.9
		3.0 ft SLR	7.3	7.8	8.1	8.5	8.9	9.8	10.2	10.7	11.9
020802060803	Lawnes Creek	4.5 ft SLR	8.8	9.4	9.7	10.1	10.5	11.3	11.8	12.3	13.4
		Existing Condition	4.0	4.6	4.9	5.3	5.7	6.5	7.1	7.6	8.7
	Morrisons	1.5 ft SLR	5.5	6.1	6.4	6.8	7.2	8.0	8.6	9.1	10.2
	Creek-James	3.0 ft SLR	7.2	7.9	8.2	8.6	9.0	9.8	10.5	11.0	12.1
020802060804	River	4.5 ft SLR	8.8	9.4	9.7	10.1	10.6	11.4	12.0	12.5	13.7
		Existing Condition	4.0	4.6	5.0	5.5	6.0	6.9	7.8	8.4	9.7
		1.5 ft SLR	5.5	6.1	6.5	7.0	7.5	8.4	9.3	9.9	11.2
	Warren Creek-	3.0 ft SLR	7.2	7.8	8.2	8.8	9.3	10.2	11.1	11.7	13.1
020802060902	Pagan River	4.5 ft SLR	8.8	9.4	9.8	10.3	10.8	11.7	12.7	13.3	14.6
		Existing Condition	3.9	4.6	5.0	5.5	6.0	6.9	7.8	8.5	9.8
		1.5 ft SLR	5.4	6.1	6.5	7.0	7.5	8.4	9.3	10.0	11.3
		3.0 ft SLR	7.1	7.8	8.2	8.8	9.3	10.2	11.1	11.8	13.2
020802060903	Cypress Creek	4.5 ft SLR	8.7	9.4	9.8	10.3	10.8	11.7	12.7	13.4	14.7
		Existing Condition	3.9	4.6	5.0	5.4	5.9	6.8	7.6	8.3	9.5
		1.5 ft SLR	5.4	6.1	6.5	6.9	7.4	8.3	9.1	9.8	11.0
	Jones Creek-	3.0 ft SLR	7.0	7.8	8.2	8.6	9.1	10.0	10.8	11.5	12.8
020802060904	Pagan River	4.5 ft SLR	8.6	9.3	9.7	10.1	10.6	11.5	12.3	13.1	14.3
		Existing Condition	4.0	4.7	5.1	5.7	6.2	7.3	8.2	8.9	10.4
		1.5 ft SLR	5.5	6.2	6.6	7.2	7.7	8.8	9.7	10.4	11.9
	Chuckatuck	3.0 ft SLR	7.1	7.8	8.2	8.8	9.3	10.5	11.4	12.1	13.6
020802060905	Creek	4.5 ft SLR	8.6	9.3	9.7	10.4	10.9	12.0	12.9	13.6	15.1
		Existing Condition	3.7	4.4	4.8	5.2	5.8	6.7	7.5	8.1	9.6
		1.5 ft SLR	5.2	5.9	6.3	6.7	7.3	8.2	9.0	9.6	11.1
	Cooper Creek-	3.0 ft SLR	6.9	7.6	8.0	8.4	9.1	10.0	10.8	11.4	13.0
020802060906	James River	4.5 ft SLR	8.4	9.2	9.6	10.0	10.6	11.5	12.3	13.0	14.5

Design Tidal Elevations – James City County

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
		Existing Condition	2.8	3.5	3.9	4.5	5.5	6.2	6.6	7.1	9.3
		1.5 ft SLR	4.3	5.0	5.4	6.0	7.0	7.7	8.1	8.6	10.8
		3.0 ft SLR	6.0	6.8	7.2	7.8	8.8	9.6	10.0	10.5	12.8
020801070101	Ware Creek	4.5 ft SLR	7.6	8.3	8.7	9.4	10.4	11.1	11.5	12.1	14.4
		Existing Condition	2.1	3.0	3.5	4.2	5.5	6.3	6.6	7.2	10.2
		1.5 ft SLR	3.6	4.5	5.0	5.7	7.0	7.8	8.1	8.7	11.7
	Philbates Creek-	3.0 ft SLR	5.3	6.2	6.7	7.4	8.8	9.6	9.9	10.6	13.7
020801070102	York River	4.5 ft SLR	6.8	7.8	8.3	9.0	10.3	11.2	11.5	12.1	15.2
		Existing Condition	3.0	3.6	4.0	4.5	5.3	6.1	6.4	6.9	8.8
		1.5 ft SLR	4.5	5.1	5.5	6.0	6.8	7.6	7.9	8.4	10.3
	Skimino Creek-	3.0 ft SLR	6.3	6.9	7.3	7.9	8.7	9.5	9.8	10.4	12.4
020801070104	York River	4.5 ft SLR	7.9	8.5	8.9	9.4	10.3	11.1	11.4	11.9	13.9
		Existing Condition	2.9	3.5	3.9	4.4	5.1	5.9	6.3	6.8	8.6
		1.5 ft SLR	4.4	5.0	5.4	5.9	6.6	7.4	7.8	8.3	10.1
		3.0 ft SLR	6.1	6.7	7.1	7.6	8.4	9.2	9.6	10.1	12.0
020801070202	Queen Creek	4.5 ft SLR	7.6	8.3	8.7	9.2	9.9	10.8	11.2	11.7	13.5
		Existing Condition	3.1	3.7	4.0	4.5	5.1	5.8	6.3	6.8	8.3
		1.5 ft SLR	4.6	5.2	5.5	6.0	6.6	7.3	7.8	8.3	9.8
	Carter Creek-	3.0 ft SLR	6.3	6.9	7.2	7.7	8.3	9.1	9.6	10.1	11.6
020801070203	York River	4.5 ft SLR	7.8	8.4	8.7	9.3	9.9	10.6	11.1	11.6	13.2
		Existing Condition	4.0	4.6	4.9	5.3	5.9	6.6	7.0	7.3	8.7
		1.5 ft SLR	5.5	6.1	6.4	6.8	7.4	8.1	8.5	8.8	10.2
	Mill Creek-	3.0 ft SLR	7.4	8.0	8.3	8.7	9.3	10.1	10.5	10.8	12.3
020802060603	Diascund Creek	4.5 ft SLR	8.9	9.6	9.9	10.3	10.9	11.7	12.1	12.4	13.9
		Existing Condition	3.8	4.4	4.7	5.2	5.9	6.6	7.0	7.3	8.9
	Yarmouth Creek-	1.5 ft SLR	5.3	5.9	6.2	6.7	7.4	8.1	8.5	8.8	10.4
	Chickahominy	3.0 ft SLR	7.1	7.7	8.1	8.6	9.3	10.1	10.5	10.8	12.5
020802060604	River	4.5 ft SLR	8.7	9.3	9.6	10.2	10.9	11.6	12.0	12.4	14.0
		Existing Condition	3.8	4.4	4.7	5.2	5.9	6.7	7.0	7.4	9.0
	Morris Creek-	1.5 ft SLR	5.3	5.9	6.2	6.7	7.4	8.2	8.5	8.9	10.5
	Chickahominy	3.0 ft SLR	7.2	7.8	8.1	8.6	9.4	10.2	10.5	11.0	12.6
020802060605	River	4.5 ft SLR	8.7	9.4	9.7	10.2	11.0	11.8	12.1	12.5	14.2

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
		Existing Condition	4.0	4.6	4.9	5.3	5.8	6.7	7.1	7.4	8.8
		1.5 ft SLR	5.5	6.1	6.4	6.8	7.3	8.2	8.6	8.9	10.3
	Broad Swamp-	3.0 ft SLR	7.3	8.0	8.3	8.7	9.2	10.2	10.6	10.9	12.4
020802060701	James River	4.5 ft SLR	8.9	9.6	9.9	10.3	10.8	11.8	12.2	12.5	14.0
		Existing Condition	3.7	4.3	4.6	5.0	5.6	6.3	6.7	7.0	8.5
		1.5 ft SLR	5.2	5.8	6.1	6.5	7.1	7.8	8.2	8.5	10.0
		3.0 ft SLR	7.0	7.6	8.0	8.4	9.0	9.7	10.2	10.5	12.0
020802060702	Powhatan Creek	4.5 ft SLR	8.6	9.2	9.5	9.9	10.6	11.3	11.7	12.0	13.6
		Existing Condition	3.9	4.5	4.8	5.2	5.7	6.5	6.9	7.3	8.6
	Lower Chippokes	1.5 ft SLR	5.4	6.0	6.3	6.7	7.2	8.0	8.4	8.8	10.1
	Creek-James	3.0 ft SLR	7.2	7.8	8.1	8.5	9.1	9.9	10.3	10.7	12.1
020802060704	River	4.5 ft SLR	8.7	9.4	9.7	10.1	10.6	11.4	11.9	12.3	13.6
		Existing Condition	3.3	3.9	4.3	4.8	5.6	6.3	6.7	7.1	9.0
		1.5 ft SLR	4.8	5.4	5.8	6.3	7.1	7.8	8.2	8.6	10.5
		3.0 ft SLR	6.6	7.2	7.6	8.1	8.9	9.7	10.1	10.5	12.5
020802060801	College Creek	4.5 ft SLR	8.1	8.7	9.2	9.7	10.5	11.2	11.6	12.1	14.0
		Existing Condition	3.6	4.2	4.5	4.9	5.6	6.3	6.7	7.1	8.6
		1.5 ft SLR	5.1	5.7	6.0	6.4	7.1	7.8	8.2	8.6	10.1
	Skiffes Creek-	3.0 ft SLR	6.9	7.5	7.8	8.2	8.9	9.7	10.1	10.5	12.1
020802060802	James River	4.5 ft SLR	8.4	9.0	9.4	9.8	10.5	11.2	11.6	12.1	13.6

Design Tidal Elevations – Newport News

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020801080101	Poquoson River-Lower Chesapeake Bay	Existing Condition	2.8	3.5	3.9	4.4	5.1	5.9	6.8	7.4	9.0
		1.5 ft SLR	4.3	5.0	5.4	5.9	6.6	7.4	8.3	8.9	10.5
		3.0 ft SLR	5.9	6.6	7.0	7.5	8.3	9.1	10.0	10.6	12.2
		4.5 ft SLR	7.4	8.2	8.6	9.1	9.8	10.6	11.5	12.1	13.8
020801080102	Northwest Branch Back River	Existing Condition	3.2	3.9	4.3	4.9	5.6	6.4	7.2	7.9	9.6
		1.5 ft SLR	4.7	5.4	5.8	6.4	7.1	7.9	8.7	9.4	11.1
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.8	9.6	10.5	11.2	12.9
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	12.0	12.7	14.5
020801080103	Southwest Branch Back River	Existing Condition	3.3	4.0	4.4	5.0	5.6	6.5	7.4	8.1	9.7
		1.5 ft SLR	4.8	5.5	5.9	6.5	7.1	8.0	8.9	9.6	11.2
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.7	9.6	10.5	11.3	12.9
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.2	11.2	12.1	12.8	14.4
020802060802	Skiffes Creek-James River	Existing Condition	3.6	4.2	4.5	4.9	5.6	6.3	6.7	7.1	8.6
		1.5 ft SLR	5.1	5.7	6.0	6.4	7.1	7.8	8.2	8.6	10.1
		3.0 ft SLR	6.9	7.5	7.8	8.2	8.9	9.7	10.1	10.5	12.1
		4.5 ft SLR	8.4	9.0	9.4	9.8	10.5	11.2	11.6	12.1	13.6
020802060804	Morrisons Creek-James River	Existing Condition	4.0	4.6	4.9	5.3	5.7	6.5	7.1	7.6	8.7
		1.5 ft SLR	5.5	6.1	6.4	6.8	7.2	8.0	8.6	9.1	10.2
		3.0 ft SLR	7.2	7.9	8.2	8.6	9.0	9.8	10.5	11.0	12.1
		4.5 ft SLR	8.8	9.4	9.7	10.1	10.6	11.4	12.0	12.5	13.7
020802060901	Warwick River	Existing Condition	3.7	4.2	4.6	5.0	5.6	6.3	6.8	7.2	8.7
		1.5 ft SLR	5.2	5.7	6.1	6.5	7.1	7.8	8.3	8.7	10.2
		3.0 ft SLR	7.1	7.7	8.1	8.5	9.2	9.9	10.4	10.9	12.5
		4.5 ft SLR	8.7	9.3	9.7	10.1	10.8	11.5	12.0	12.5	14.1
020802060906	Cooper Creek-James River	Existing Condition	3.7	4.4	4.8	5.2	5.8	6.7	7.5	8.1	9.6
		1.5 ft SLR	5.2	5.9	6.3	6.7	7.3	8.2	9.0	9.6	11.1
		3.0 ft SLR	6.9	7.6	8.0	8.4	9.1	10.0	10.8	11.4	13.0
		4.5 ft SLR	8.4	9.2	9.6	10.0	10.6	11.5	12.3	13.0	14.5
020802080303	Hampton River-Hampton Roads	Existing Condition	3.5	4.1	4.4	4.9	5.4	6.2	7.0	7.6	8.9
		1.5 ft SLR	5.0	5.6	5.9	6.4	6.9	7.7	8.5	9.1	10.4
		3.0 ft SLR	6.7	7.3	7.6	8.1	8.6	9.5	10.3	10.9	12.2
		4.5 ft SLR	8.2	8.9	9.2	9.7	10.2	11.0	11.8	12.5	13.8

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802080304	Hampton Roads Channel	Existing Condition	3.3	4.0	4.4	4.9	5.5	6.4	7.1	7.8	9.4
		1.5 ft SLR	4.8	5.5	5.9	6.4	7.0	7.9	8.6	9.3	10.9
		3.0 ft SLR	6.5	7.2	7.6	8.1	8.7	9.6	10.4	11.1	12.7
		4.5 ft SLR	8.0	8.7	9.1	9.6	10.3	11.2	11.9	12.6	14.3

Design Tidal Elevations – Norfolk

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020801080202	Little Creek-Lower Chesapeake Bay	Existing Condition	3.2	3.8	4.2	4.7	5.3	6.1	6.8	7.4	8.9
		1.5 ft SLR	4.7	5.3	5.7	6.2	6.8	7.6	8.3	8.9	10.4
		3.0 ft SLR	6.4	7.0	7.4	8.0	8.6	9.4	10.1	10.7	12.3
		4.5 ft SLR	8.0	8.6	9.0	9.5	10.1	10.9	11.7	12.3	13.8
020802080203	Deep Creek-Southern Branch Elizabeth River	Existing Condition	3.4	4.1	4.5	5.1	5.9	6.7	7.3	8.0	10.0
		1.5 ft SLR	4.9	5.6	6.0	6.6	7.4	8.2	8.8	9.5	11.5
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.9	9.7	10.3	11.0	13.0
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	11.8	12.5	14.5
020802080204	Eastern Branch Elizabeth River	Existing Condition	2.9	3.7	4.2	4.8	5.9	6.6	7.3	8.0	10.4
		1.5 ft SLR	4.4	5.2	5.7	6.3	7.4	8.1	8.8	9.5	11.9
		3.0 ft SLR	6.0	6.8	7.3	7.9	9.1	9.8	10.5	11.2	13.6
		4.5 ft SLR	7.5	8.3	8.9	9.5	10.6	11.3	12.0	12.7	15.2
020802080206	Elizabeth River	Existing Condition	3.2	3.9	4.4	4.9	5.8	6.5	7.3	7.9	9.9
		1.5 ft SLR	4.7	5.4	5.9	6.4	7.3	8.0	8.8	9.4	11.4
		3.0 ft SLR	6.3	7.1	7.6	8.1	9.0	9.7	10.5	11.2	13.2
		4.5 ft SLR	7.9	8.6	9.1	9.6	10.5	11.3	12.1	12.7	14.7
020802080302	Willoughby Bay	Existing Condition	3.2	3.8	4.2	4.7	5.4	6.2	6.9	7.6	9.2
		1.5 ft SLR	4.7	5.3	5.7	6.2	6.9	7.7	8.4	9.1	10.7
		3.0 ft SLR	6.3	6.9	7.3	7.8	8.6	9.4	10.1	10.8	12.4
		4.5 ft SLR	7.8	8.5	8.9	9.4	10.1	10.9	11.6	12.3	14.0
020802080304	Hampton Roads Channel	Existing Condition	3.3	4.0	4.4	4.9	5.5	6.4	7.1	7.8	9.4
		1.5 ft SLR	4.8	5.5	5.9	6.4	7.0	7.9	8.6	9.3	10.9
		3.0 ft SLR	6.5	7.2	7.6	8.1	8.7	9.6	10.4	11.1	12.7
		4.5 ft SLR	8.0	8.7	9.1	9.6	10.3	11.2	11.9	12.6	14.3

Design Tidal Elevations – Poquoson

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020801080101	Poquoson River-Lower Chesapeake Bay	Existing Condition	2.8	3.5	3.9	4.4	5.1	5.9	6.8	7.4	9.0
		1.5 ft SLR	4.3	5.0	5.4	5.9	6.6	7.4	8.3	8.9	10.5
		3.0 ft SLR	5.9	6.6	7.0	7.5	8.3	9.1	10.0	10.6	12.2
		4.5 ft SLR	7.4	8.2	8.6	9.1	9.8	10.6	11.5	12.1	13.8
020801080102	Northwest Branch Back River	Existing Condition	3.2	3.9	4.3	4.9	5.6	6.4	7.2	7.9	9.6
		1.5 ft SLR	4.7	5.4	5.8	6.4	7.1	7.9	8.7	9.4	11.1
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.8	9.6	10.5	11.2	12.9
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	12.0	12.7	14.5
020801080104	Back River-Lower Chesapeake Bay	Existing Condition	3.2	3.9	4.3	4.7	5.4	6.1	6.8	7.5	9.0
		1.5 ft SLR	4.7	5.4	5.8	6.2	6.9	7.6	8.3	9.0	10.5
		3.0 ft SLR	6.4	7.1	7.5	7.9	8.6	9.3	10.1	10.8	12.3
		4.5 ft SLR	7.9	8.6	9.0	9.4	10.2	10.9	11.6	12.3	13.9

Design Tidal Elevations – Portsmouth

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802080203	Deep Creek-Southern Branch Elizabeth River	Existing Condition	3.4	4.1	4.5	5.1	5.9	6.7	7.3	8.0	10.0
		1.5 ft SLR	4.9	5.6	6.0	6.6	7.4	8.2	8.8	9.5	11.5
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.9	9.7	10.3	11.0	13.0
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	11.8	12.5	14.5
020802080205	Western Branch Elizabeth River	Existing Condition	3.7	4.5	4.9	5.4	6.1	7.0	7.9	8.6	10.3
		1.5 ft SLR	5.2	6.0	6.4	6.9	7.6	8.5	9.4	10.1	11.8
		3.0 ft SLR	6.9	7.7	8.1	8.6	9.3	10.2	11.2	11.9	13.6
		4.5 ft SLR	8.4	9.2	9.6	10.1	10.9	11.8	12.7	13.4	15.2
020802080206	Elizabeth River	Existing Condition	3.2	3.9	4.4	4.9	5.8	6.5	7.3	7.9	9.9
		1.5 ft SLR	4.7	5.4	5.9	6.4	7.3	8.0	8.8	9.4	11.4
		3.0 ft SLR	6.3	7.1	7.6	8.1	9.0	9.7	10.5	11.2	13.2
		4.5 ft SLR	7.9	8.6	9.1	9.6	10.5	11.3	12.1	12.7	14.7
020802080301	Streeter Creek-Hampton Roads	Existing Condition	3.3	4.0	4.5	5.0	5.7	6.6	7.4	8.1	9.9
		1.5 ft SLR	4.8	5.5	6.0	6.5	7.2	8.1	8.9	9.6	11.4
		3.0 ft SLR	6.5	7.2	7.7	8.2	8.9	9.9	10.7	11.4	13.2
		4.5 ft SLR	8.0	8.7	9.2	9.7	10.5	11.4	12.2	12.9	14.8

Design Tidal Elevations – Smithfield

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802060902	Warren Creek-Pagan River	Existing Condition	4.0	4.6	5.0	5.5	6.0	6.9	7.8	8.4	9.7
		1.5 ft SLR	5.5	6.1	6.5	7.0	7.5	8.4	9.3	9.9	11.2
		3.0 ft SLR	7.2	7.8	8.2	8.8	9.3	10.2	11.1	11.7	13.1
		4.5 ft SLR	8.8	9.4	9.8	10.3	10.8	11.7	12.7	13.3	14.6
020802060903	Cypress Creek	Existing Condition	3.9	4.6	5.0	5.5	6.0	6.9	7.8	8.5	9.8
		1.5 ft SLR	5.4	6.1	6.5	7.0	7.5	8.4	9.3	10.0	11.3
		3.0 ft SLR	7.1	7.8	8.2	8.8	9.3	10.2	11.1	11.8	13.2
		4.5 ft SLR	8.7	9.4	9.8	10.3	10.8	11.7	12.7	13.4	14.7
020802060904	Jones Creek-Pagan River	Existing Condition	3.9	4.6	5.0	5.4	5.9	6.8	7.6	8.3	9.5
		1.5 ft SLR	5.4	6.1	6.5	6.9	7.4	8.3	9.1	9.8	11.0
		3.0 ft SLR	7.0	7.8	8.2	8.6	9.1	10.0	10.8	11.5	12.8
		4.5 ft SLR	8.6	9.3	9.7	10.1	10.6	11.5	12.3	13.1	14.3

Design Tidal Elevations – Suffolk

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802060905	Chuckatuck Creek	Existing Condition	4.0	4.7	5.1	5.7	6.2	7.3	8.2	8.9	10.4
		1.5 ft SLR	5.5	6.2	6.6	7.2	7.7	8.8	9.7	10.4	11.9
		3.0 ft SLR	7.1	7.8	8.2	8.8	9.3	10.5	11.4	12.1	13.6
		4.5 ft SLR	8.6	9.3	9.7	10.4	10.9	12.0	12.9	13.6	15.1
020802060906	Cooper Creek-James River	Existing Condition	3.7	4.4	4.8	5.2	5.8	6.7	7.5	8.1	9.6
		1.5 ft SLR	5.2	5.9	6.3	6.7	7.3	8.2	9.0	9.6	11.1
		3.0 ft SLR	6.9	7.6	8.0	8.4	9.1	10.0	10.8	11.4	13.0
		4.5 ft SLR	8.4	9.2	9.6	10.0	10.6	11.5	12.3	13.0	14.5
020802080105	Cedar Lake-Nansemond River	Existing Condition	4.0	4.9	5.4	6.1	6.9	8.0	9.1	9.9	12.0
		1.5 ft SLR	5.5	6.4	6.9	7.6	8.4	9.5	10.6	11.4	13.5
		3.0 ft SLR	7.4	8.3	8.8	9.6	10.4	11.6	12.7	13.6	15.8
		4.5 ft SLR	8.9	9.9	10.4	11.1	12.0	13.1	14.3	15.1	17.3
020802080106	Bennett Creek-Nansemond River	Existing Condition	4.0	4.9	5.4	6.0	6.8	7.9	8.9	9.8	11.7
		1.5 ft SLR	5.5	6.4	6.9	7.5	8.3	9.4	10.4	11.3	13.2
		3.0 ft SLR	7.1	8.1	8.6	9.2	10.0	11.1	12.2	13.1	15.0
		4.5 ft SLR	8.7	9.6	10.1	10.7	11.5	12.7	13.7	14.6	16.5
020802080205	Western Branch Elizabeth River	Existing Condition	3.7	4.5	4.9	5.4	6.1	7.0	7.9	8.6	10.3
		1.5 ft SLR	5.2	6.0	6.4	6.9	7.6	8.5	9.4	10.1	11.8
		3.0 ft SLR	6.9	7.7	8.1	8.6	9.3	10.2	11.2	11.9	13.6
		4.5 ft SLR	8.4	9.2	9.6	10.1	10.9	11.8	12.7	13.4	15.2
020802080301	Streeter Creek-Hampton Roads	Existing Condition	3.3	4.0	4.5	5.0	5.7	6.6	7.4	8.1	9.9
		1.5 ft SLR	4.8	5.5	6.0	6.5	7.2	8.1	8.9	9.6	11.4
		3.0 ft SLR	6.5	7.2	7.7	8.2	8.9	9.9	10.7	11.4	13.2
		4.5 ft SLR	8.0	8.7	9.2	9.7	10.5	11.4	12.2	12.9	14.8

Design Tidal Elevations – Surry County

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802060303	Upper Chippokes Creek	Existing Condition	4.2	4.8	5.1	5.5	6.0	7.0	7.3	7.6	9.0
		1.5 ft SLR	5.7	6.3	6.6	7.0	7.5	8.5	8.8	9.1	10.5
		3.0 ft SLR	7.9	8.6	8.9	9.4	9.9	11.0	11.4	11.7	13.2
		4.5 ft SLR	9.6	10.3	10.6	11.0	11.6	12.7	13.0	13.3	14.9
020802060304	Sunken Meadow Pond-James River	Existing Condition	4.0	4.5	4.9	5.3	5.9	6.8	7.2	7.5	9.0
		1.5 ft SLR	5.5	6.0	6.4	6.8	7.4	8.3	8.7	9.0	10.5
		3.0 ft SLR	7.4	7.9	8.4	8.8	9.4	10.4	10.8	11.1	12.7
		4.5 ft SLR	9.0	9.5	10.0	10.4	11.0	12.0	12.4	12.7	14.3
020802060701	Broad Swamp-James River	Existing Condition	4.0	4.6	4.9	5.3	5.8	6.7	7.1	7.4	8.8
		1.5 ft SLR	5.5	6.1	6.4	6.8	7.3	8.2	8.6	8.9	10.3
		3.0 ft SLR	7.3	8.0	8.3	8.7	9.2	10.2	10.6	10.9	12.4
		4.5 ft SLR	8.9	9.6	9.9	10.3	10.8	11.8	12.2	12.5	14.0
020802060703	Grays Creek	Existing Condition	4.1	4.6	4.9	5.3	5.7	6.6	7.0	7.3	8.5
		1.5 ft SLR	5.6	6.1	6.4	6.8	7.2	8.1	8.5	8.8	10.0
		3.0 ft SLR	7.5	8.0	8.3	8.7	9.2	10.1	10.5	10.8	12.1
		4.5 ft SLR	9.1	9.6	9.9	10.3	10.7	11.7	12.1	12.4	13.7
020802060704	Lower Chippokes Creek-James River	Existing Condition	3.9	4.5	4.8	5.2	5.7	6.5	6.9	7.3	8.6
		1.5 ft SLR	5.4	6.0	6.3	6.7	7.2	8.0	8.4	8.8	10.1
		3.0 ft SLR	7.2	7.8	8.1	8.5	9.1	9.9	10.3	10.7	12.1
		4.5 ft SLR	8.7	9.4	9.7	10.1	10.6	11.4	11.9	12.3	13.6
020802060802	Skiffes Creek-James River	Existing Condition	3.6	4.2	4.5	4.9	5.6	6.3	6.7	7.1	8.6
		1.5 ft SLR	5.1	5.7	6.0	6.4	7.1	7.8	8.2	8.6	10.1
		3.0 ft SLR	6.9	7.5	7.8	8.2	8.9	9.7	10.1	10.5	12.1
		4.5 ft SLR	8.4	9.0	9.4	9.8	10.5	11.2	11.6	12.1	13.6
020802060803	Lawnes Creek	Existing Condition	4.0	4.5	4.8	5.2	5.6	6.4	6.8	7.3	8.4
		1.5 ft SLR	5.5	6.0	6.3	6.7	7.1	7.9	8.3	8.8	9.9
		3.0 ft SLR	7.3	7.8	8.1	8.5	8.9	9.8	10.2	10.7	11.9
		4.5 ft SLR	8.8	9.4	9.7	10.1	10.5	11.3	11.8	12.3	13.4
020802060804	Morrisons Creek-James River	Existing Condition	4.0	4.6	4.9	5.3	5.7	6.5	7.1	7.6	8.7
		1.5 ft SLR	5.5	6.1	6.4	6.8	7.2	8.0	8.6	9.1	10.2
		3.0 ft SLR	7.2	7.9	8.2	8.6	9.0	9.8	10.5	11.0	12.1
		4.5 ft SLR	8.8	9.4	9.7	10.1	10.6	11.4	12.0	12.5	13.7

Design Tidal Elevations – Williamsburg

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
		Existing Condition	2.9	3.5	3.9	4.4	5.1	5.9	6.3	6.8	8.6
		1.5 ft SLR	4.4	5.0	5.4	5.9	6.6	7.4	7.8	8.3	10.1
		3.0 ft SLR	6.1	6.7	7.1	7.6	8.4	9.2	9.6	10.1	12.0
020801070202	Queen Creek	4.5 ft SLR	7.6	8.3	8.7	9.2	9.9	10.8	11.2	11.7	13.5
		Existing Condition	3.3	3.9	4.3	4.8	5.6	6.3	6.7	7.1	9.0
		1.5 ft SLR	4.8	5.4	5.8	6.3	7.1	7.8	8.2	8.6	10.5
		3.0 ft SLR	6.6	7.2	7.6	8.1	8.9	9.7	10.1	10.5	12.5
020802060801	College Creek	4.5 ft SLR	8.1	8.7	9.2	9.7	10.5	11.2	11.6	12.1	14.0

Design Tidal Elevations – York County

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020801070104	Skimino Creek-York River	Existing Condition	3.0	3.6	4.0	4.5	5.3	6.1	6.4	6.9	8.8
		1.5 ft SLR	4.5	5.1	5.5	6.0	6.8	7.6	7.9	8.4	10.3
		3.0 ft SLR	6.3	6.9	7.3	7.9	8.7	9.5	9.8	10.4	12.4
		4.5 ft SLR	7.9	8.5	8.9	9.4	10.3	11.1	11.4	11.9	13.9
020801070201	Jones Creek-York River	Existing Condition	3.2	3.8	4.1	4.6	5.2	6.0	6.4	6.8	8.5
		1.5 ft SLR	4.7	5.3	5.6	6.1	6.7	7.5	7.9	8.3	10.0
		3.0 ft SLR	6.4	7.0	7.3	7.8	8.5	9.3	9.7	10.1	11.9
		4.5 ft SLR	7.9	8.6	8.9	9.4	10.0	10.8	11.2	11.7	13.4
020801070202	Queen Creek	Existing Condition	2.9	3.5	3.9	4.4	5.1	5.9	6.3	6.8	8.6
		1.5 ft SLR	4.4	5.0	5.4	5.9	6.6	7.4	7.8	8.3	10.1
		3.0 ft SLR	6.1	6.7	7.1	7.6	8.4	9.2	9.6	10.1	12.0
		4.5 ft SLR	7.6	8.3	8.7	9.2	9.9	10.8	11.2	11.7	13.5
020801070203	Carter Creek-York River	Existing Condition	3.1	3.7	4.0	4.5	5.1	5.8	6.3	6.8	8.3
		1.5 ft SLR	4.6	5.2	5.5	6.0	6.6	7.3	7.8	8.3	9.8
		3.0 ft SLR	6.3	6.9	7.2	7.7	8.3	9.1	9.6	10.1	11.6
		4.5 ft SLR	7.8	8.4	8.7	9.3	9.9	10.6	11.1	11.6	13.2
020801070204	Sarah Creek-York River	Existing Condition	3.0	3.6	3.9	4.3	4.9	5.5	6.1	6.6	7.9
		1.5 ft SLR	4.5	5.1	5.4	5.8	6.4	7.0	7.6	8.1	9.4
		3.0 ft SLR	6.1	6.7	7.1	7.5	8.1	8.7	9.3	9.8	11.1
		4.5 ft SLR	7.7	8.3	8.6	9.0	9.6	10.2	10.8	11.4	12.7
020801080101	Poquoson River-Lower Chesapeake Bay	Existing Condition	2.8	3.5	3.9	4.4	5.1	5.9	6.8	7.4	9.0
		1.5 ft SLR	4.3	5.0	5.4	5.9	6.6	7.4	8.3	8.9	10.5
		3.0 ft SLR	5.9	6.6	7.0	7.5	8.3	9.1	10.0	10.6	12.2
		4.5 ft SLR	7.4	8.2	8.6	9.1	9.8	10.6	11.5	12.1	13.8
020801080102	Northwest Branch Back River	Existing Condition	3.2	3.9	4.3	4.9	5.6	6.4	7.2	7.9	9.6
		1.5 ft SLR	4.7	5.4	5.8	6.4	7.1	7.9	8.7	9.4	11.1
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.8	9.6	10.5	11.2	12.9
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	12.0	12.7	14.5
020802060802	Skiffes Creek-James River	Existing Condition	3.6	4.2	4.5	4.9	5.6	6.3	6.7	7.1	8.6
		1.5 ft SLR	5.1	5.7	6.0	6.4	7.1	7.8	8.2	8.6	10.1
		3.0 ft SLR	6.9	7.5	7.8	8.2	8.9	9.7	10.1	10.5	12.1
		4.5 ft SLR	8.4	9.0	9.4	9.8	10.5	11.2	11.6	12.1	13.6

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
		Existing Condition	3.7	4.2	4.6	5.0	5.6	6.3	6.8	7.2	8.7
		1.5 ft SLR	5.2	5.7	6.1	6.5	7.1	7.8	8.3	8.7	10.2
		3.0 ft SLR	7.1	7.7	8.1	8.5	9.2	9.9	10.4	10.9	12.5
020802060901	Warwick River	4.5 ft SLR	8.7	9.3	9.7	10.1	10.8	11.5	12.0	12.5	14.1

Non-Linearity Factors for Hampton Roads Watersheds

HUC12	Name	Non-Linearity Factor
020403040304	Smith Island Inlet-The Thorofare	1.07
020403040404	Lower Eastern Shore-Atlantic Ocean	1.09
020403040501	Rudee Inlet-Atlantic Ocean	1.07
020403040502	020403040502-Atlantic Ocean	1.08
020801010000	Lower Chesapeake Bay	1.03
020801020301	Carvers Creek-Piankatank River	1.00
020801020302	Hills Bay-Piankatank River	1.03
020801020303	Milford Haven-Lower Chesapeake Bay	1.01
020801020401	Beaverdam Swamp	1.03*
020801020402	Crany Creek-Fox Mill Run	1.01
020801020403	Ware River	1.02
020801020404	North River	1.03
020801020405	East River	1.04
020801020406	Winter Harbor-Lower Chesapeake Bay	1.02
020801020407	Severn River	1.02
020801020408	Monday Creek-Mobjack Bay	1.03
020801050504	Aylett Creek-Mattaponi River	1.03
020801050601	Garnetts Creek	1.04*
020801050602	Courthouse Creek-Mattaponi River	1.05
020801050603	Heartquake Creek-Mattaponi River	1.04
020801050604	Cabin Creek-Mattaponi River	1.04
020801061003	Black Creek	1.10*
020801061004	Montague Creek-Pamunkey River	1.10
020801061005	Jacks Creek	1.10*
020801061101	Cohoke Mill Creek-Pamunkey River	1.11
020801061102	Mill Creek-Pamunkey River	1.04
020801070101	Ware Creek	1.04*
020801070102	Philbates Creek-York River	1.03
020801070103	Poropotank River	1.09
020801070104	Skimino Creek-York River	1.05
020801070201	Jones Creek-York River	1.03
020801070202	Queen Creek	1.03
020801070203	Carter Creek-York River	1.03
020801070204	Sarah Creek-York River	1.02
020801080101	Poquoson River-Lower Chesapeake Bay	1.02
020801080102	Northwest Branch Back River	1.02
020801080103	Southwest Branch Back River	1.01
020801080104	Back River-Lower Chesapeake Bay	1.03
020801080201	Lynnhaven River	1.03
020801080202	Little Creek-Lower Chesapeake Bay	1.03
020801110901	Hungars Creek-Lower Chesapeake Bay	1.03
020801110902	Cherrystone Inlet-Lower Chesapeake Bay	1.04
020802050607	Little Westham Creek-James River	2.73
020802060101	Almond Creek-James River	2.54

HUC12	Name	Non-Linearity Factor
020802060102	Falling Creek	1.85*
020802060103	Proctors Creek-James River	2.09
020802060104	Fourmile Creek	1.85*
020802060105	Turkey Island Creek	1.85*
020802060106	Curles Creek-James River	1.48
020802060201	Bailey Creek-James River	1.12
020802060202	Powell Creek	1.11
020802060203	Herring Creek	1.12*
020802060204	Courthouse Creek-Queens Creek	1.12*
020802060205	Flowerdew Hundred Creek-James River	1.09
020802060301	Wards Creek	1.07*
020802060302	Kittewan Creek-James River	1.07
020802060303	Upper Chippokes Creek	1.10
020802060304	Sunken Meadow Pond-James River	1.06
020802060506	Big Swamp-Chickahominy River	1.04
020802060601	Barrows Creek-Chickahominy River	1.04
020802060603	Mill Creek-Diascund Creek	1.05*
020802060604	Yarmouth Creek-Chickahominy River	1.05
020802060605	Morris Creek-Chickahominy River	1.05
020802060701	Broad Swamp-James River	1.05
020802060702	Powhatan Creek	1.05
020802060703	Grays Creek	1.05
020802060704	Lower Chippokes Creek-James River	1.04
020802060801	College Creek	1.04*
020802060802	Skiffes Creek-James River	1.04
020802060803	Lawnes Creek	1.04*
020802060804	Morrisons Creek-James River	1.04
020802060901	Warwick River	1.07
020802060902	Warren Creek-Pagan River	1.03*
020802060903	Cypress Creek	1.03*
020802060904	Jones Creek-Pagan River	1.02
020802060905	Chuckatuck Creek	1.01
020802060906	Cooper Creek-James River	1.03
020802070904	Franks Branch-Swift Creek	1.15
020802071001	Oldtown Creek-Appomattox River	1.14
020802071002	Ashton Creek-Appomattox River	1.14
020802080105	Cedar Lake-Nansemond River	1.05
020802080106	Bennett Creek-Nansemond River	1.02
020802080201	New Mill Creek-Southern Branch Elizabeth River	0.99
020802080202	Big Entry Ditch-Dismal Swamp	1.01*
020802080203	Deep Creek-Southern Branch Elizabeth River	1.00
020802080204	Eastern Branch Elizabeth River	1.02
020802080205	Western Branch Elizabeth River	1.02
020802080206	Elizabeth River	1.02
020802080301	Streeter Creek-Hampton Roads	1.03

HUC12	Name	Non-Linearity Factor
020802080302	Willoughby Bay	1.02
020802080303	Hampton River-Hampton Roads	1.03
020802080304	Hampton Roads Channel	1.03
030102051104	Indian Creek-Northwest River	1.04
030102051105	Moyock Run	1.04*
030102051107	Tull Creek	1.04*
030102051108	Tull Bay-Northwest River	1.04
030102051201	Chesapeake Canal	1.00
030102051202	West Neck Creek	1.04*
030102051203	Upper North Landing River	1.04
030102051204	Pocaty River	1.04*
030102051205	Blackwater Creek-North Landing River	1.03
030102051206	Milldam Creek-North Landing River	1.03
030102051207	Town of Currituck-North Landing River	1.06
030102051301	Ashville Bridge Creek	1.07*
030102051302	North Bay-Shipps Bay	1.08
030102051303	Back Bay	1.09
030102051304	Coinjock Bay-Currituck Sound	1.05
030102051701	Sand Ridge-Atlantic Ocean	1.09
030102051702	Town of Corolla-Oceanside Seashore	1.12
030102051706	030102051706-Atlantic Ocean	1.10

* Non-Linearity Factor for corresponding HUC-10 watershed

Design Rainfall Depths – Methodology

The goal of this effort is to develop design rainfall depths for communities in Hampton Roads that account for project climate change for use as inputs for stormwater management calculations. Design rainfall depths are commonly based on the NOAA Atlas 14 Precipitation-Frequency Atlas for the United States. Virginia is included in Volume 2, which covers the states in and around the Ohio River basin. Volume 2 was last published in 2004 and revised in 2006. It only includes data through 2000, so does not account for observed changes in precipitation patterns since then, nor does it account for future climate change.

This analysis is based on two previous projects. The first was conducted by the City of Virginia Beach to help inform the development of the city's revised public facilities manual. The second was completed by RAND and the Mid-Atlantic Regional Integrated Sciences and Assessments (MARISA) program to develop a Chesapeake Bay watershed-wide tool for the Chesapeake Bay Program. Both efforts use NOAA's Atlas 14[4] precipitation data as a starting point along with multiple downscaled climate projections to generate future precipitation values.

The primary deliverable from the RAND study was the development of change factors for individual counties and county-equivalent units (e.g., independent cities in Virginia) in the Chesapeake Bay watershed and all of Virginia (Figure 5). Change factors are multipliers applied to values from the current NOAA Atlas 14 volume to generate estimates that correspond to future climate conditions.

Future Precipitation = NOAA Atlas 14 Precipitation x Change Factor

Change factors were developed for different combinations of climate scenarios, time periods, and recurrence intervals. For example, a change factor would be calculated for the 2-year recurrence interval for 2020-2069 under representative concentration pathway 4.5.

- Climate scenarios: representative concentration pathways (RCPs) 4.5 and 8.5[5]
- Time periods: 2020-2069 and 2050-2099 (baseline time period is 1950-2000)
- Recurrence intervals: 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year

In order to account for uncertainty, the RAND/MARISA team calculated multiple values for each factor, including the 10th-percentile, 25th-percentile, 50th-percentile, 75th-percentile, and 90th-percentile, in addition to minimum and maximum values.

[4] NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 2 (2006) https://www.weather.gov/media/owp/oh/hdsc/docs/Atlas14_Volume2.pdf

[5] Representative concentration pathways (RCPs) are greenhouse gas emissions scenarios based on different assumptions about energy usage and economic activity in the future. RCP 4.5 represents a decline in emissions around 2045. RCP 8.5 represents increasing emissions through the 21st century.

The Virginia Beach study[6] included both a statistical analysis of rainfall data after the cutoff for NOAA Atlas 14 and projections of future rainfall with climate change. The analysis found that the current 10-year event was approximately 10% larger in the Hampton Roads region than what is in NOAA Atlas 14. The climate analysis also considered both climate scenarios RCP 4.5 and RCP 8.5. The Virginia Beach study included mid-term (2045) and long-term (2075) estimates for the 24-hour rainfall duration for the 1-year, 2-year, 5-year, 10-year, 20-year, 50-year, and 100-year return periods. The study also modeled historical values to compare with NOAA Atlas 14. The change between the modeled historical value and the future projected value ranged from 11% to 23% for the mid-term and from 19% to 36% for the long-term. Although the Virginia Beach study provided both mid-term and long-term estimates of future rainfall depths for each return period, the final recommendation was for the city to apply a 20% increase above NOAA Atlas 14 values for all return periods instead of using the individual calculated values.

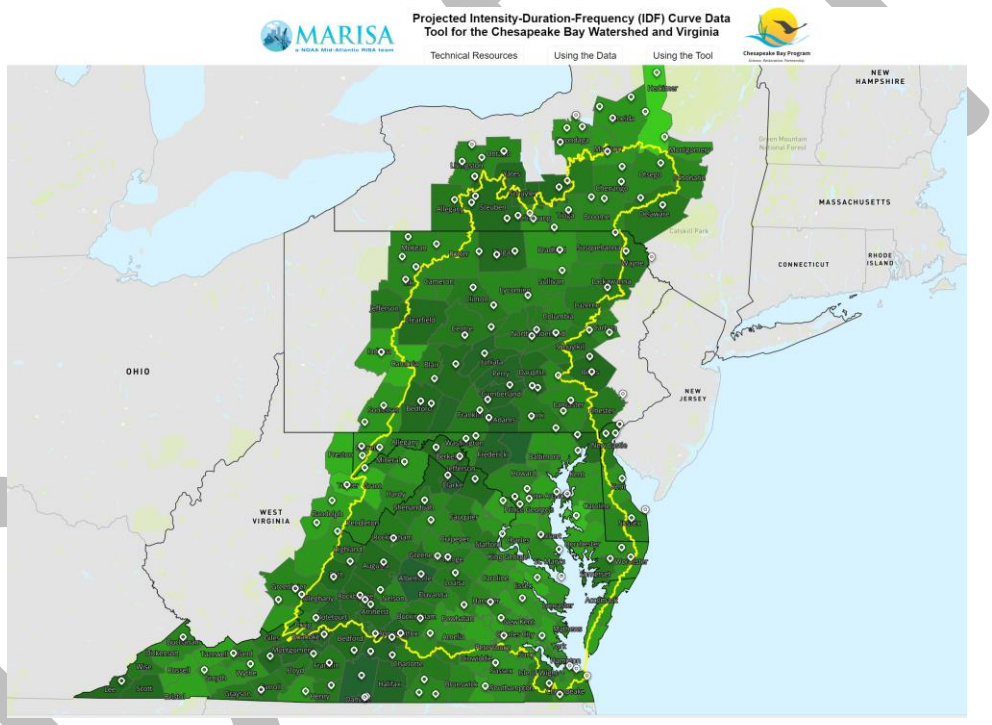


Figure 5: Screenshot of MARISA IDF Curve Data Tool Showing Median County Change Factors[7]

[6] "Analysis of Historical and Future Heavy Precipitation," March 26, 2018 (CIP 7-030, PWCN-15-0014, Work Order 9A) https://www.vbgov.com/government/departments/public-works/comp-sea-level-rise/Documents/anaylsis-hist-and-future-hvy-precip-4-2-18.pdf

[7] Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia (https://midatlantic-idf.rcc-acis.org/)

Methodology for Design Rainfall Depths

1. Calculate centroid of locality in ArcGIS using Convert Feature To Point
2. Use Extract Multi Values to Points to append NOAA Atlas 14 rainfall depths to Locality Centroid Feature
3. Export Feature and convert to Excel format
4. Multiply NOAA Atlas 14 rainfall depths for locality centroids by selected change factors to calculate future rainfall depths for selected climate scenarios

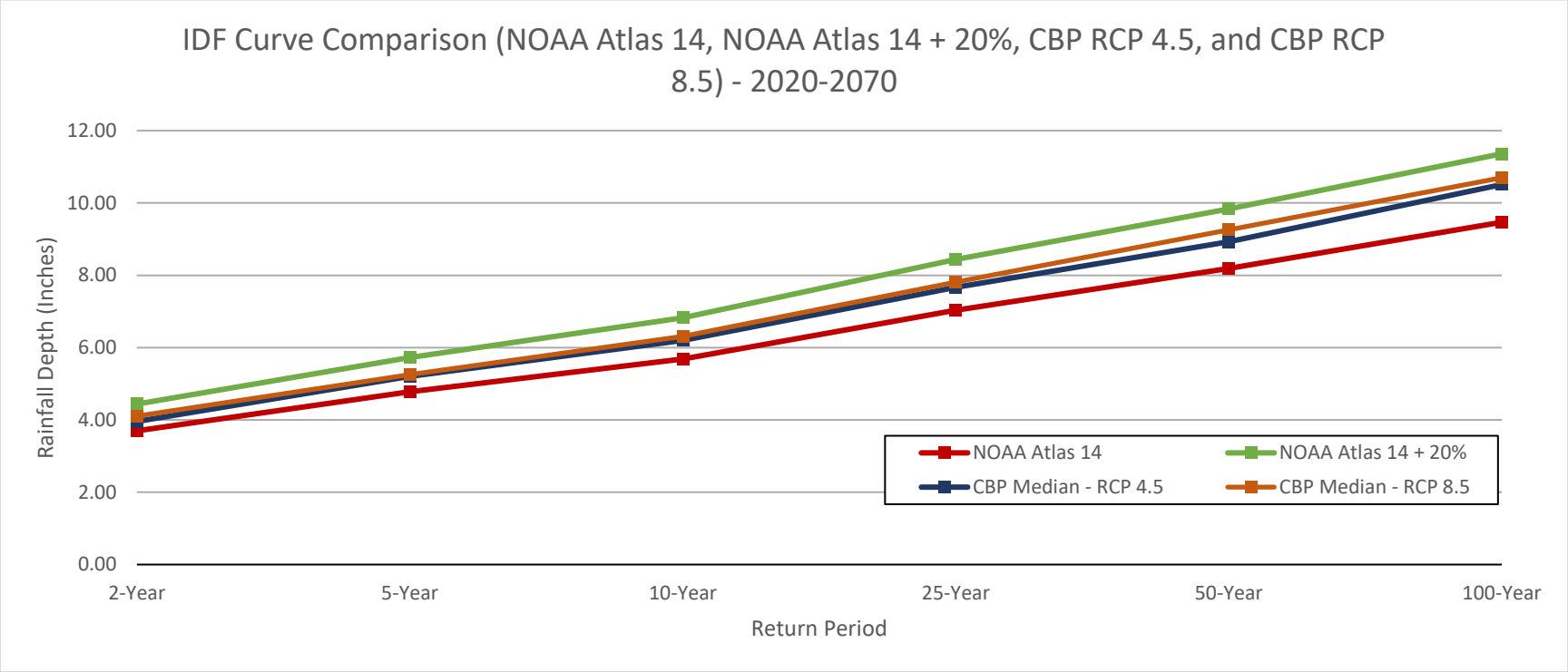
Design Rainfall Depths for Hampton Roads Localities

Notes:

1. All values are in inches
2. All values are for the 24-hour duration event
3. Atlas 14 values are for the centroid of each locality
4. RCP 4.5 and RCP 8.5 values are based on centroid Atlas 14 values and change factors from RAND/MARISA IDF Curve Data Tool

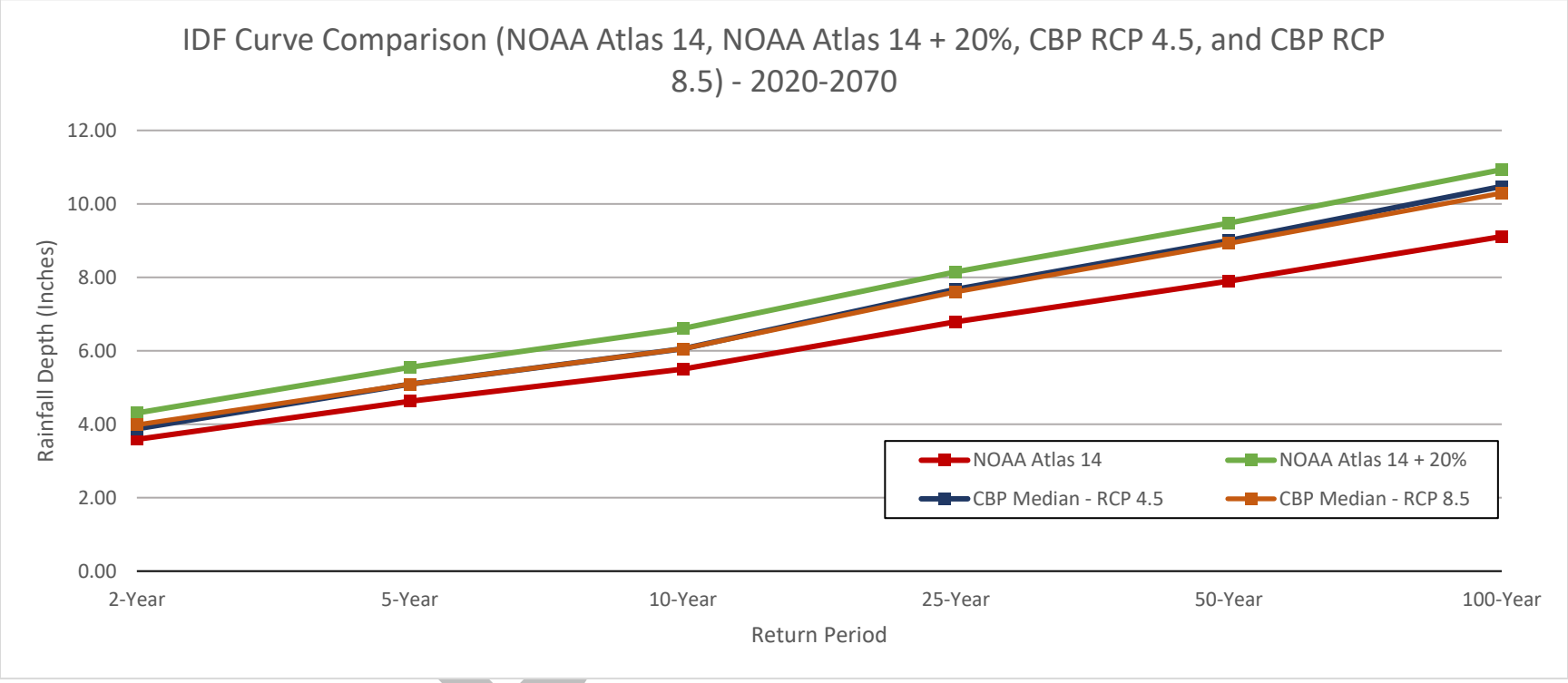
Chesapeake – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.70	4.44	3.66	3.77	3.96	4.22	4.44	3.63	3.85	4.11	4.25	4.40
5-Year	4.78	5.73	4.68	4.78	5.20	5.49	5.92	4.63	4.97	5.25	5.63	5.97
10-Year	5.69	6.83	5.46	5.63	6.20	6.71	7.45	5.52	5.92	6.31	6.83	7.28
25-Year	7.04	8.44	6.47	6.96	7.67	8.51	9.36	6.47	7.32	7.81	8.65	9.22
50-Year	8.19	9.83	7.13	8.19	8.93	10.16	11.14	7.29	8.44	9.26	10.41	11.06
100-Year	9.47	11.36	8.05	9.47	10.51	11.93	13.82	8.24	9.66	10.70	12.12	13.16



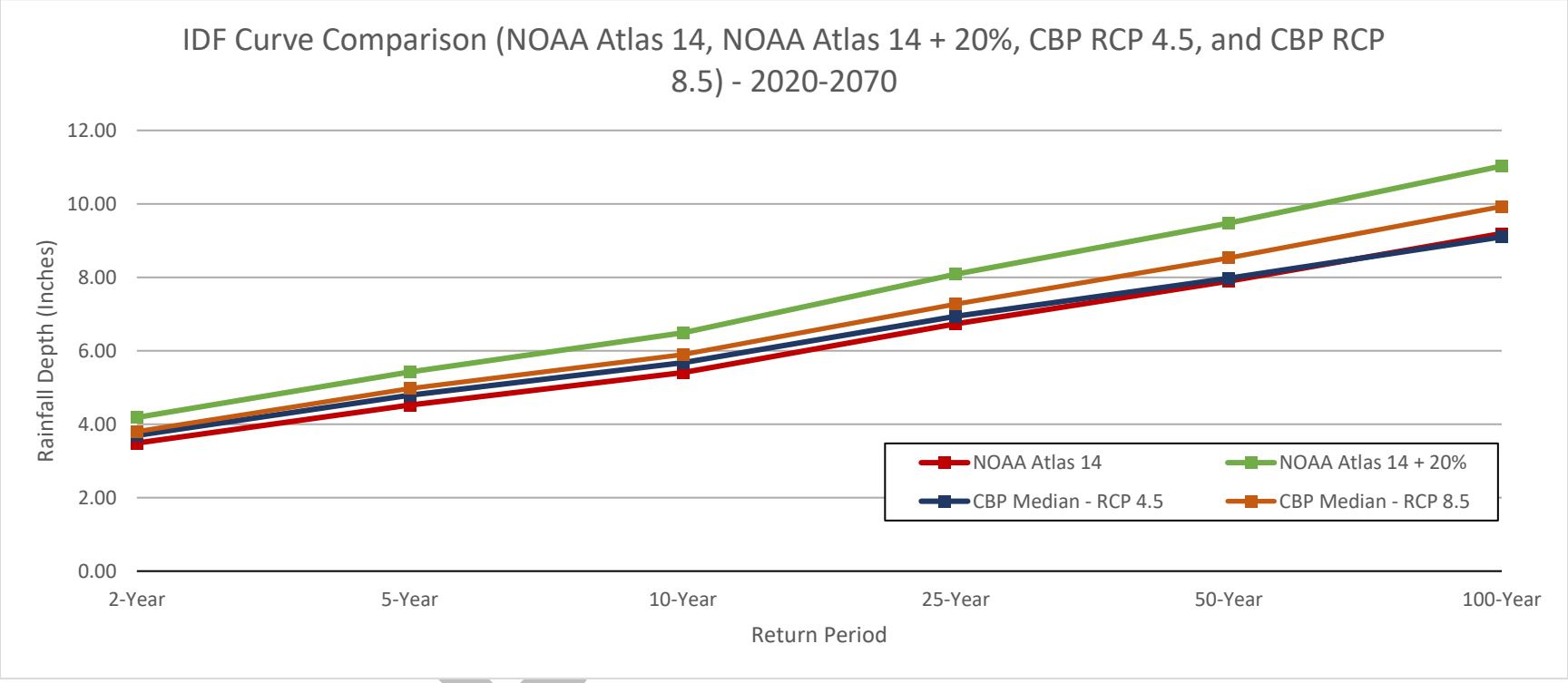
Franklin – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.59	4.31	3.52	3.77	3.88	4.05	4.23	3.62	3.77	3.98	4.13	4.34
5-Year	4.63	5.55	4.49	4.86	5.09	5.32	5.64	4.58	4.90	5.09	5.46	5.69
10-Year	5.50	6.60	5.23	5.72	6.05	6.49	6.88	5.28	5.72	6.05	6.66	6.93
25-Year	6.79	8.15	6.11	6.93	7.67	8.22	8.97	6.18	6.93	7.61	8.35	8.83
50-Year	7.90	9.48	7.11	7.90	9.00	9.79	10.74	6.95	7.82	8.92	9.87	10.58
100-Year	9.11	10.93	7.74	9.20	10.48	11.66	12.84	7.83	8.74	10.29	11.75	12.75



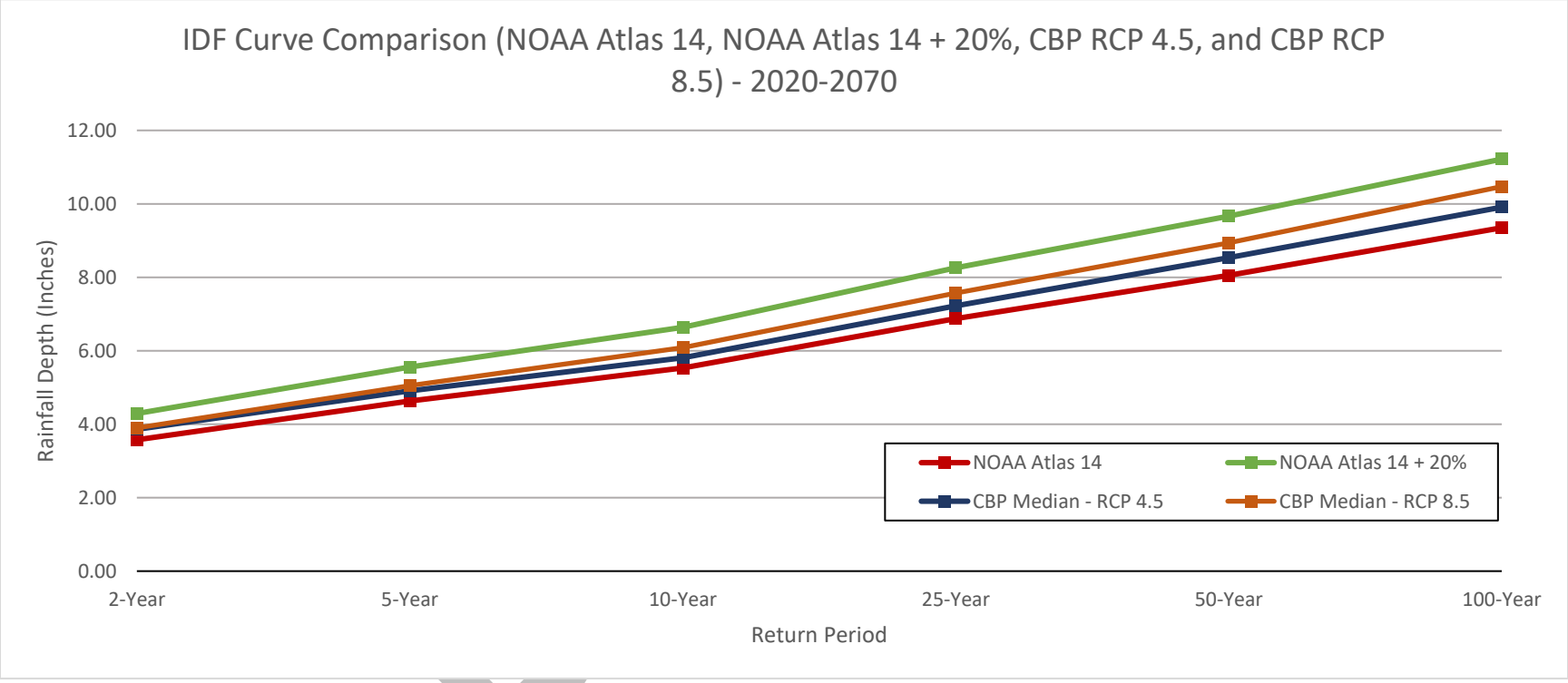
Gloucester County – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.49	4.18	3.45	3.59	3.70	3.87	4.01	3.59	3.63	3.80	3.94	4.11
5-Year	4.52	5.42	4.34	4.61	4.79	5.06	5.20	4.52	4.65	4.97	5.15	5.38
10-Year	5.41	6.49	4.97	5.35	5.68	6.06	6.33	5.30	5.52	5.89	6.22	6.60
25-Year	6.74	8.08	5.79	6.40	6.94	7.54	8.35	6.47	6.74	7.27	7.88	8.35
50-Year	7.90	9.48	6.48	7.11	7.98	8.84	10.03	7.42	7.82	8.53	9.32	10.19
100-Year	9.19	11.03	7.17	7.91	9.10	10.57	12.23	8.46	8.92	9.93	11.03	12.23



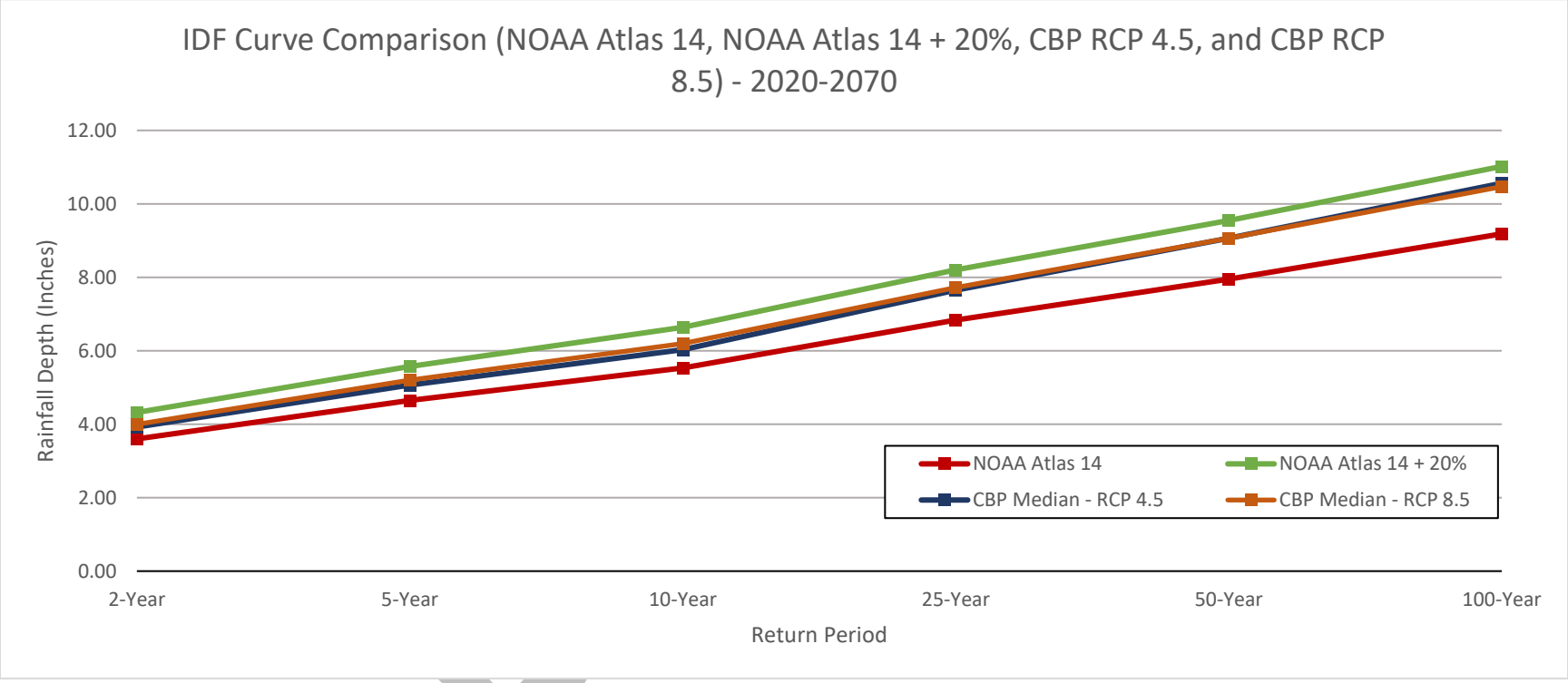
Hampton – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.58	4.29	3.54	3.65	3.86	4.01	4.11	3.50	3.75	3.90	4.11	4.29
5-Year	4.63	5.56	4.49	4.58	4.91	5.28	5.46	4.54	4.77	5.05	5.42	5.56
10-Year	5.53	6.64	5.26	5.42	5.81	6.36	6.75	5.31	5.70	6.09	6.47	6.75
25-Year	6.88	8.26	6.19	6.74	7.22	8.05	8.94	6.60	7.09	7.57	8.12	8.81
50-Year	8.05	9.66	7.01	7.81	8.54	9.82	11.03	7.65	8.21	8.94	9.74	10.63
100-Year	9.35	11.22	7.85	8.69	9.91	11.59	13.28	8.51	9.44	10.47	11.78	12.90



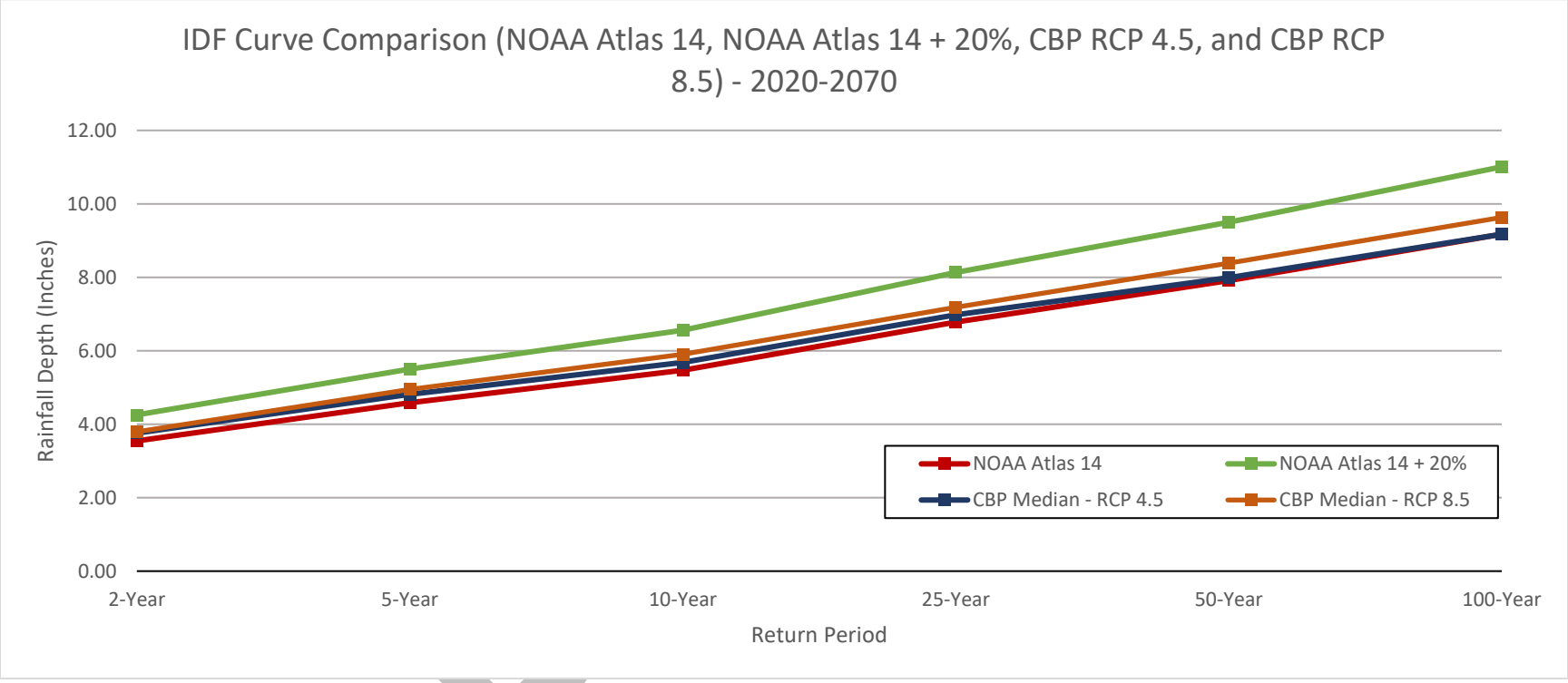
Isle of Wight County – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.60	4.32	3.53	3.74	3.92	4.10	4.32	3.56	3.82	4.00	4.18	4.32
5-Year	4.65	5.57	4.55	4.78	5.06	5.39	5.67	4.51	4.92	5.20	5.48	5.71
10-Year	5.53	6.64	5.31	5.64	6.03	6.53	6.97	5.31	5.81	6.19	6.58	6.91
25-Year	6.83	8.20	6.08	6.83	7.65	8.20	8.82	6.49	7.04	7.72	8.34	8.75
50-Year	7.95	9.54	6.92	7.79	9.07	9.78	10.58	7.32	8.11	9.07	9.86	10.42
100-Year	9.18	11.02	7.62	8.72	10.56	11.66	12.67	7.99	9.18	10.47	11.66	12.67



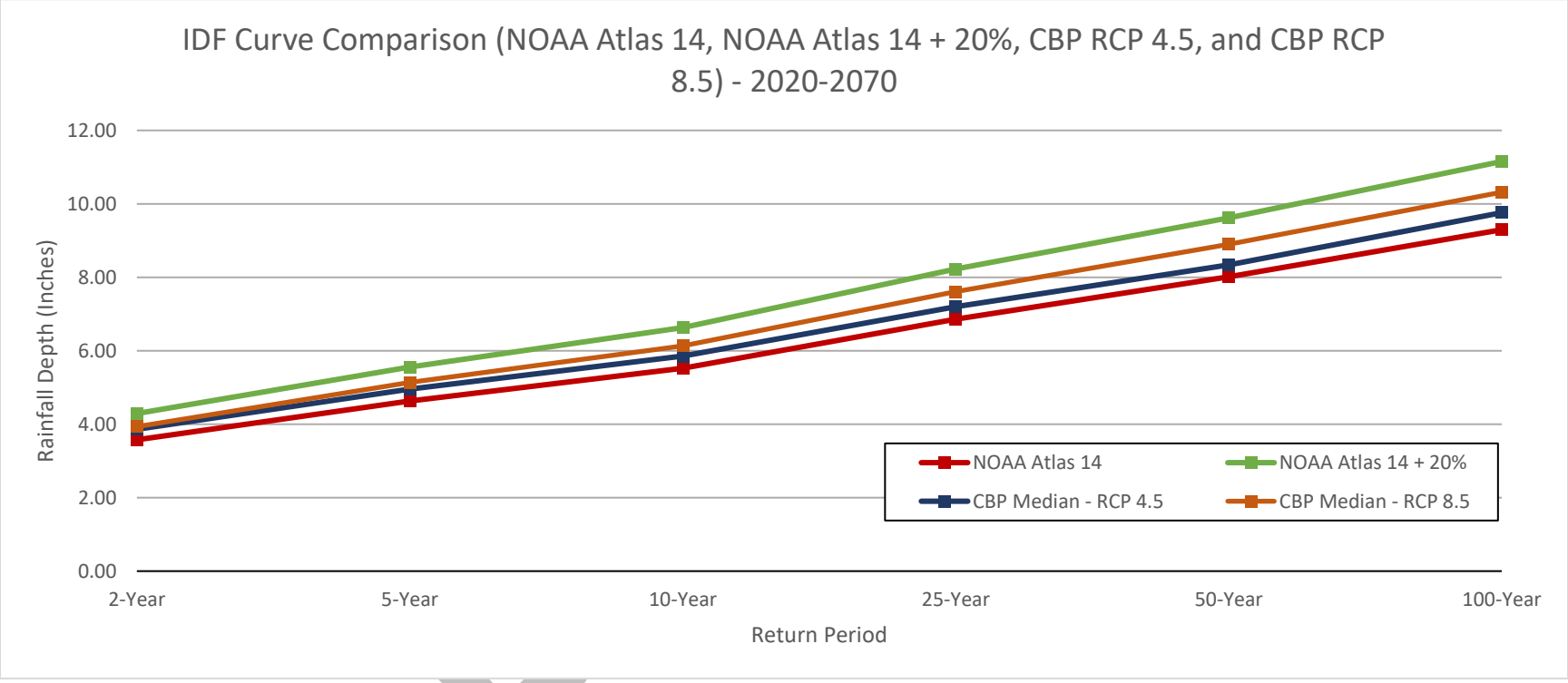
James City County – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.55	4.26	3.44	3.62	3.76	3.87	4.11	3.58	3.69	3.79	4.04	4.18
5-Year	4.59	5.50	4.36	4.63	4.81	4.95	5.32	4.45	4.68	4.95	5.18	5.50
10-Year	5.47	6.56	4.97	5.41	5.69	5.90	6.40	5.25	5.47	5.90	6.29	6.62
25-Year	6.78	8.13	5.83	6.30	6.98	7.46	8.00	6.24	6.64	7.18	8.00	8.54
50-Year	7.91	9.50	6.41	7.04	7.99	8.78	9.50	7.04	7.52	8.39	9.42	10.45
100-Year	9.17	11.01	6.79	7.71	9.17	10.27	11.65	7.89	8.53	9.63	10.92	12.48



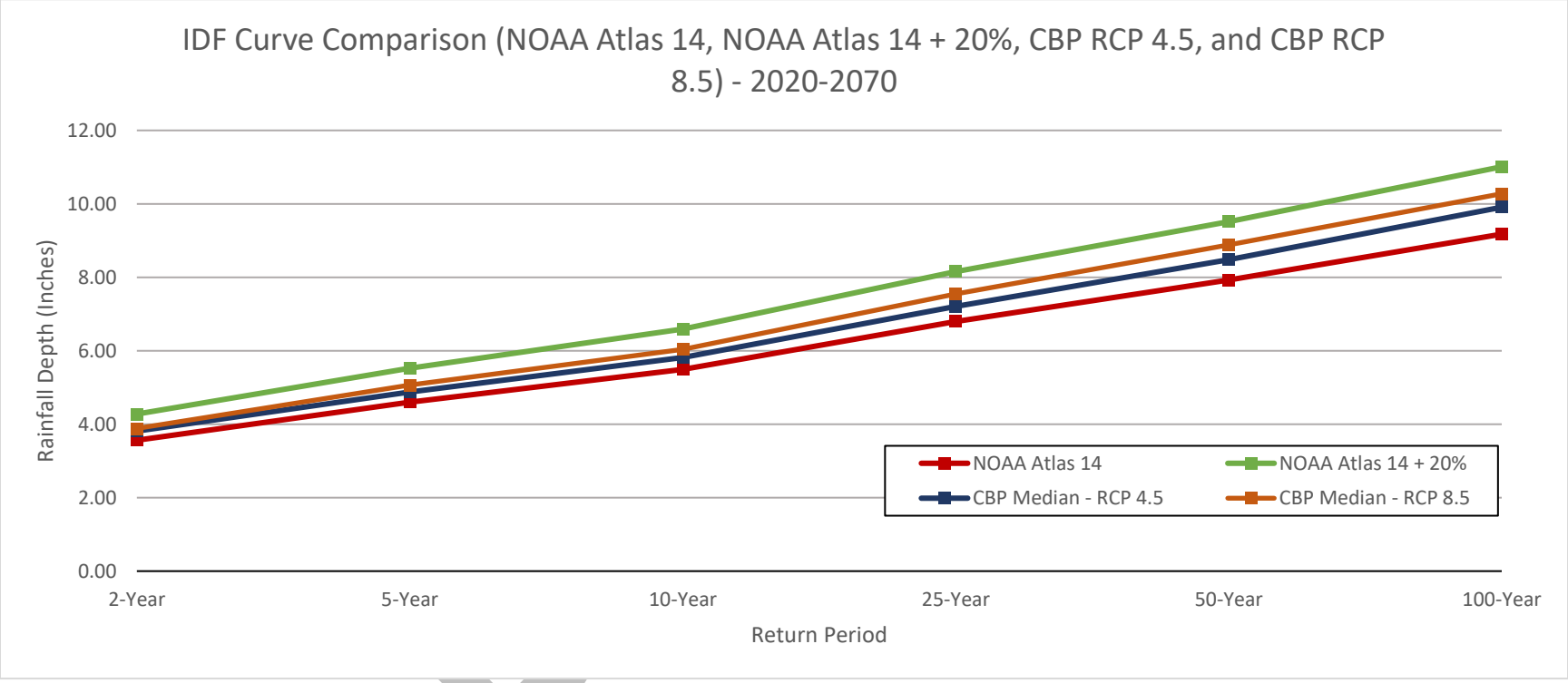
Newport News – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.58	4.29	3.54	3.65	3.86	4.04	4.22	3.58	3.75	3.93	4.11	4.33
5-Year	4.63	5.55	4.49	4.67	4.95	5.32	5.46	4.49	4.86	5.14	5.37	5.60
10-Year	5.53	6.63	5.14	5.53	5.86	6.30	6.69	5.36	5.75	6.13	6.41	6.80
25-Year	6.86	8.23	6.17	6.65	7.20	7.96	8.71	6.72	7.00	7.61	8.03	8.64
50-Year	8.01	9.62	6.89	7.53	8.33	9.54	10.50	7.45	8.09	8.90	9.54	10.34
100-Year	9.30	11.15	7.53	8.37	9.76	11.34	12.64	8.27	9.20	10.32	11.34	12.36



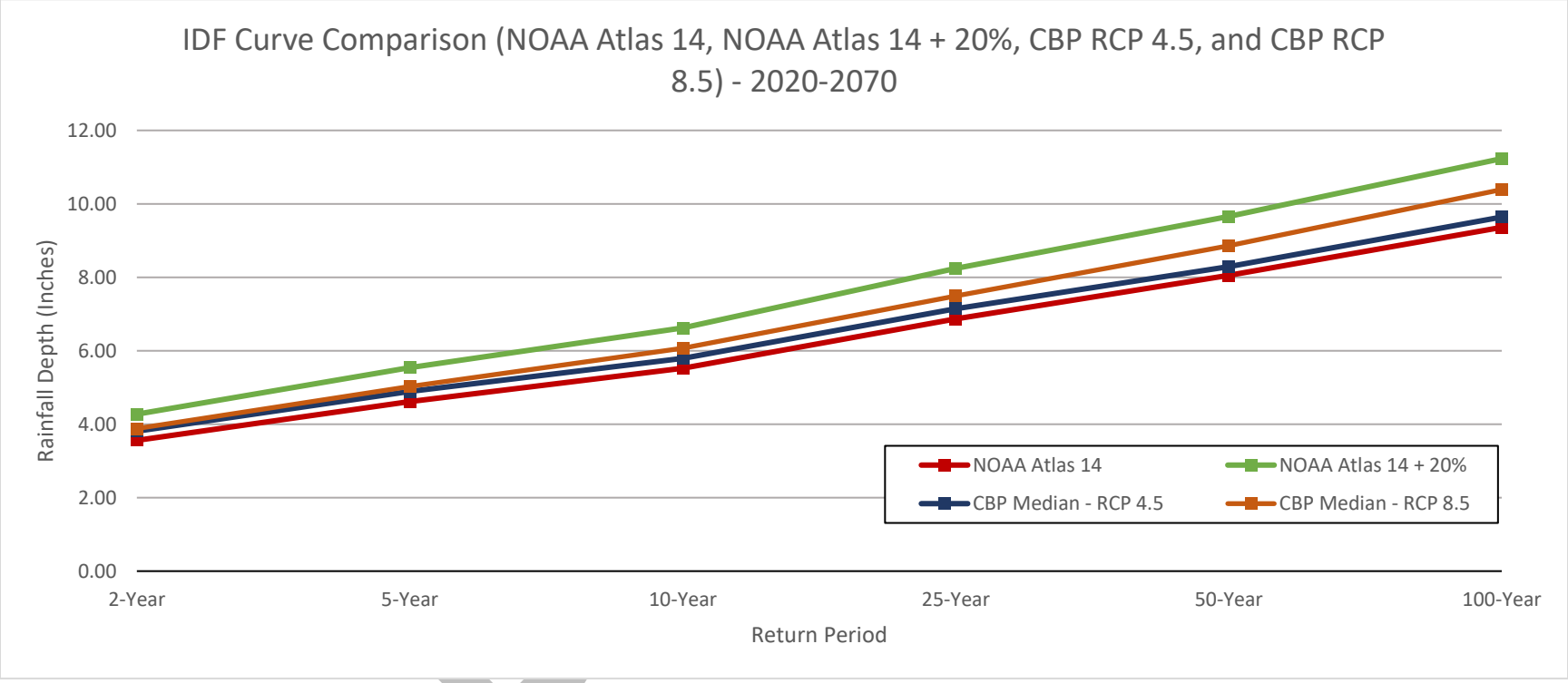
Norfolk – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.56	4.28	3.53	3.67	3.81	4.03	4.31	3.56	3.67	3.88	4.06	4.28
5-Year	4.60	5.52	4.33	4.65	4.88	5.29	5.94	4.56	4.74	5.06	5.43	5.80
10-Year	5.49	6.59	5.05	5.44	5.82	6.31	7.47	5.33	5.66	6.04	6.64	7.14
25-Year	6.80	8.16	5.98	6.53	7.21	8.09	9.86	6.39	6.87	7.55	8.57	9.25
50-Year	7.93	9.51	6.74	7.37	8.48	9.83	11.97	7.14	7.93	8.88	10.31	11.10
100-Year	9.18	11.01	7.34	8.17	9.91	12.02	14.59	7.80	9.08	10.28	12.20	13.58



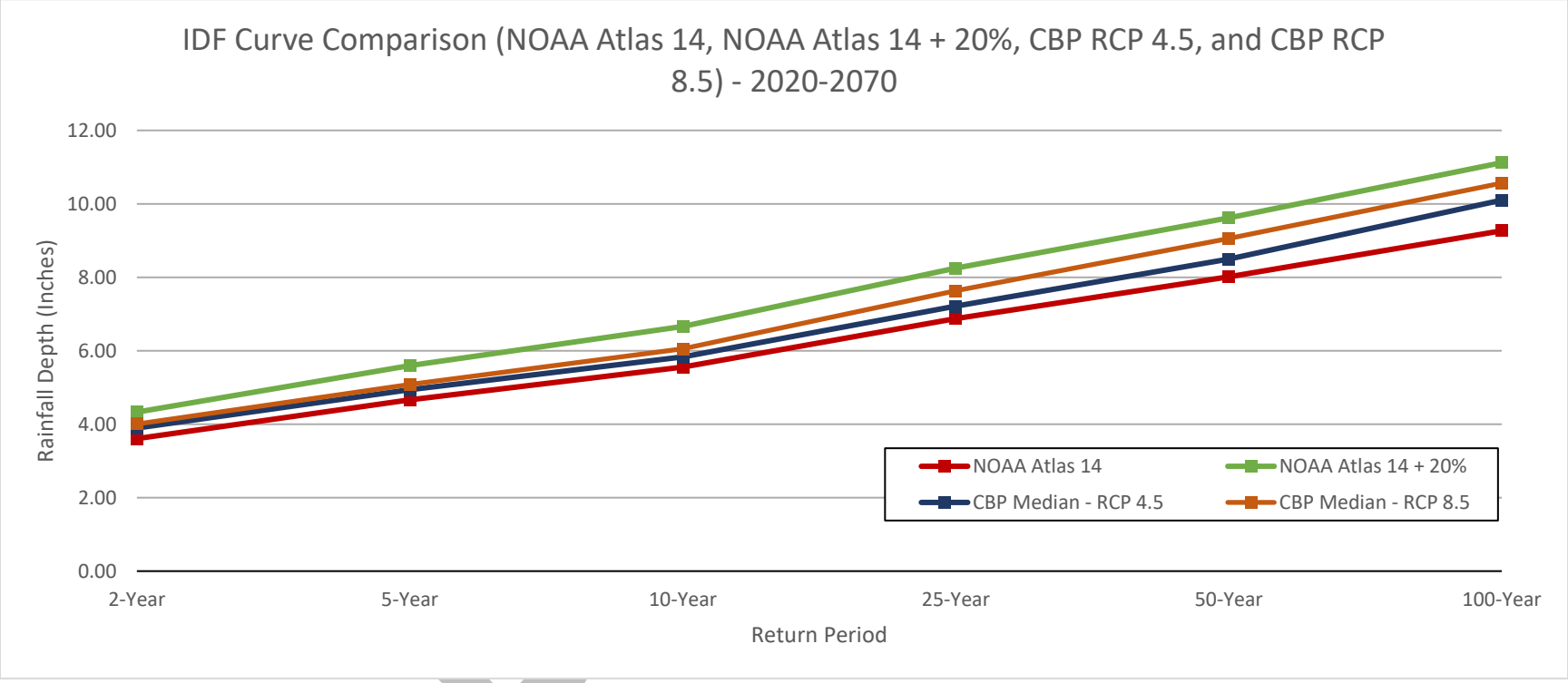
Poquoson – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.56	4.27	3.53	3.63	3.81	3.95	4.06	3.53	3.74	3.88	4.10	4.24
5-Year	4.62	5.54	4.48	4.57	4.89	5.26	5.40	4.48	4.80	5.03	5.35	5.49
10-Year	5.52	6.63	5.19	5.41	5.80	6.35	6.68	5.30	5.69	6.07	6.46	6.63
25-Year	6.87	8.25	6.18	6.66	7.15	8.11	8.73	6.53	7.01	7.49	8.11	8.59
50-Year	8.05	9.66	7.00	7.65	8.29	9.82	10.79	7.57	8.13	8.86	9.74	10.39
100-Year	9.36	11.23	7.86	8.52	9.64	11.79	13.10	8.42	9.36	10.39	11.70	12.82



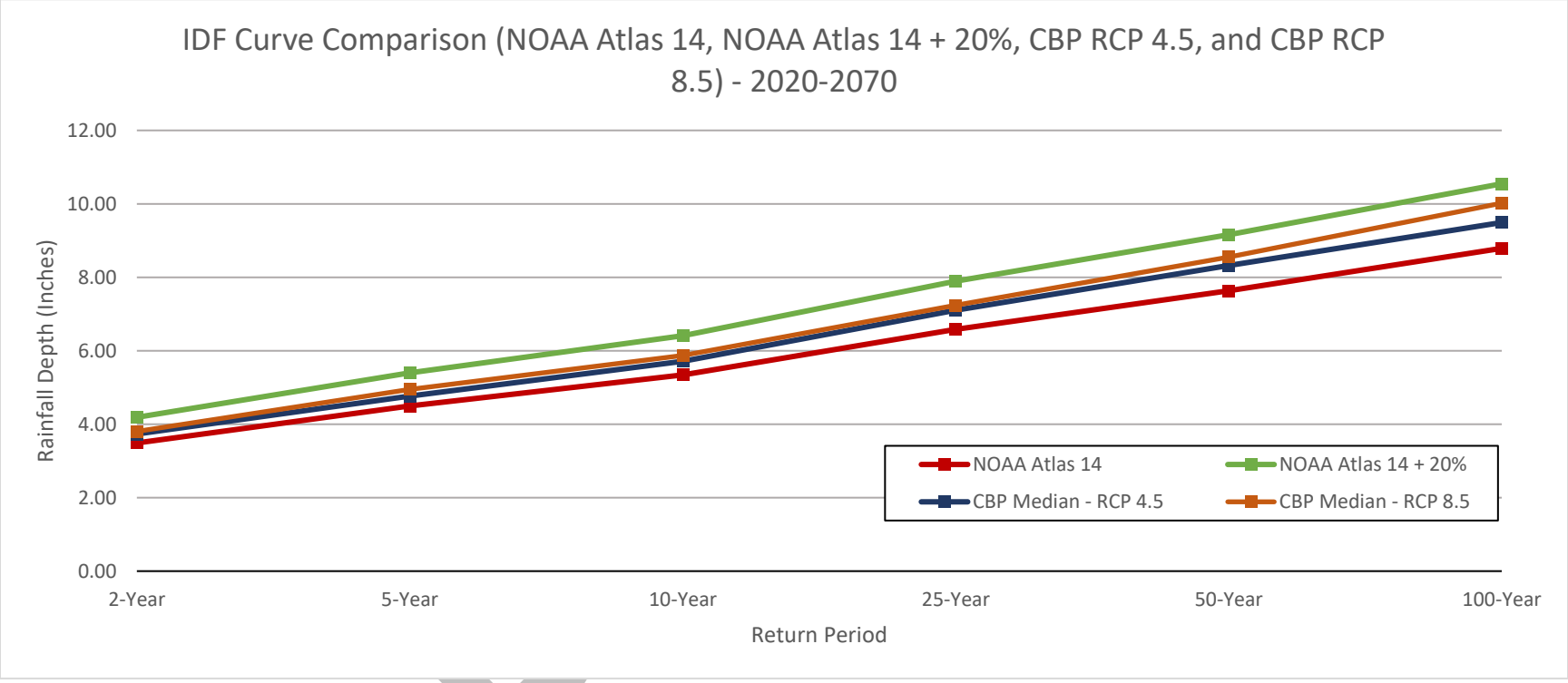
Portsmouth – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.61	4.33	3.64	3.75	3.90	4.15	4.37	3.57	3.72	4.00	4.15	4.40
5-Year	4.66	5.59	4.47	4.71	4.94	5.36	5.96	4.57	4.80	5.08	5.45	5.87
10-Year	5.55	6.66	5.17	5.50	5.83	6.39	7.39	5.33	5.72	6.05	6.66	7.16
25-Year	6.88	8.25	6.05	6.60	7.22	8.25	9.76	6.39	6.94	7.63	8.46	9.28
50-Year	8.01	9.62	6.73	7.53	8.49	10.10	11.94	7.05	8.09	9.06	10.18	11.30
100-Year	9.27	11.12	7.23	8.43	10.10	12.23	14.27	7.78	9.27	10.56	12.05	13.44



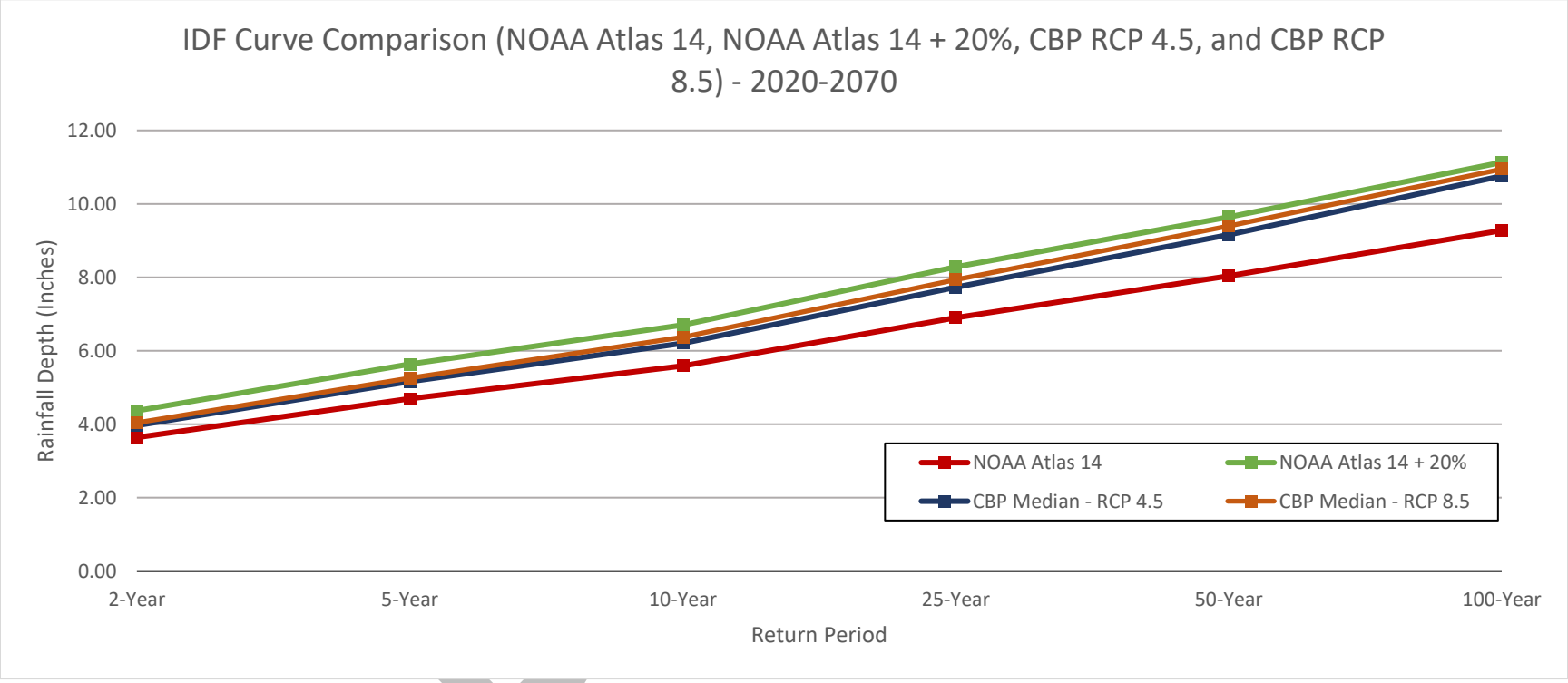
Southampton County – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.49	4.19	3.46	3.59	3.73	3.91	4.12	3.39	3.63	3.80	4.01	4.22
5-Year	4.50	5.40	4.41	4.63	4.77	5.13	5.49	4.45	4.63	4.95	5.31	5.53
10-Year	5.34	6.41	5.07	5.50	5.71	6.09	6.68	5.18	5.55	5.88	6.36	6.68
25-Year	6.58	7.90	6.32	6.71	7.11	7.63	8.42	6.25	6.78	7.24	8.03	8.49
50-Year	7.64	9.16	7.25	7.71	8.32	9.16	10.00	7.03	7.71	8.55	9.47	10.16
100-Year	8.79	10.55	8.17	8.79	9.49	10.72	11.69	7.82	8.61	10.02	11.16	12.13



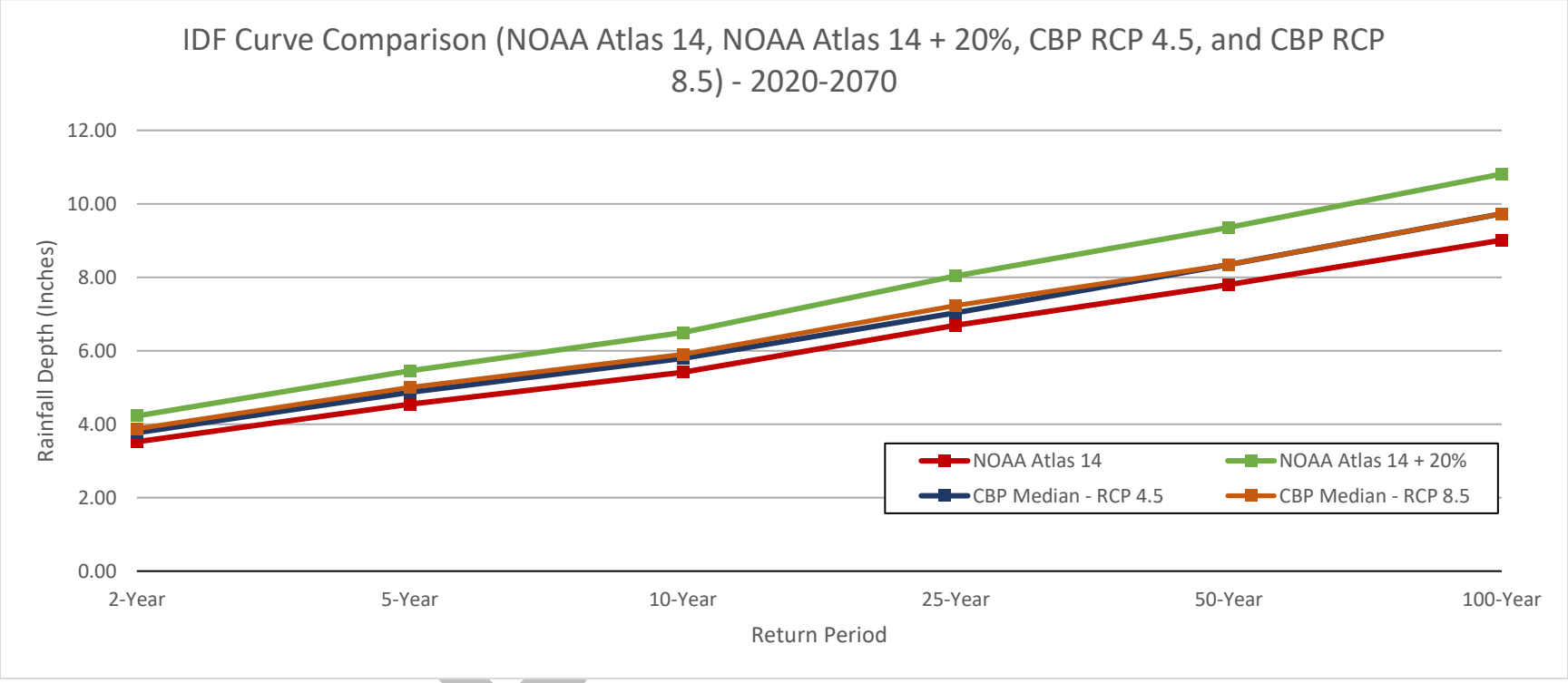
Suffolk – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.64	4.37	3.60	3.78	3.97	4.15	4.33	3.68	3.86	4.04	4.18	4.33
5-Year	4.69	5.63	4.55	4.83	5.16	5.49	5.68	4.55	4.93	5.26	5.54	5.73
10-Year	5.59	6.71	5.31	5.76	6.20	6.65	7.04	5.42	5.87	6.37	6.71	6.93
25-Year	6.90	8.28	6.42	6.97	7.73	8.35	9.18	6.42	7.11	7.94	8.42	8.77
50-Year	8.04	9.64	7.39	7.87	9.16	9.96	10.85	7.23	8.20	9.40	9.88	10.53
100-Year	9.28	11.13	7.98	9.00	10.76	11.96	12.99	8.25	9.46	10.94	11.69	12.52



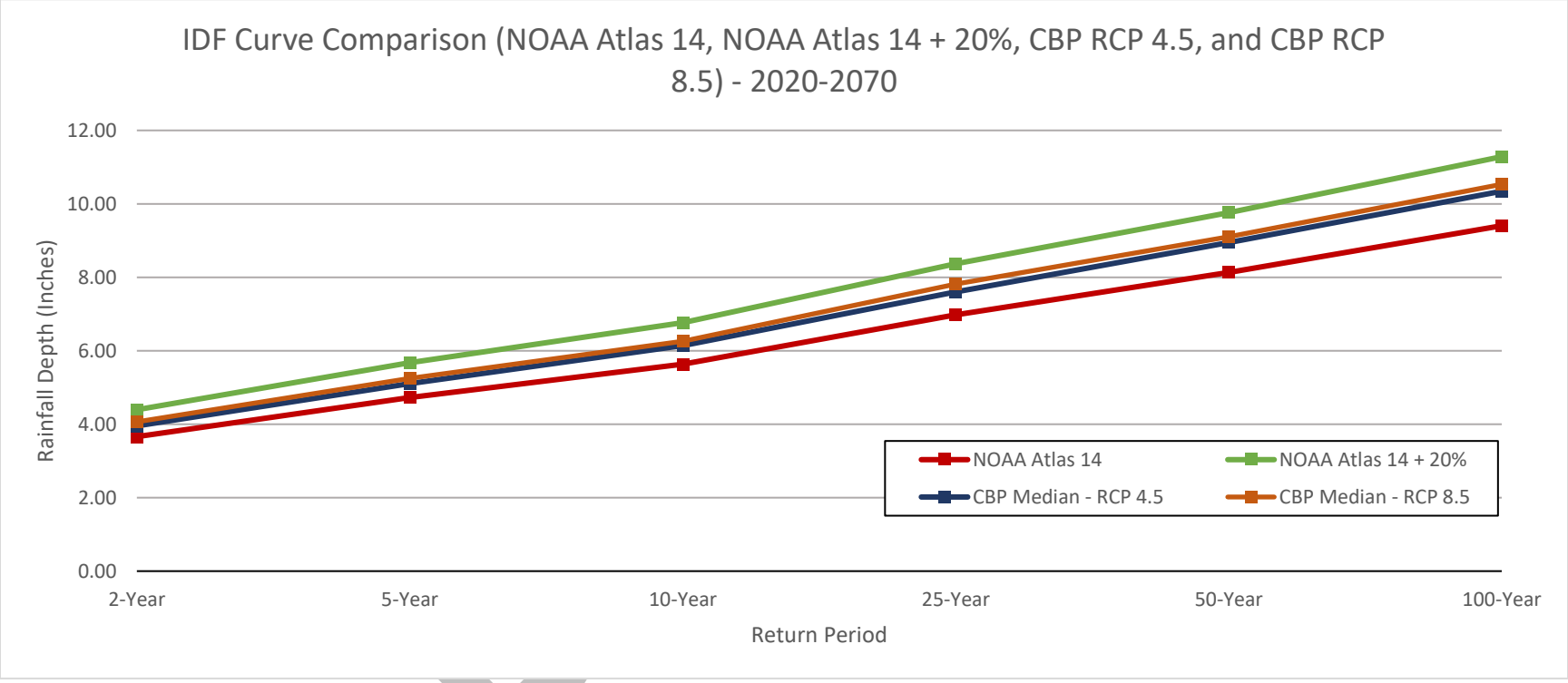
Surry County – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.52	4.23	3.49	3.63	3.77	3.91	4.16	3.45	3.73	3.87	4.05	4.26
5-Year	4.55	5.46	4.41	4.64	4.87	5.05	5.46	4.50	4.77	5.00	5.27	5.50
10-Year	5.42	6.50	5.04	5.47	5.79	6.12	6.50	5.31	5.63	5.90	6.28	6.61
25-Year	6.70	8.04	6.09	6.56	7.03	7.77	8.17	6.43	6.76	7.23	7.97	8.30
50-Year	7.80	9.36	6.86	7.49	8.34	9.05	9.83	7.18	7.72	8.34	9.28	9.90
100-Year	9.01	10.81	7.30	8.38	9.73	10.54	11.71	7.93	8.65	9.73	10.81	11.89



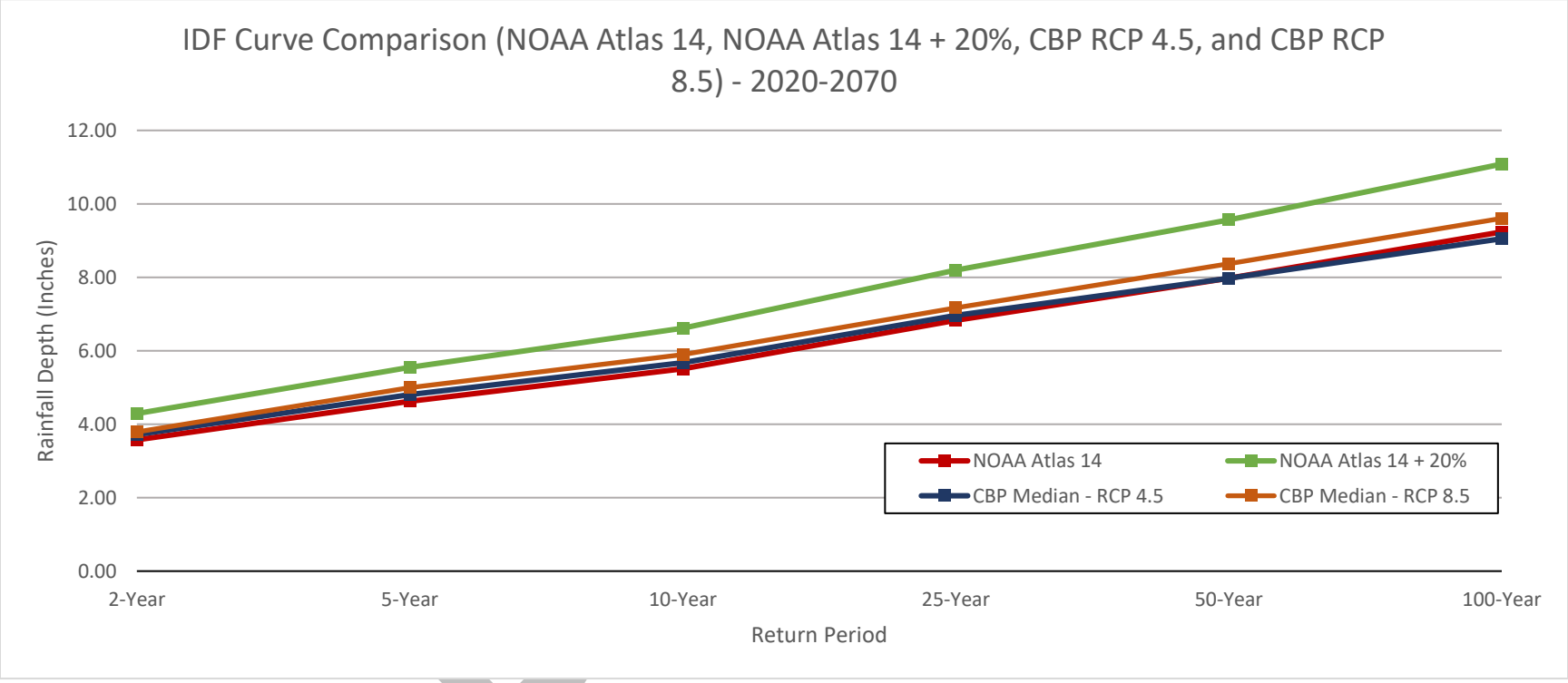
Virginia Beach – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.66	4.39	3.52	3.81	3.95	4.10	4.43	3.66	3.88	4.06	4.28	4.43
5-Year	4.73	5.68	4.45	4.82	5.11	5.39	6.20	4.68	5.06	5.25	5.63	6.05
10-Year	5.64	6.76	5.30	5.64	6.14	6.48	7.55	5.47	5.97	6.26	6.82	7.38
25-Year	6.98	8.37	6.42	6.84	7.60	8.30	9.63	6.56	7.32	7.81	8.58	9.35
50-Year	8.13	9.76	7.24	7.97	8.94	9.84	11.55	7.40	8.46	9.11	10.08	10.98
100-Year	9.40	11.28	7.99	9.03	10.34	11.66	13.82	8.37	9.40	10.53	11.76	12.88



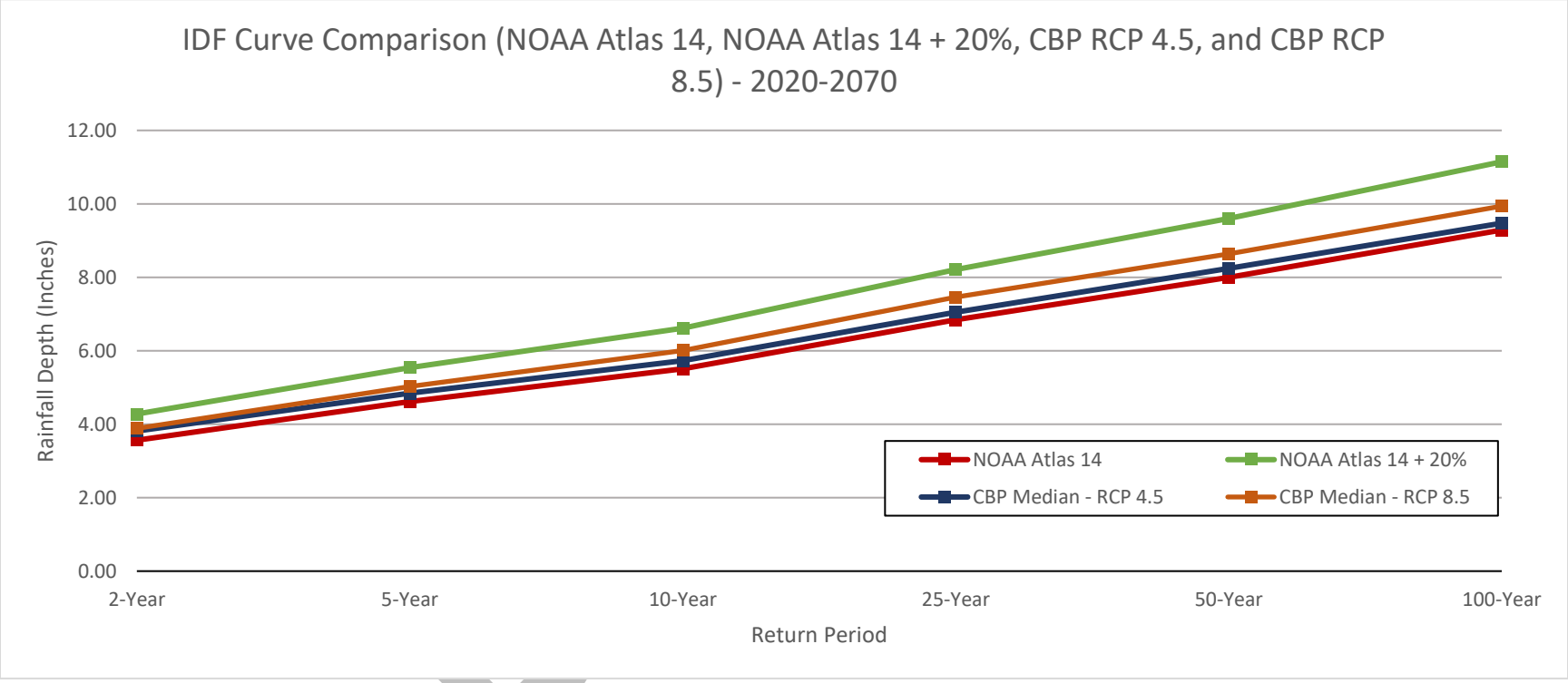
Williamsburg – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.58	4.29	3.47	3.58	3.72	3.86	4.08	3.58	3.68	3.79	4.04	4.22
5-Year	4.62	5.55	4.34	4.58	4.81	5.04	5.22	4.44	4.67	4.99	5.18	5.50
10-Year	5.51	6.61	4.96	5.34	5.68	5.95	6.28	5.18	5.45	5.90	6.34	6.67
25-Year	6.83	8.19	5.67	6.15	6.97	7.44	8.06	6.21	6.49	7.17	8.06	8.67
50-Year	7.97	9.57	6.14	6.93	7.97	8.77	9.88	6.86	7.49	8.37	9.49	10.84
100-Year	9.24	11.08	6.28	7.67	9.05	10.34	12.19	7.67	8.50	9.61	11.18	13.30



York County – 24-Hour Design Precipitation Depths (Inches)

Return Period	Atlas 14	Atlas 14 + 20%	RCP 4.5 10th	RCP 4.5 25th	RCP 4.5 50th	RCP 4.5 75th	RCP 4.5 90th	RCP 8.5 10th	RCP 8.5 25th	RCP 8.5 50th	RCP 8.5 75th	RCP 8.5 90th
2-Year	3.57	4.28	3.53	3.64	3.81	3.89	4.21	3.64	3.74	3.89	3.99	4.24
5-Year	4.61	5.54	4.43	4.61	4.84	5.08	5.35	4.52	4.80	5.03	5.26	5.49
10-Year	5.51	6.61	5.12	5.40	5.73	6.12	6.45	5.40	5.68	6.01	6.28	6.72
25-Year	6.84	8.21	6.02	6.36	7.05	7.73	8.28	6.43	6.84	7.46	7.94	8.76
50-Year	8.00	9.60	6.64	7.20	8.24	9.12	10.00	7.28	7.84	8.64	9.44	10.48
100-Year	9.29	11.15	7.24	7.99	9.47	10.87	12.17	8.27	8.92	9.94	11.24	12.72



RESILIENCE RUBRIC: A PROJECT EVALUATION TOOL

Prepared for: Office of Resilience Office
Norfolk, Virginia

Abstract

A project evaluation tool designed to build the coastal community of the future by selecting the right projects today to eliminate, mitigate or reduce risk due to current and future flooding events in Norfolk, Virginia.

William G. Delmar

Program Analyst Intern, Hire Vets Now

TABLE OF CONTENTS

1.0. BACKGROUND

In December 2020, the Flood Prevention Executive Committee (FPEC) conducted a workshop in response to a question from the City Council of Norfolk, Virginia:

"How do we choose which projects are best for our long-term resilience strategy and how do we communicate that decision making process to our residents?"

Previous project selection was based on input from various local government stakeholders but was an informal process focused on traditional cost and schedule project metrics. Historically, there were various methods used to determine a project's Benefit-to-Cost Ratio (BCR) or its relative BCR among a list of competing projects.

In April 2021, the Office of Resilience set to develop a more precise method to understand project BCR through the development of a Resilience Rubric (know as the "Rubric" here) and use a standardized scoring method to compare project benefits BEFORE cost considerations. In an e-mail to City of Norfolk stakeholders on April 19th, 2021, Chief Resilience Officer, Doug Beaver outlined two key outcomes:

1) SMART Resilience- Create a resilience rubric that synchronizes and prioritizes city projects across all departments that emphasizes our commitment to diversity, equity, and inclusion, and

2) Unity of Message- Create a Flood Prevention communications strategy to address City Council and resident concerns on progress being made to ensure Norfolk continues its path to becoming and sustaining our status as the Coastal Community of the Future.

2.0 THE VIRGINIA DEPARTMENT OF TRANSPORTATION (VDOT) SMART SCALE[i]

In 2013, the Commonwealth of Virginia needed to find a way to better balance transportation needs and prioritize investments for both urban and rural communities throughout the Commonwealth following the signing of House Bill 2313. In 2016, the process was renamed SMART SCALE which stands for System Management and Allocation of Resources for Transportation: Safety, Congestion, Accessibility, Land Use, Economic Development and Environment.

The purpose of SMART SCALE is to fund the right transportation projects through a prioritization process that evaluates each project's merits using key factors, including improvements to safety, congestion reduction, accessibility, land use, economic development and the environment. The evaluation focuses on the degree to which a project addresses a problem or need relative to the requested funding for the project.

Prior to the implementation of SMART SCALE, the Commonwealth utilized a politically driven and opaque transportation funding process that included uncertainty for local communities and businesses. SMART SCALE requires the Commonwealth Transportation Board (CTB) to develop and implement a quantifiable and transparent prioritization process for making funding decisions for capacity enhancing projects within the Six-Year Improvement Program (SYIP).

The ultimate goal in the implementation of SMART SCALE is investing limited tax dollars in the right projects that meet the most critical transportation needs in Virginia. Transparency and accountability are crucial aspects of delivering a process that project sponsors will support. SMART SCALE projects will be evaluated based on a

uniform set of measures that are applicable statewide, while recognizing that factors should be valued differently based on regional priorities[ii].

The Rubric shares in a similar ultimate goal to invest limited tax dollars and grant funding in the right projects that meet the most critical resilience needs in Norfolk. Transparency and accountability remain crucial aspects of delivering a process that project sponsors will support.

2.1 WHAT IS A RUBRIC?

While the SMART SCALE is designed to be used as a tool for prioritization of transportation projects across the Commonwealth, the concepts and philosophy are applicable to the resilience strategy for Norfolk. In the dynamic environment of climate change, the need for a resilience projects will outpace available funding and require local government leaders to prioritize projects which both address today's problems but also results in tangible progress towards building a resilient coastal community of the future.

In US education terminology, rubric means "a scoring guide used to evaluate the quality of students' constructed responses". Put simply, it is a set of criteria for grading assignments[iii]. A rubric, however, is neither the first nor the only tool to evaluate the value of a project. A rubric is a tool that can be used in an overall project evaluation process. A rubric may produce a numerical score but it can be misleading to evaluate projects by a single rubric resultant outside of the context of an overall resilience strategy.

Similarly, as discussed in the following paragraphs, project evaluation based on a few select Primary Aims distorts the intention of this Rubric. The Rubric is designed to be a tool employed as a holistic approach with a common resilience theme throughout. No singular Aim will provide the true level of benefit of a project and may, at its worst, hide a potential or unintended adverse effect if implemented.

3.0 ALIGNMENT OF PLANS AND VALUES

Should we create rubric metrics and measures that align to Commonwealth or national level resilience plans?

Local resilience strategies should be tailored to the unique economic, social, and environmental conditions in its specific region. As resilience strategies take shape nationwide, it is important to consider how local strategy aligns with regional, Commonwealth, and national strategies which form the requirements and goals of major grant programs. It is important that local resilience strategies and tools be mindful of the values and goals of partner cities, regions, and the Commonwealth to search for opportunities to achieve common objectives and potentially complimentary or additive co-benefits with other projects or city goals.

In most cases, rubric measures will align when values are shared across organizations. Communication across organizations is the key to unlocking maximum resilience benefits.

4.0 FUNDING SOURCE AS A DECISION FACTOR

Should we create rubric metrics and measures that align to major grant programs or funding sources?

In the current fiscal environment, the cost of projects exceeds available funding and prioritization is required. To address funding shortfalls, local governments depend on public and private grants to obtain funding for the most

important projects. In this reality, it is tempting for local governments to select a project based on the provisions of a grant and constantly change project selection on the "next great grant opportunity".

The disadvantages of evaluating a project based on a source of funding may be:

- The source and amount of funding may vary seasonally,
- The definition of "value" of project to the local government may deviate from local plans,
- The definition of value for a local government changes based on the values of the grantor,
- Relative project evaluation within a local area loses meaning.

In designing the Rubric, cost not used as an input factor. While the cost and the funding source are real considerations, it should be used as a decision factor AFTER a benefit score is determined by using the rubric. As with current practice, criteria for grant funding may naturally filter those projects that qualify under those premises, but those projects will benefit from a Rubric score prioritization to better inform local government leaders during the grant application.

5.0 PROJECT EVALUATION PROCESS

SMART SCALE requires the CTB to develop and implement a quantifiable and transparent prioritization process for making funding decisions for capacity enhancing projects within the Six-Year Improvement Program (SYIP). This approach enables the CTB to employ valuable screening methodologies that enable a critical focus on viable projects and reduces the workload of the evaluation team by eliminating immature or ambiguous efforts. By using the SYIP as a backdrop for project viability, it enables the CTB to determine the most value in today's need without losing sight of the strategic view[iv].

5.1 SMART DATA ANALYSIS

In any project evaluation process, the criteria of any measurement must allow for easy access to data for simplified and straight-forward analysis. Variable data, stratified across a representative sample, provides excellent data for analysis. The SMART SCALE contains measures and data requirements that are quantified (e.g. "Amount of population…", "Change in average…", etc.) but also measures that require a qualified assessment (e.g. "Assessment of the project support…"). Since all measures are weighted and scored, a quantified score is attainable.

5.2 DATA NORMALIZATION: THE IMPORTANCE OF A BOUNDED PROJECT LIST

For various measures in the SMART SCALE and the Rubric, teams employed a mathematical process of data normalization for select metric values. A normalized measure value is a numerical value given to each measure based on the measure value as a percentage of the maximum or best measure value in the state (*or project list*). In other words, scoring is based on proportion of the highest measure value within the evaluation group[v].

The purpose of data normalization is to determine the relative impact of a metric based on the values of that same metric for all projects within the evaluation scope. When employing data normalization techniques, it is critical to bound the number of projects under consideration prior to scoring. Since normalization accounts for the best value in each measure, more than one project may be used for the maximum value benefit results. Adding a late project will disrupt normalized measure values across the project list if the new project contains a new superlative value to change normalized calculations and rubric category scores.

5.3 THOUGHTFUL DATA ANALYSIS

As demonstrated by the SMART SCALE project, however, all measures cannot be simplified to a number and associated calculation. When determining the benefits of a resilience project, it is an evaluation of "the good". Determination of the good varies based on the locality, its residents, and its strategy for resilience. The Rubric development team strove for measures and metrics that contained variable data where best applicable but retained quality metrics with the recommendation for project review by a panel of experts to "determine the good" within the confines of approved Rubric measures.

VDOT employs a technical evaluation team to collect and calculate each measure across the six factor areas. This is an open process that involves state agency collaboration and review from an external team of stakeholders to ensure transparency and improve consistency. Additionally, a key step in the rating process is to perform quality assurance / quality control (QA/QC) review of the calculated measures for each project[vi].

6.0 PROCESS METHODOLOGY

To develop the Rubric, informal sessions were conducted by the Office of Resilience with internal stakeholders. Additional meetups were conducted with external stakeholders to gain broad perspectives from community resilience partners. Following approximately three weeks of research, the Office of Resilience presented the FPEC with a visual description of project evaluation criteria ranked by frequency of stakeholder comments.

On May 10th, 2021, the FPEC approved the strategy for the Rubric. The following day, spiral development of the Primary Aims began through small group discussions meeting approximately two times per week. The first meeting consisted of a collaborative brainstorming event to develop measures and metrics for a specific Aim. During the interval between meetings, individual members weighted each measure and the average weightings provided for discussion by the group at the second meeting. Once consensus was reached on category weightings, the meeting was concluded and the small group tackled a subsequent Aim, repeating the process.

6.1 EXTERNAL STAKEHOLDER ENGAGEMENT

Informative discussions are on-going with resilience stakeholders from the National Institute of Standards and Technology, the Centers for Disease Control and Prevention (CDC), the Commonwealth of Virginia, and the Hampton Roads Planning District Commission. The goal of each engagement is to support and inform development of the Rubric, its strategy, its Aims, and its measures.

6.2 INTENAL STAKEHOLDER COORDINATION

The following City of Norfolk departments and/or offices were instrumental in the development of Primary Aims and measures of evaluation.

- Office of Budget and Strategic Planning
- Office of Diversity, Equity and Inclusion
- Office of General Services
- Office of Resilience
- Department of City Planning
- Department of Emergency Management
- Department of Neighborhood Development

- Department of Public Works
- Department of Utilities

6.3 STAKEHOLDER LIMITATIONS

Based on the short (12 weeks) development cycle of the Rubric, discussions did not involve participation from City Council members or the general public of the City of Norfolk.

7.0 A STRATEGIC FOCUS

The strategic focus of this Rubric is to eliminate, mitigate or reduce risk due to current and future flooding events in Norfolk.

8.0. DEVELOPING PRIMARY AIMS

The strategic focus is supported by five Primary Aims in the Rubric. Each Aim must be weighted according to the importance of impact in the overall evaluation of a project. While some measures and categories have been initially weighted, the development team did not place weighted values for any Aim. Each Aim should be given a fraction of 100 percent whereas the total Aim weight does not exceed 100 percent for the Rubric.

8.1 PRIMARY AIM 1: INFRASTRUCTURE

- **Does the project protect critical infrastructure?**

The Infrastructure Primary Aim is not fully developed but uses the PPD-21: Presidential Policy Directive on Critical Infrastructure Security and Resilience as the basis for understanding critical industries. PPD-21 outlines 16 critical infrastructure industries that require resilience planning to sustain national level industries[vii]. Preliminary discussions have also attempted to address:

1) Does the project reduce risk or vulnerability to primary critical CISA sectors: Communications, Critical Manufacturing, Defense/Defense Industrial Base, Transportation and Water/Wastewater as outlined by PPD-21?
2) Does the project reduce risk or vulnerability to any other critical CISA sector as outlined by PPD-21?
3) Does the project reduce risk to corridors for critical city assets: Emergency services, schools, or public transportation?
4) Does the project strengthen or improve utility reliability for primary critical assets and/or corridors (e.g. electrical, gas, oil, internet, telephone)?

8.2 PRIMARY AIM 2: ECONOMIC IMPACT

- **Does the project sustain vital economic industries or spur economic growth?**

The Economic Aim was divided into four categories with associated measures and weightings. A co-benefit bonus category was also included:

Category Weight	Measure	Metric
40%	How well does the project meet risk mitigation within the industry category in terms of severity and amount of industry protected? Critical Industries: 1. DoD, 2. shipyard, 3. Logistics, 4. Healthcare, 5. Education, 6. Essential Community Lifelines (per FEMA guidelines), or 7. Designated Economic Corridors per Plans	Meets one critical industry – max 20 points Meets 2-3 critical industries – max 30 points More than 3 critical industries – max 40 points
24%	How well does the project meet risk mitigation within the industry category in terms of severity and amount of industry protected? Primary Industries: 1. Professional Services, 2. Tourism, and 3. Supply-Chain Industries or 4. located in designated Enterprise Zones	Meets one critical industry - max 15 points Meets 2-3 critical industries - max 20 points More than 3 categories - 24 points
23%	How well does the project meet risk mitigation within the business category in terms of severity and amount of industry protected? Resident Owned Small Business 1. Connection to critical or primary industries 2. Long term or "historic" businesses 3. Opportunities for new businesses 4. Preservation, protection or growth businesses with MOSB, WOSB, VOSB, etc. as identified by the SBA.	Meets one critical industry - max 15 points Meets 2-3 critical industries - max 19 points More than 3 categories - 23 points
13%	Businesses bringing job, training and skills growth to Norfolk residents through the development of the project *- For skilled labor (trades, secondary or HS attainment, etc.) multiply by 1.1 per ACS?*	Number of jobs normalized by maximum number of jobs provided
5%	**Co-benefit Bonus:** Is the proposed project in a low-income geographic area? *Measured by percent of the overall population that meet median household income levels described below out of the total population (and normalized).*	Percentage of census tract coverage normalized by maximum census tract amounts

Table 8.1 Economic Aim Rubric

8.3 PRIMARY AIM 3: COMMUNITY IMPACTS

- **Does the project benefit the residents, communities, or neighborhoods of Norfolk with the goal of diversity, inclusiveness, and equity?**

The Community Aim was divided into three categories with associated measures and weightings. A co-benefit bonus category was also included:

Category Weight	Measure	Metric
28.6%	Total number of residents (per census data) benefitted by proposed project scope area. List number of residents per census tract.	Number of residents
12.9%	Total number of head of household residents (per census data) below the age of 40 that may benefit by proposed project scope area	Number of residents
39.2%	Is the project area considered socially vulnerable based on 15 factors in the CDC's Social Vulnerability Index Scores (range 0.0 (least vulnerable) - 1.0 (most vulnerable)). Calculated as sum of number of residents in census tract times CDC SVI value for the tract.	Average SVI score for project area
12.4%	Number of properties within the boundary of the proposed project scope of benefit that is occupied by primary homeowners	Number of properties
6.9%	Number of properties within the boundary of the proposed project scope of benefit that is occupied by renters or temporary residents	Number of properties
5%	**Co-benefit Bonus:** Number of critical community assets that support community well-being such as childcare centers, nursing homes, community centers, grocery stores, places of worship, and transportation hubs.	Number of Assets

Table 8.2 Community Aim Rubric

8.4 PRIMARY AIM 4: PROPERTY AND ASSET MITIGATION

- **Does the project preserve real/tangible property and/or assets of Norfolk residents and businesses?**

The Property Aim was divided into eight categories with associated measures and weightings. A co-benefit bonus category was also included:

Category Weight	Measure	Metric
13.67%	Residental: Total assessed real estate value of residential property within the protected area of the proposed project per the most recent tax assessment.	Dollars ($M)
8.83%	Residental: Total amount of land area within the residential area of the proposed project.	Acreage
14.17%	Commercial: Total assessed real estate value per square foot of commercial or business buildings within the protected area of the proposed project per the most recent tax assessment.	Dollars ($M)

Category Weight	Measure	Metric
7.50%	Commercial: Total amount of usable (or living) area within the commercial or business buildings of the proposed project.	Square Footage
20%	Number of parcels with houses, buildings or structures affected by the project scope and area benefitted by a reduced risk of flooding effects. - Then add: number of structures subject to repetitive loss multiplied by 2.0 - Then add: number of structures subject to severe repetitive loss multiplied by 3.0	Total Number
9.17%	Does the project serve a historical neighborhood identified by the NHR or by local government as historically important? Calculated by percent of land area within a historic or designated historic neighborhood.	Acreage
17.50%	Total amount of real estate residential and/or commercial property taxes provided to the city within the protected area of the proposed project.	Dollars ($100K)
9.17%	Does the project protect a federal or state property or parcel? If yes, calculated by percent of federal or state land area within project boundaries.	Acreage
5%	**Co-benefit Bonus:** Project benefits a community through improved or increased assets (e.g. open space, recreation, etc.). Determined by business case as evaluated by expert panel of reviewers.	Scaled

Table 8.3 Property Aim Rubric

8.5 PRIMARY AIM 5: RISK MITIGATION

- **Does the project reduce risk to flooding? Is the project static or adaptable to changing threats to resilience? Is the project possible, practical, or feasible?**

While the small group discussions have not addressed this Aim, some preliminary questions have been discussed, such as:

1) Does the project address the current crisis or issue? How well does it mitigate the next occurrence?
2) Does the project address a future crisis or issue? What standard of "future crisis" is applicable? How well does it mitigate a future occurrence?
3) What is the ratio of life expectancy of the project engineering value to the designed values across risk data curves? Which data curves are the basis for project analysis?
4) If a project mitigates risk for a defined period (e.g. 20 years), can it be adapted to maintain the risk mitigation if flooding forecasts worsen and risk increases?
5) What is the complexity in design, construction, sustainability, and funding for a proposed project?
6) Is a project is aligned with specific city, state, or federal resilience strategies or plans?
7) Is a project nested with or within other projects? Can a project provide complimentary or additive benefits to other projects?

9.0 RUBRIC LIMITATIONS

The Rubric is in developmental stages and has not been peer reviewed or tested in a pilot or beta phase environment. There are a few inherent and statistical limitations to the current version of this Rubric:

1) The Rubric is not a substitute for a thorough project evaluation process.
2) The Rubric is a tool to objectively score projects using the same subjective scorecard.
3) In small group meetings, measures were determined through consensus while measure weights were determined by group average.
4) Category range values were not consistent within or across Aims.
5) Weighting means were determined via a small sample size (less than 10). Outliers may have outsized influence on the mean value.

10.0 FUTURE DEVELOPMENT

10.1 MODEL MATURITY

The Rubric is in development stage and not considered complete at this time. It is not recommended for use until all measures and weightings are determined and approved by City of Norfolk leadership. Following a robust trial period, the Rubric should be used as a tool in a more thorough project evaluation process.

10.2 THE EVALUATION PROCESS

Capital improvement projects under consideration should provide a detailed business case analysis (BCA) to address project benefit, cost, examination of alternatives, etc. with a resultant demonstration of how the project will improve resilience through the elimination, mitigation, or reduction of risk due to current and future flooding events in Norfolk. There are numerous BCA examples, notably in grant applications. The BCA for resilience projects in Norfolk should strongly address the categories and Aims included in the final Rubric.

It is recommended that local government develop an annual or biennial project evaluation cycle for any proposed capital improvement projects designed to improve city resiliency against climate effects, notably flooding.

It is recommended that projects are parsed or binned into like categories (such as cost, size, timing, etc.) prior to application of the rubric. When similar projects are correctly grouped, comparison of project benefits can be more evenly compared without a single factor (e.g., cost) having an overwhelming effect.

After final draft of the Rubric, it is recommended that the FPEC confer final Aim weightings to be endorsed by the Chief Resilience Officer and City Manager and approved by the City Council.

10.3 ALIGNMENT TO THE CAPITAL IMPROVEMENT PROJECT PROCESS CYCLE

The City of Norfolk local government fiscal year ends on June 30th and the next year's budget is approved approximately 30 days in advance. Along with routine fiscal requirements, the City Council approves a list of Capital Improvement Projects during this time for investment or improvement across Norfolk. The Capital Improvement process also undergoes an independent review process to inform its recommendations to the annual budget.

Figure 10.1 is a depiction of the biennial project evaluation process from the SMART SCALE technical guide[viii]. The figure is provided as an example of timelines for project submission, screening, evaluation, funding considerations, long-term strategy development and lessons learned to inform the next project cycle.

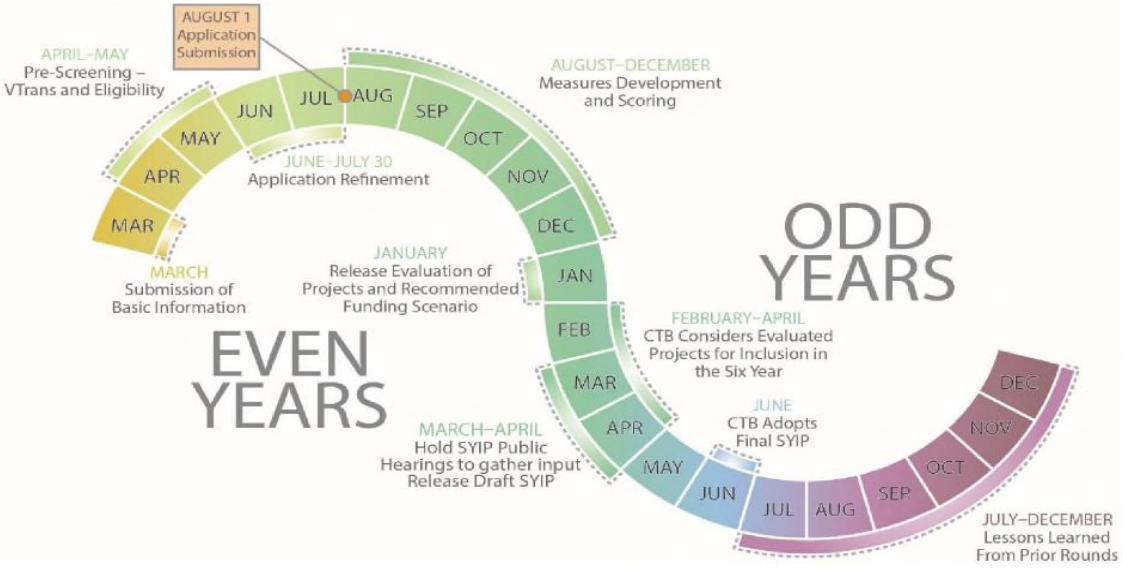


Figure 10.1 Anticipated SMART SCALE Biennial Cycle

It is recommended that the resilience project evaluation review process align to support and eventually merge with the Capital Improvement Project process to create a singular and informed proposal to City Council that maximizes the benefits of resilience in major projects across Norfolk.

10.4 AREAS OF GROWTH AND OPPORTUNITY

The Rubric should be considered a living tool with programmed opportunities to review and renew the information and assumptions that support its development. Through continued efforts to understand the effects of climate change and the issues that affect the residents of Norfolk, there may be numerous untapped resources that may be used to better inform Aims, categories, measures and metrics in the Rubric (e.g. local Climate Equity Index[ix]).

It is recommended that a periodic review of the Rubric be programmed to align and support the project evaluation process.

APPENDIX

The Resilience Rubric Spreadsheet

Master Rubric Calculator 210623.xl

[i] http://smartscale.org/documents/2020documents/technical-guide-2022.pdf
[ii] Ibid.

[iii] https://en.wikipedia.org/wiki/Rubric_(academic)
[iv] http://smartscale.org/documents/2020documents/technical-guide-2022.pdf
[v] Ibid
[vi] Ibid
[vii] https://www.cisa.gov/critical-infrastructure-sectors
[viii] http://smartscale.org/documents/2020documents/technical-guide-2022.pdf
[ix] https://www.arcgis.com/apps/webappviewer/index.html?id=e4d732f225fe457d83df11fe9bf71daf

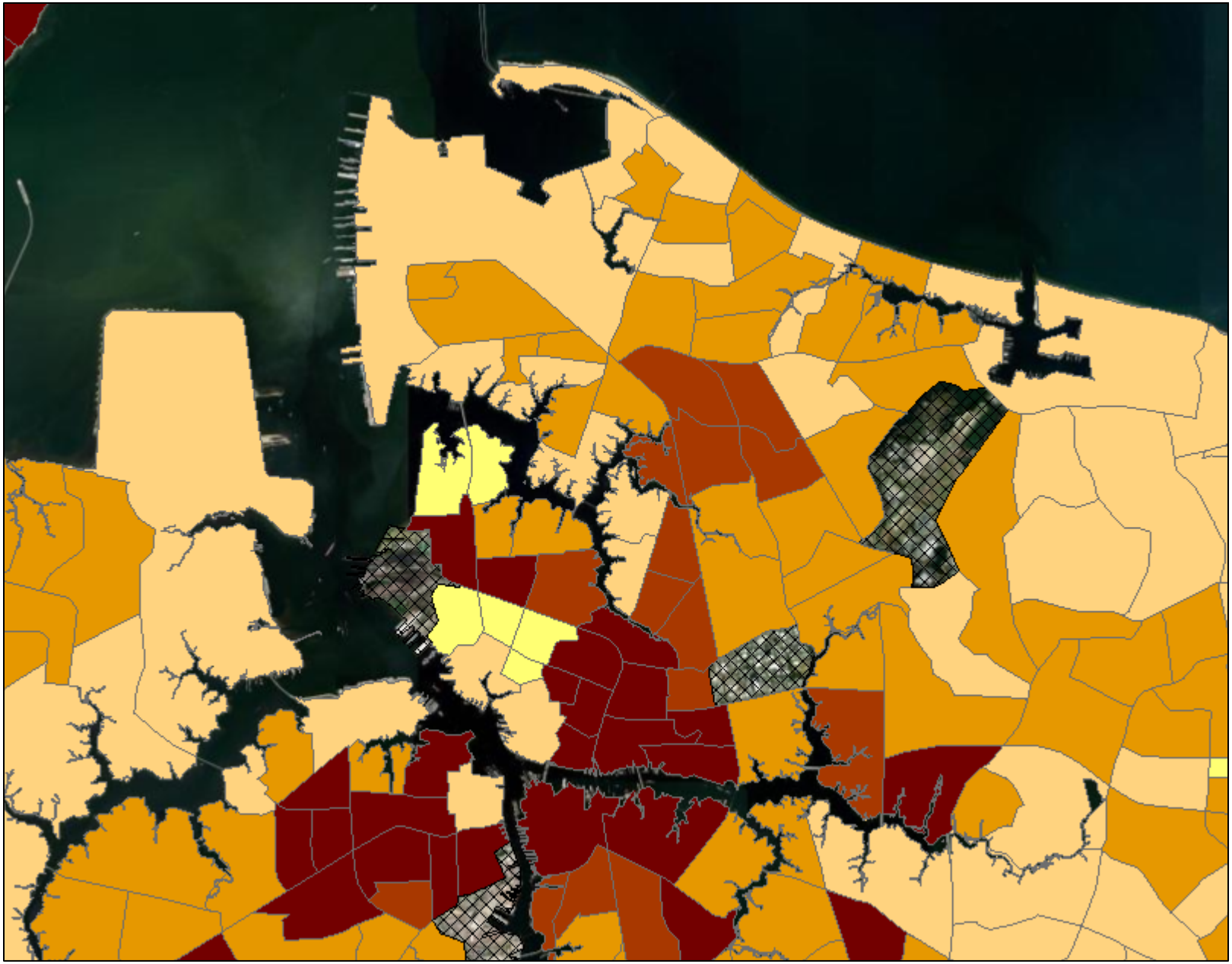
Appendix D

Required Attachments

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

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



August 3, 2021

1:144,448

0 0.75 1.5 3 mi

0 1.25 2.5 5 km

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Created from the Virginia Vulnerability Viewer

Center for Coastal Resources Management
Virginia Institute of Marine Science

ADAPT VA

Norfolk Social Vulnerability Index Score

Census Tract Name	Social Vulnerability Index Score
Census Tract 25, Norfolk city, Virginia	1.69
Census Tract 27, Norfolk city, Virginia	1.71
Census Tract 29, Norfolk city, Virginia	1.37
Census Tract 31, Norfolk city, Virginia	1.40
Census Tract 34, Norfolk city, Virginia	2.33
Census Tract 35.01, Norfolk city, Virginia	2.25
Census Tract 41, Norfolk city, Virginia	3.62
Census Tract 42, Norfolk city, Virginia	4.47
Census Tract 43, Norfolk city, Virginia	2.28
Census Tract 44, Norfolk city, Virginia	1.37
Census Tract 45, Norfolk city, Virginia	1.83
Census Tract 46, Norfolk city, Virginia	2.34
Census Tract 47, Norfolk city, Virginia	2.84
Census Tract 48, Norfolk city, Virginia	3.44
Census Tract 50, Norfolk city, Virginia	1.66
Census Tract 51, Norfolk city, Virginia	2.44
Census Tract 57.01, Norfolk city, Virginia	1.20
Census Tract 59.01, Norfolk city, Virginia	1.22
Census Tract 69.02, Norfolk city, Virginia	1.63
Census Tract 20, Norfolk city, Virginia	1.48
Census Tract 26, Norfolk city, Virginia	0.15
Census Tract 28, Norfolk city, Virginia	0.50
Census Tract 32, Norfolk city, Virginia	1.08
Census Tract 33, Norfolk city, Virginia	1.38
Census Tract 57.02, Norfolk city, Virginia	1.17
Census Tract 58, Norfolk city, Virginia	1.33
Census Tract 62, Norfolk city, Virginia	0.90
Census Tract 64, Norfolk city, Virginia	0.89
Census Tract 70.02, Norfolk city, Virginia	1.28
Census Tract 9.01, Norfolk city, Virginia	0.26
Census Tract 1, Norfolk city, Virginia	-0.42
Census Tract 11, Norfolk city, Virginia	0.00
Census Tract 12, Norfolk city, Virginia	-0.48
Census Tract 13, Norfolk city, Virginia	0.29
Census Tract 14, Norfolk city, Virginia	0.75
Census Tract 15, Norfolk city, Virginia	-0.51
Census Tract 16, Norfolk city, Virginia	0.55
Census Tract 17, Norfolk city, Virginia	0.28
Census Tract 2.01, Norfolk city, Virginia	0.01
Census Tract 2.02, Norfolk city, Virginia	0.38

Census Tract 21, Norfolk city, Virginia	-0.27
Census Tract 22, Norfolk city, Virginia	-0.93
Census Tract 23, Norfolk city, Virginia	-1.28
Census Tract 24, Norfolk city, Virginia	-1.16
Census Tract 3, Norfolk city, Virginia	-0.21
Census Tract 30, Norfolk city, Virginia	-0.08
Census Tract 36, Norfolk city, Virginia	-1.10
Census Tract 37, Norfolk city, Virginia	-1.29
Census Tract 38, Norfolk city, Virginia	-1.31
Census Tract 4, Norfolk city, Virginia	-0.08
Census Tract 40.01, Norfolk city, Virginia	-1.96
Census Tract 40.02, Norfolk city, Virginia	-0.95
Census Tract 49, Norfolk city, Virginia	-0.44
Census Tract 5, Norfolk city, Virginia	0.15
Census Tract 55, Norfolk city, Virginia	0.11
Census Tract 56.01, Norfolk city, Virginia	0.24
Census Tract 56.02, Norfolk city, Virginia	0.23
Census Tract 59.02, Norfolk city, Virginia	0.26
Census Tract 59.03, Norfolk city, Virginia	0.26
Census Tract 6, Norfolk city, Virginia	0.12
Census Tract 60, Norfolk city, Virginia	0.58
Census Tract 61, Norfolk city, Virginia	0.60
Census Tract 65.01, Norfolk city, Virginia	0.43
Census Tract 65.02, Norfolk city, Virginia	-0.56
Census Tract 66.01, Norfolk city, Virginia	-0.18
Census Tract 66.02, Norfolk city, Virginia	0.33
Census Tract 66.03, Norfolk city, Virginia	0.10
Census Tract 66.04, Norfolk city, Virginia	0.69
Census Tract 66.05, Norfolk city, Virginia	0.64
Census Tract 66.06, Norfolk city, Virginia	-0.03
Census Tract 66.07, Norfolk city, Virginia	0.54
Census Tract 68, Norfolk city, Virginia	-0.07
Census Tract 69.01, Norfolk city, Virginia	0.57
Census Tract 7, Norfolk city, Virginia	-0.17
Census Tract 70.01, Norfolk city, Virginia	0.01
Census Tract 8, Norfolk city, Virginia	-0.31
Census Tract 9.02, Norfolk city, Virginia	-0.32
Norfolk Average Social Vulnerability Index Score	**0.59**

Matthew J. Strickler
Secretary of Natural and Historic Resources and Chief Resilience Officer

Clyde E. Cristman
Director

COMMONWEALTH of VIRGINIA
DEPARTMENT OF CONSERVATION AND RECREATION

Rochelle Altholz
Deputy Director of Administration and Finance

Nathan Burrell
Deputy Director of Government and Community Relations

Darryl M. Glover
Deputy Director of Dam Safety & Floodplain Management and Soil & Water Conservation

Thomas L. Smith
Deputy Director of Operations

August 9, 2021

Matt Simons, AICP CZA CFM
Principal Planner and Floodplain Administrator
Department of Planning and Community Development
810 Union St, Suite 508
Norfolk, VA 23510

RE: City of Norfolk Resilience Plan Second Submission - CFPF

Dear Mr. Simons:

Thank you for providing an overview of your Resilience Plan, and informing DCR of the various plans that the City of Norfolk will be utilizing to fulfill the Resilience Plan submission requirements. After careful review and consideration, the Virginia Department of Conservation and Recreation has deemed the Plan complete and meets all the criteria outlined in the June 2021 Community Flood Preparedness Grant Manual. This approval will remain in effect for a period of three years, ending on August 8, 2024.

The following elements were evaluated as part of this review:

1. **Element 1: It is project-based with projects focused on flood control and resilience. DCR RESPONSE**

    a. Project-based: Nine watersheds—each with a defined geographic area, analysis of community social and environmental characteristics, types of flooding, and a tailored flood resilience strategy divided into 15 project areas, each with discrete projects identified.

    b. Projects focused on flood control and resilience included city-wide and various coastal projects and a specific project in Chesterfield Heights.

2. **Element 2: It incorporates nature-based infrastructure to the maximum extent possible. DCR RESPONSE**

    a. Natural and nature-based flood management measures are identified for use in projects throughout the city in the *Final Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study / Environmental Impact Statement*, the *Combined Coastal and Precipitation Flooding Master Plan*, the *Hampton Roads Mitigation Plan* and *A Green Infrastructure Plan for Norfolk: Building Resilient Communities*.

3. **Element 3: It includes considerations of all parts of a locality regardless of socioeconomics or race. DCR RESPONSE**

    a. All parts of a locality: Locality divided into 9 watersheds, with 90 planning districts covering the entirety of the jurisdictional boundary.

    b. Social vulnerability: Social implications of flood hazards and analysis of populations at-risk documented in the USACE *Final Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study / Environmental Impact Statement*, the *Combined Coastal and Precipitation Flooding Master Plan* and in *PlaNorfolk 2030*.

    c. Demographic Analysis: Demographic Analysis conducted by USACE, utilizing U.S. Census Bureau, Bureau of Labor and Statistics, Virginia Employment Commision, and other information from local planning agencies, and incorporated into the *Final Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study / Environmental Impact Statement*.

4. **Element 4: It includes coordination with other local and inter-jurisdictional projects, plans, and activities and has a clearly articulated timeline or phasing for plan implementation. DCR RESPONSE**

    a. Coordination with other projects, plans, and activities: Contains the planning processes and frameworks which outline local and regional plans used by the City and address resilience; and how they have been integrated for flood adaptation planning.

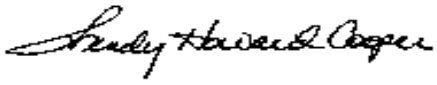
    b. Clearly articulated timeline or phasing for plan implementation: 5 year timeline presented in the *Combined Coastal and Precipitation Flooding Master Plan*. Phased time-line for completion found within *PlaNorfolk 2030, Vision2100*, and *A Green Infrastructure Plan for Norfolk: Building Resilient Communities*. Phased approach for project implementation contained within the Fugro Atlantic *Norfolk Preliminary City-wide Coastal Flooding Mitigation Concept Evaluation and Master Plan Development*. Program phases clearly articulated and an impact statement completed in USACE *Final Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study / Environmental Impact Statement*.

5. **Element 5: Is based on the best available science, and incorporates climate change, sea level rise, storm surge (where appropriate), and current flood maps.**

    a. Technically backed water-resources analysis, sea level rise projections, storm surge, and climate change incorporated into the strategic approach presented in the *Hampton Roads Hazard Mitigation Plan*, the *Final Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study / Environmental Impact Statement*.

VA DCR looks forward to working with you as you work to make the City of Norfolk a more resilient community. If you have questions or need additional assistance, please contact us at cfpf@dcr.virginia.gov. Again, thank you for your interest in the Community Flood Preparedness Fund.

Sincerely,



Wendy Howard Cooper, Director
Dam Safety and Floodplain Management

cc: Darryl Glover, DCR

Resilience Planning Overview for the City of Norfolk

In response to the resilience planning requirements of the **Community Flood Preparedness Fund** ("the CFPF" or "Fund") outlined within the 2021 CFPF Grant Manual (Appendix G: Elements of Resilience Plans), the City of Norfolk ("the City") has prepared the following Resilience Planning Overview of formal and relevant plans utilized for resilience planning efforts by the City to prioritize potential projects and to assist the City is its efforts to secure funding for such critical resilience plans, studies and projects.

The **Elements of Resilience Plans** taken from Appendix G of the 2021 CFPF Grant Manual, from which communities are expected to highlight the stated resilience planning contents as they related to CFPF grant applications, are as follows:

1. *It is project-based with projects focused on flood control and resilience.*
2. *It incorporates nature-based infrastructure to the maximum extent possible.*
3. *It includes considerations of all parts of a locality regardless of socioeconomics or race.*
4. *It includes coordination with other local and inter-jurisdictional projects, plans, and activities and has a clearly articulated timeline or phasing for plan implementation.*
5. *Is based on the best available science, and incorporates climate change, sea level rise, storm surge (where appropriate), and current flood maps.*

Norfolk's resilience planning elements are not contained within an adopted "stand alone" plan. However, Norfolk's utilizes various plans within a resilience repertoire, which altogether serve multiple needs for various audiences; from technical to public-facing to operational. This Resilience Planning Overview will expressly identify to the grant reviewer, and to the public, how various resilience planning documents of the City of Norfolk satisfy all the CFPF Resilience Plan elements.

The following plans for the City of Norfolk will contribute to this Resilience Planning Overview:

- ***plaNorfolk2030*** (2013, as amended)
- ***Vision2100*** (2016)
- ***Hampton Roads Hazard Mitigation Plan*** (2017)
- ***Combined Coastal and Precipitation Flooding Master Plan*** (2017)
    - Appendix A: ***Norfolk Preliminary City-wide Coastal Flooding Mitigation Concept Evaluation and Master Plan Development*** **(Fugro Atlantic)**
    - Appendix B: ***City-wide Drainage and Watershed Master Plan*** **(Timmons Group)**
- ***A Green Infrastructure Plan for Norfolk*** (2018, as amended)
- ***USACE Coastal Storm Risk Management (CSRM) Feasibility Study and Environmental Impact Statement*** (2019)
- ***Zoning Ordinance of the City of Norfolk*** (2018, as amended)
- ***Development of an Urban Resilience Analysis Framework with Application to Norfolk, VA*** (2016)

Responses are provided below in red based on the various Norfolk plans for the following example resilience elements outlined in Appendix G of the 2021 CFPF Grant Manual:

- ***Equity based strategic polices for local government-wide flood protection and prevention.***
  The ***Hampton Roads Hazard Mitigation Plan*** recommends the highest priority of protection to be reserved towards protection projects for severe repetitive loss areas (Mitigation Actions 8 &

11) in Norfolk. Research in Norfolk has shown that these areas are often places where the most vulnerable residents are housed.

Additionally, Mitigation Action 12 recommends Norfolk begin risk/hazard mitigation efforts equitably by first implementing a major flood control project within the historically black community of Chesterfield Heights; implementation of a $112M HUD project awarded through the National Disaster Resilience Competition (construction currently underway).

- **Proposed projects that enables communities to adapt to and thrive through natural or human hazards.**
  The ***Combined Coastal and Precipitation Flooding Master Plan*** (Norfolk's "Flooding Master Plan") is based on a major multi-year study effort supported by technical analyses and recommendations from Fugro Atlantic within the ***Norfolk Preliminary City-wide Coastal Flooding Mitigation Concept Evaluation and Master Plan Development*** (the "Fugro report"). The Flooding Master Plan is also supporting by a thorough analysis and priority ranking technical guide of the City's drainage conveyance system, ***City-wide Drainage and Watershed Master Plan*** by Timmons Group.

  Together, with this technical supporting documentation, the Flooding Master Plan provides the framework for Norfolk to intelligently review and prioritize flood protections project to enable Norfolk to adapt and thrive to current and future flood threats.

- **Documentation of existing social, economic, natural, and other conditions present in the local government.**
  Sandia National Laboratories provided an analysis framework (***Development of an Urban Resilience Analysis Framework with Application to Norfolk, VA***) for conceptualizing the resilience needs for Norfolk, including vulnerability assessments for critical infrastructure with the context of local economic and logistical impacts. The findings of which have been incorporated into other resiliency plans such as the USACE Coastal Storm Risk Management Study.

  The ***USACE Coastal Storm Risk Management*** **(CSRM)** ***Feasibility Study and Environmental Impact Statement*** presents a robust analysis of the best recommendations for City-wide flood protection measures for the City of Norfolk. This report includes 10% engineered designs for the various flood protection measures recommended throughout the entire community, and a preliminary Environmental Impact Statement is included outlining the existing social, economic, natural conditions, vulnerabilities and stressors within the natural and social environment, as well as proposed impacts. See the various CSRM appendices for these detailed conditions and impact reports.

- **Review of the vulnerabilities and stressors, both natural and social in the local government.**
  See CSRM comment above. Additional overview of the vulnerabilities and stressors can be found in the ***Hampton Roads Hazard Mitigation Plan***.

- **Forward-looking goals, actionable strategies, and priorities through as seen through an equity-based lens.**
  Norfolk remains committed to presenting all action plans through an equity-based lens, as found within the actionable strategies of ***A Green Infrastructure Plan for Norfolk*** and the ***Hampton Roads Hazard Mitigation Plan***. Both plans are tactical, and recommendation are based on a 5-year forward-looking outlay. Recommendations of the Fugro report are based on a 50-year outlay, and recommendations of ***Vision2100*** geared towards the year 2100.

- **Strategies that guides growth and development away from high-risk locations that may include strategies in comprehensive plans or other land use plans or ordinances or other studies, plans or strategies adopted by a local government.**
  Vision2100 is serves a land use guide for the City. The plan divides Norfolk up into four main areas by which the City will focus new investments and make necessary steps to prepare for a changing environment:
  - ✓ Purple: Low Flood Risk / Low Degree of Civic Assets: Establishing Neighborhoods of the Future
  - ✓ Green: Low Flood Risk / High Degree of Civic Assets: Designing New Urban Centers
  - ✓ Yellow: High Flood Risk / Low Degree of Civic Assets: Adapting to Rising Waters
  - ✓ Red: High Flood Risk / High Degree of Civic Assets: Enhancing Economic Engines (protect!)

- **Proposed acquisition of land or conservation easements or identification of areas suitable for conservation particularly areas identified as having high flood attenuation benefit by *ConserveVirginia* or similar data driven tools.**
  Vision2100 provides the framework for selecting the areas suitable for conservation easements. The ***Norfolk Zoning Ordinance*** provides the mechanism for purchasing land conservation easement credits from the Coastal Resilience Overlay through transferring Resilient Quotient points to the Upland Resilience Overlay (requires extinguishment of a density unit – developable dwelling unit). The conservation easement, while recorded on the deed and kept on file with the Planning Department, can be held by the property owner, the Zoning Ordinance also permits it to be placed in a land trust.

- **Identification of areas suitable for property buyouts in frequently flooded areas.**
  See ***Vision2100*** "Yellow" areas (High Flood Risk / Low Degree of Civic Assets: Adapting to Rising Waters) and Coastal Resilient Overlay areas on the Norfolk Zoning Map.

- **Identification of critical facilities and their vulnerability throughout the local government such as water and sewer or other types identified as "lifelines" by FEMA.**
  A list of all critical facilities is contained within the *Norfolk Emergency Operations Manual* (2020). See Mitigation Action 5 from ***Hampton Roads Hazard Mitigation Plan***: "Purchase and install generators or other continuous power sources for critical facilities and infrastructure. This action may include, but is not limited to pump stations, EOC (Emergency Operations Center), shelters, underpasses and important traffic signals." The critical facilities list is available upon request.

- **Identified ecosystems/wetlands/floodplains suitable for permanent protection.**
  See ***A Green Infrastructure Plan for Norfolk***, this includes an *Action Plan Appendix for Threatened and Endangered Species* within critical floodplain habitats, as well as a detailed ecological inventory with recommendations for floodplain protection measures within an connected open space corridor network.

- **Identified incentives for restoring riparian and wetland vegetation.**
  - The City's Public Works Division of Stormwater Management offers the **Stormwater Fee Reduction Program** for homeowners and businesses who opt to implement water quality improvements on their private property including riparian buffer and shoreline management improvement.
  - **Environmental Conservation Consulting** – Norfolk annually funds a contract to coordinate with residential property owners for implementation of water quality improvements on their private property including riparian buffer and shoreline management improvement through a cost-share program. Property owners get a percentage of the project paid through the contractor via the Environmental Conservation Consulting services contract.
  - Norfolk regularly applies for grants to partner with community organizations for implementation of green infrastructure of public lands – projects are reviewed by the **Watershed Management Task Force** to ensure that projects are furthering the goals and objectives of the adopted ***Green Infrastructure Plan for Norfolk***.

- **A framework for implementation, capacity building and community engagement.**
  The **Watershed Management Task Force** and the recently created Program for Public Information committee are two groups made up of joint staff/citizen/technical expert members, which collectively drive the City's ongoing programing for green infrastructure projects and flood mitigation messaging. Capital Improvement Project funding recommendations from the ***Green Infrastructure Plan for Norfolk*** are also reviewed monthly by the Watershed Management Task Force.

- **Strategies for creating knowledgeable, inclusive community leaders and networks.**
  The 12-member Norfolk Coastal Management Review Board (CMRB) provides recommendations to the 7-member Erosion Advisory Commission, which is partially comprised of members of the CMRB. The CMRB is made up of elected leaders, civic league presidents/community leaders and technical experts from the Virginia Institute of Marine Science, Virginia Marine Resources Commission, Army Corp of Engineers, Old Dominion University Department of Ocean, Earth and Atmospheric Sciences, and city technical staff, providing workshops, seminars and project assessments of coastal mitigation and erosion projects; specifically intended to build grassroots technical capabilities and citizen champions within the community. The Norfolk CMRB and Erosion Advisory Commission is established by City Code and guided by the City's adopted Sand Management Plan.

- **A community dam safety inventory and risk assessment posed by the location and condition of dams.**
  Not applicable in Norfolk – not at dam risk.

- **A characterization of the community including population, economics, cultural and historic resources, dependence on the built environment and infrastructure and the risks posed to such infrastructure and characteristics by flooding from climate change, sea level rise, tidal events or storm surges or other weather.**
  This general characterization is well documented within the general/comprehensive plan for the City of Norfolk – ***plaNorfolk2030***. This includes dozens of resiliency recommendations for flood risk reduction and communication.

- **Strategies to address other natural hazards that would cause, affect or result from flooding events including:**
  - **Earthquakes.**
  - **Storage of hazardous materials**
  - **Landslides/mud/debris flow/rock falls.**
  - **Prevention of wildfires that would result in denuded lands making flooding, mudslides or similar events more likely.**
  - **Preparations for severe weather events including tropical storms or other severe storms, including winter storms.**

  The ***Hampton Roads Hazard Mitigation Plan*** is a FEMA-accredited all-hazards plan.

DS KM

DS

THE CITY OF NORFOLK

For CM Office use only:
DTS # _____

DOCUMENT TRANSMITTAL FORM

Use for All City Documents Which Require the City Manager's Staff Approval

DS AMS DS AV

*** PLEASE INDICATE IF THERE IS A LEGITIMATE DUE DATE BY WHICH THE CITY MANAGER MUST RESPOND ***

Due Date: ____11/3/2021__ Return Completed Document To: __Stephanie Daniel, Office of Resilience_

DEPARTMENT	City Planning
A. TO BE COMPLETED FOR CONTRACTS, AGREEMENTS, RFPS, AND GRANTS:	
TITLE	DCR Community Flood Preparedness Fund November Application 2021
PARTY (Company and principal's names with which the City is entering into the agreement.)	Virginia Department of Conservation and Recreation (DCR)
EFFECTIVE DATES (Start & end dates)	Upon award– 1/1/2025
TOTAL DOLLAR VALUE	$350,000 ($315,000 grant request; $35,000 match)
FUNDING SOURCE (Operating or capital budget; budget year; grant or other source. Show account information)	**SOURCE:** STORMWATER **ACCOUNT:** 2300-35-010-906-5303 ($35,000 for Watershed Master Plan update)
TYPE (New or extension)	New Grant Application
SUMMARY OF SCOPE OF SERVICE/ PROGRAM	The City is applying for funds to support the City's Watershed Master Plan update to increase the CRS NFIP rating for flood insurance.
CALL OUTS (Indicate any unique circumstances regarding provisions such as procurement protest pending, emergency purchase or other time sensitivity, so forth, along with any other pertinent information)	The grant submission package is due to DCR by 11/5/21 by 4pm EST.
B. TO BE COMPLETED FOR HUMAN RESOURCES DOCUMENTS:	
TYPE OF DOCUMENT:	N/A

BRIEF DESCRIPTION: N/A

Certificate of Satisfaction: *I (We) hereby certify that all reasonable due diligence has been performed to sufficiently develop the contents and implications of the attached document in a manner to protect and account to the public.* ***Further, all City policies and procedures have been adhered to and therefore, I (we) recommend the City Manager execute this document.***

Matt Simons
10-29-2021
Document Owner Date

DocuSigned by: George Homewood 10/29/2021 | 3:10 PM ED
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Department Head Signature Date

DocuSigned by: Richard Broad 10/29/2021 | 3:21 PM E
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Department Head Signature Date

Review by DCM Approve ☐ Disapprove ☐

DocuSigned by: Patrick Roberts 11/4/2021 | 6:31 AM EDT
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Deputy City Manager Date

Review by CM Approve ☐ Disapprove ☐

DocuSigned by: 11/4/2021 | 7:10 AM PDT
C45AA22E7D6047B...
City Manager Date

Required & Supporting Documents: Links

FIRM Maps: https://drive.google.com/drive/folders/1zISYqMWhmwSFTz1-5gWA61RVpD1GRy45?usp=sharing

Citywide Precipitation Master Plan (Timmons Group): https://drive.google.com/file/d/1MTC-pXJhrfs7PnNAnQZDotXwyTger77A/view?usp=sharing

Watershed Maps (Timmons Group): https://drive.google.com/file/d/1_HcVTinCz6JetCJCL8cxnYQ5lsPTcnY_/view?usp=sharing

Citywide Coastal Flooding Evaluation (Fugro Atlantic Report): https://drive.google.com/file/d/1D_cQJbBNrlHzkdV8tcECLg7H3ZNldMdb/view?usp=sharing

Comprehensive Plan (plaNorfolk2030): https://www.norfolk.gov/DocumentCenter/View/2483

Green Infrastructure Plan: https://www.norfolk.gov/DocumentCenter/View/38067

Vision2100: https://www.norfolk.gov/DocumentCenter/View/27768

Hampton Roads Hazard Mitigation Plan: https://www.hrpdcva.gov/library/view/620/2017-hampton-roads-hazard-mitigation-plan-and-appendices/

Norfolk Floodplain Ordinance: https://www.norfolkva.gov/norfolkzoningordinance/#Norfolk-ZO/3_9_Overlay_Districts_and_Designations.htm#_Toc502655724?TocPath=Article%25203%253A%2520Zoning%2520Districts%257C3.9%2520Overlay%2520Districts%2520and%2520Designations%257C_____7

CFPF Watershed Master Plan Study Costs

Table 1- Scope of Work Project Costs

Project Tasks	Grant Funds (90%)	Match Funds (10%)	Total
Task I Project Initiation, Plan Alignment, Data Integration, Model Development	$36,000	$4,000	$40,000
Task II Purchase and Installation of Flood Sensors (20)	$18,000	$2,000	$20,000
Task III Optimization of Flood Sensors within real-time GIS dashboard and H&H model	$49,500	$5,500	$55,000
Task IV Future Conditions H&H Modeling	$103,500	$11,500	$115,000
Task V Resilience Rubric Integration and Scoring - Watershed Action Recommendations	$67,500	$7,500	$75,000
Task VI Action Refinement, Final Report and Project Closeout - DCR-approval for watershed revisions to approved Resilience Plan	$40,500	$4,500	$45,000
Total Project Costs:	**$315,000**	**$35,000**	**$350,000**

Table 2- Budget Table by Tasks and Budget Categories

	Budget Categories:	Project Tasks ($)						
		Task 1	**Task 2**	**Task 3**	**Task 4**	**Task 5**	**Task 6**	**TOTAL:**
Direct Costs	Personnel/ Salaries (Contractual)	$40,000	$19,337.40	$55,000	$115,000	$75,000	$45,000	**$349,337.40**
	Fringe Benefits	$0	$0	$0	$0	$0	$0	$0
	Travel	$0	$0	$0	$0	$0	$0	$0
	Equipment	$0	$662.60	$0	$0	$0	$0	$662.20
	Supplies	$0	$0	$0	$0	$0	$0	$0
Total Direct Costs:		$40,000	$20,000	$55,000	$115,000	$75,000	$45,000	**$350,000**
Indirect Costs:		$0	$0	$0	$0	$0	$0	$0
Total Grant Funding:		$36,000	$18,000	$49,500	$103,500	$67,500	$40,500	**$315,000**
Cost Share (City match):		$4,000	$2,000	$5,500	$11,500	$7,500	$4,500	$35,000
Total Budget:		$40,000	$20,000	$55,000	$115,000	$75,000	$45,000	**$350,000**

Budget Breakdown

Task I: Project Initiation, Plan Alignment, Data Integration, Model Development ($40,000): The City will adhere to required procurement processes and regulations to procure a qualified consultant to assist the City with this effort. Contractual expenses are estimated at $40,000 ((Principal $210/hr, Project Manager $188/hr, Senior Engineer $178/hr, Engineers range from $110-$142/hr, Administrative Assistant $70/hr). City will commit to 10% of costs ($4,000) via cash contribution from the Stormwater Reserve Fund. Any staff time that may be required will be provided at no cost.

Task II: Purchase and Installation of Flood Sensors (20) ($20,000): The City will plan to purchase 20 sensors at an estimated equipment cost of $33.13 unit cost, installation cost of $815.58 per sensor, and anticipated monthly maintenance cost of $12.61 per sensor for a total cost of $20,000. Anticipated contractual costs associated with installation are estimated at $20,000, 10% of which ($2,000) will be paid by the City's match via cash contribution from the City's Stormwater Reserve Fund.

Task III: Optimization of Flood Sensors within real-time GIS dashboard and H&H model ($55,000): The City will adhere to required procurement processes and regulations to procure a qualified consultant to assist the City with this effort. Contractual expenses are estimated at $55,000 (Principal $210/hr, Project Manager $188/hr, Senior Engineer $178/hr, Engineers range from $110-$142/hr, Administrative Assistant $70/hr). City will commit to 10% of costs ($5,500) via cash contribution from the Stormwater Reserve Fund. Any staff time that may be required will be provided at no cost.

Task IV: Future Conditions H&H Modeling ($115,000): The City will adhere to required procurement processes and regulations to procure a qualified consultant to assist the City with this effort. Contractual expenses are estimated at $115,000 (Principal $210/hr, Project Manager $188/hr, Senior Engineer $178/hr, Engineers range from $110-$142/hr, Administrative Assistant $70/hr). City will commit to 10% of costs ($11,500) via cash contribution from the Stormwater Reserve Fund. Any staff time that may be required will be provided at no cost.

Task V: Resilience Rubric Integration and Scoring - Watershed Action Recommendations ($75,000): The City will adhere to required procurement processes and regulations to procure a qualified consultant to assist the City with this effort. Contractual expenses are estimated at $75,000 (Principal $210/hr, Project Manager $188/hr, Senior Engineer $178/hr, Engineers range from $110-$142/hr, Administrative Assistant $70/hr). City will commit to 10% of costs ($7,500) via cash contribution from the Stormwater Reserve Fund. Any staff time that may be required will be provided at no cost.

Task VI: Action Refinement, Final Report and Project Closeout - DCR-approval for watershed revisions to approved Resilience Plan ($45,000): The City will adhere to required procurement processes and regulations to procure a qualified consultant to assist the City with this effort. Contractual expenses are estimated at $45,000 (Principal $210/hr, Project Manager $188/hr, Senior Engineer $178/hr, Engineers range from $110-$142/hr, Administrative Assistant $70/hr). City will commit to 10% of costs ($4,500) via cash contribution from the Stormwater Reserve Fund. Any staff time that may be required will be provided at no cost.

Additional budget information:

Travel: No travel costs are anticipated for this project as there are many engineering firms in the Hampton Roads area with H&H modeling and planning capabilities.

Equipment/Supplies: The only specialist equipment that will be purchased and utilized for this project is the flood sensors itemized in Task II. Deliverables will be digital.

Fringe: No fringe costs are anticipated for this project.