Charlestown Watershed Master Plan

December 2023

Dewberry

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Town Resolution adopting WMP

NOTICE TO READERS

A community-level watershed master plan (WMP) responds to recurring stormwater-related flooding along streams and rivers applied to local geography and current and future anticipated urban development. WMP's are designed to "look ahead" to anticipate climate change and the community's desired growth. As change and unexpected weather events occur, WMP implementation needs to be flexible over time and the plan amended as needed. Generally, graphics provided in the WMP are for illustrative purposes only and not an obligation to a specific management project, predictive of a flooding or non-flooding event at a specific location, or a substitute for a Flood Insurance Rating Map.

No part of this document should be used for insurance and/or risk determinations.

INCORPORATION BY REFERENCE

The Charlestown Watershed Master Plan Technical Memo (December 2023) prepared by Dewberry Engineers, Inc, is incorporated by reference as Appendix 3, including its three sub-appendices:

A. Chesapeake Road Storm Drain Improvements
B. Trinity Woods SWM #1/FEMA Property Project
C. Avalon Park Shoreline Restoration Project

This document is available in PDF digital format from the Town of Charlestown.

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Executive Summary

The hydrologic and hydraulic (H&H) analysis performed as part of the Charlestown Watershed Master Plan project provides the Town of Charlestown with a better understanding of the flood hazards within the identified study area boundary, as well as the Town itself. In addition, the analysis will help the Town forecast flood vulnerabilities for a range of precipitation events; identify mitigation opportunities; and begin planning for future mitigation strategies.

The project consisted of a community survey, two community workshops, steering committee meetings, and simulations for existing and future flooding conditions.

Stakeholder Input

Data was gathered from a variety of stakeholders via a community survey, two community workshops, and steering committee meetings. Seventy-four (74) responses to the community survey and feedback received during both community workshops were used to validate the model and inform the development of mitigation strategies.

Flood Simulation

A two-step H&H analysis was conducted to quantify flood risk within the study area and Town of Charlestown. The first step incorporated a 2D rain-on-grid HEC-RAS model to simulate the combined overland stormwater (pluvial) and coastal flooding for the entire study area. The second step included development of 2D PCSWMM models for three (3) smaller sub-drainage areas within the Town to incorporate the underground stormwater system.

Mitigation Strategies

Project locations were identified and prioritized using a combination of the model results, community feedback, and input from Town stakeholders. Project locations were prioritized using a variety of metrics including but not limited to the degree of flood threat, critical infrastructure impacts, town access, project co-benefits, design/construction requirements, public acceptance, and permitting requirements. Concepts were developed for the two (2) highest ranked projects and one (1) additional shoreline restoration project was identified by the Town prior to this planning process.

Goals and Objectives

Below are three general goals for the Charlestown Watershed Master Plan:

GOAL 1: Flood Mitigation and Resilience

- Develop and implement floodplain management strategies to minimize the impact of flooding on communities and infrastructure.
- Enhance the watershed's resilience to extreme weather events by adopting green infrastructure practices, such as the preservation of wetlands and forest and the creation of natural retention areas.
- Incorporate planned future development, with best-available anticipated climate-change weather scenarios, and best-available sea level rise forecasts.
- Include analyses and topics consistent with Cecil County, the State of Maryland, and the FEMA National Flood Insurance Program Community Rating System.

GOAL 2: Habitat Protection

- Identify and prioritize areas for habitat protection, restoration and enhancement, focusing on the rehabilitation of degraded ecosystems and the preservation of critical wildlife habitats.
- Promote community involvement in habitat restoration projects through education and outreach programs.

GOAL 3: Community Engagement and Education

- Foster a sense of community stewardship through educational programs that raise awareness about the importance of watershed conservation and sustainable water use practices.
- Encourage community participation in planning and decision-making processes related to watershed management through public meetings, workshops, and outreach events.
- Collaborate with local schools, government agencies, non-profit groups, and businesses to promote environmental education and sustainable practices within the watershed.

Below are four specific objectives for the Charlestown Watershed Master Plan:

OBJECTIVE 1: Incorporate Local Knowledge

Engage local residents and community stakeholders as an action item of the Town's 2019 Stormwater Vulnerability & Floodplain Management Assessment, to help determine what areas are currently impacted by local flooding.

OBJECTIVE 2: Utilize Best-Practice Modeling and Data

Use appropriate models to analyze existing and future land use and build out scenarios in the watershed to better understand the watershed's existing and future characteristics.

OBJECTIVE 3: Identify Feasible Effective Projects

Identify strategic restoration or mitigation projects to reduce flooding impacts.

OBJECTIVE 4: Develop Three Concept Plans

Complete three concept plans for priority projects identified during the planning process, one of which is a living shoreline demonstration project.

Charlestown Watershed Master Plan

I. INTRODUCTION

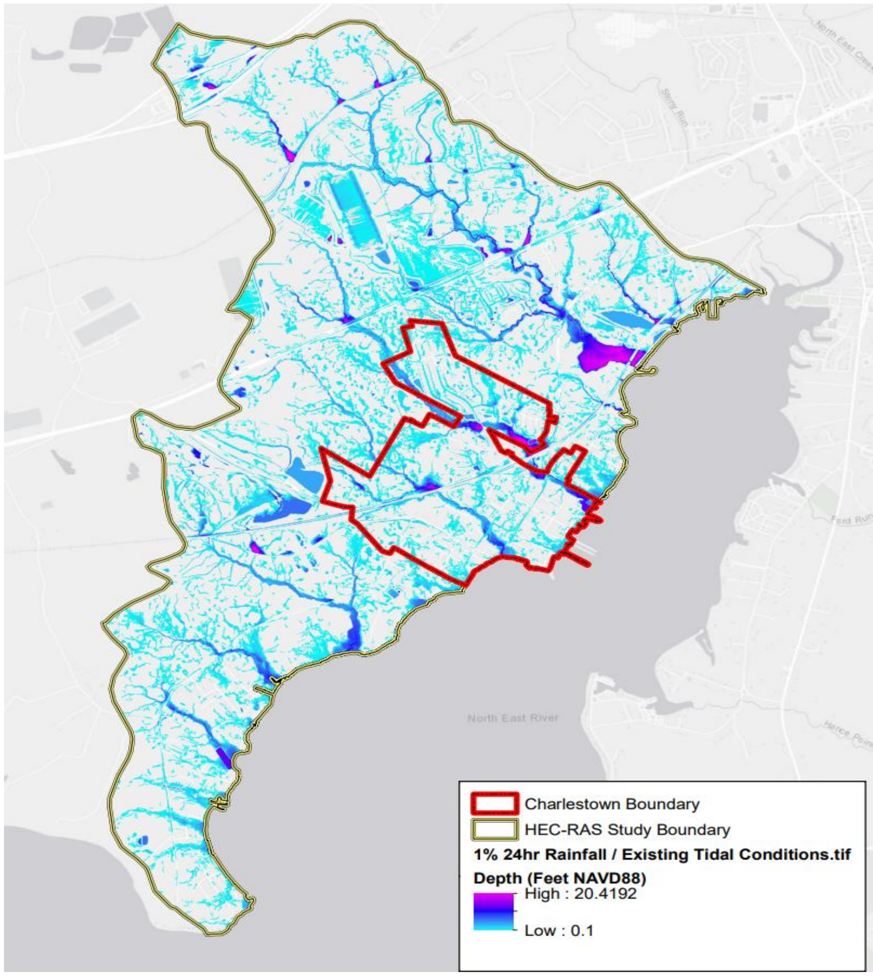
CHARLESTOWN AND THE NORTH EAST RIVER WATERSHED

The Town of Charlestown (Charlestown) is a small town in Cecil County, Maryland located in the northeastern corner of the state (Figure 1). Charlestown is located along the west bank of the North East River which merges with several other rivers to form the head of the Chesapeake Bay. The town was established in the 18th Century and has maintained its historic semi-rural charm with well-preserved buildings and a quaint atmosphere. One notable feature is the Charlestown Historic District which includes various buildings dating back to the 18th and 19th Centuries. The town has a waterfront area with several marinas offering scenic views of and recreational access to the North East River and Chesapeake Bay. The community is relatively close-knit, and residents take pride in the town's heritage.

The regional North East River watershed is a picturesque and ecologically significant region occupying the central portion of Cecil County. Stretching across approximately 44,000 acres, the watershed is defined by the North East River which flows north from Pennsylvania southward to the North East River which eventually flows into the Chesapeake Bay. Figure 2 illustrates Charlestown's town limits and the portion of the surrounding North East watershed that is the study area for this WMP.

Figure 1: Charlestown, MD Regional Location

Figure 2: Charlestown Community WMP Study Area



The study area is an 8.2-square mile sub-watershed of the North East River which is vulnerable to riverine, coastal, and pluvial (urban stormwater) flooding. The Town of Charlestown is a low-density, largely residential community of approximately 1.5 square miles, centrally located within the study area where two of the six major creeks flow downhill and eastward into the North East River: Peddlers Run Creek and Red Rum Creek. The area generally rises gently northwestward from the river bank as an undulating wooded plain unless land was cleared for structures, yards, parking, and streets. Four regional transportation facilities cross the area from southwest to northeast: Interstate 95 (6 and 8 lanes, limited access), Route 40 (4 to 6 lanes, at-grade signalized intersections with frequent commercial uses near each town), Route 7 (2 lanes), and the Northeast Regional Amtrak rail line. In several locations, drainage culverts under these facilities fail to convey peak storm drainage and create nuisance flooding, especially where the two creeks pass under Route 7 within the Town of Charlestown.

EXISTING STORM WATER SYSTEM

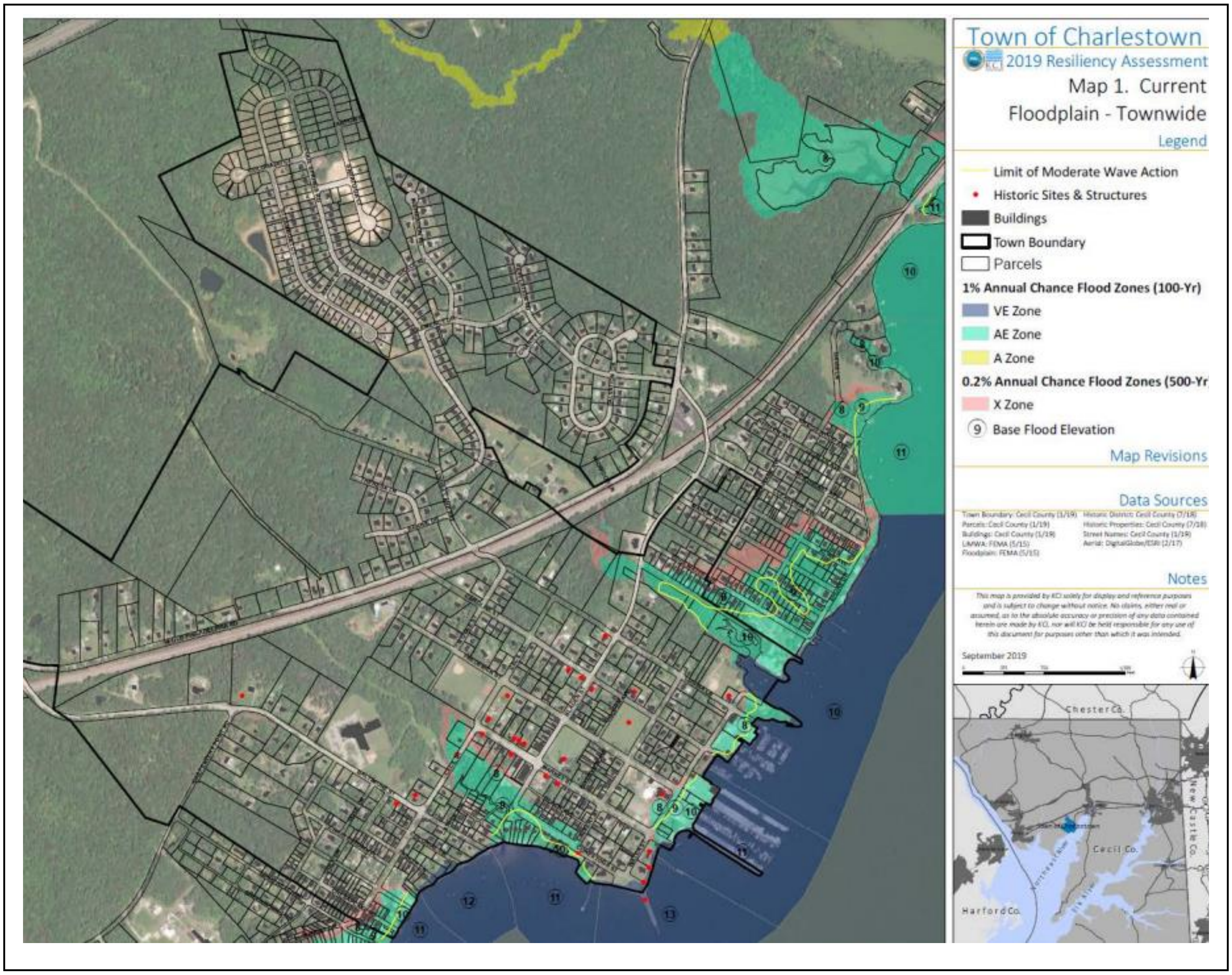
The Town's existing stormwater system of retention areas, inlets, pipes, and surface swales are shown in Figure 3.

Figure 3: Charlestown Stormwater System (2023)

FEMA FIRM DESIGNATIONS

Figure 4 illustrates the FEMA FIRM designations as of 2019. FEMA maps do not reflect the potential impact of riverine and creek flooding shown as AE and X zones combined with stormwater runoff in the upper watershed areas combined with anticipated higher rainfall and rising mean high tide due to general sea level rise.

Figure 4: FEMA FIRM Designated Areas (2019)

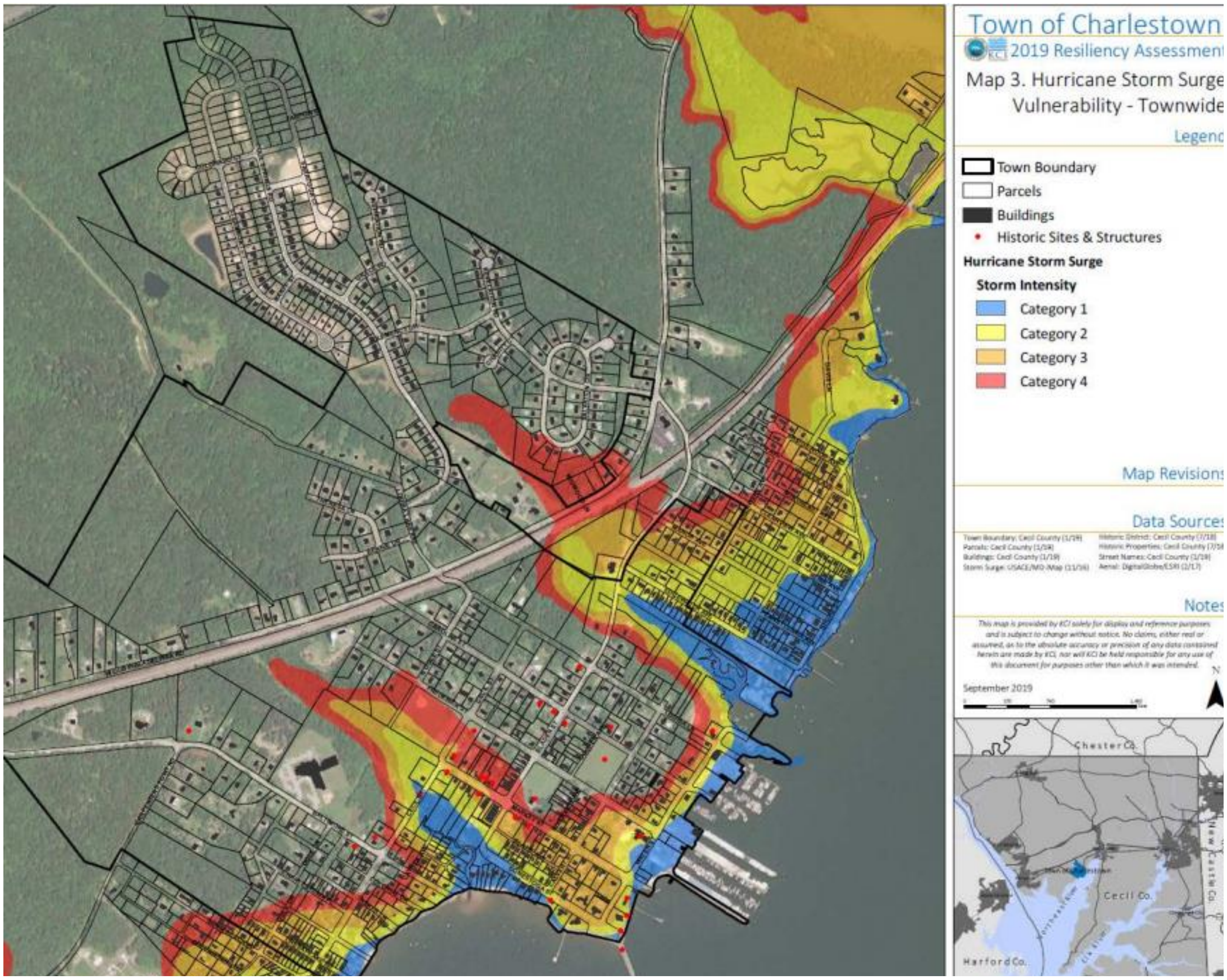


Source: 2019 Stormwater Vulnerability & Floodplain Management Assessment

STORM SURGE

Figure 5 illustrates the Town's vulnerability to storm surge that would likely occur as a hurricane or large storm event travels generally northward up the Atlantic coast and 'pushes' Chesapeake Bay water northward. As the bay narrows and grows increasingly shallower, the storm surge extends into the rivers that create the bay, including the North East River, and from the river into the smaller streams and creeks. Water entering a narrower and shallower channel has no path except to increase in height, or surge, and overflow into adjoining land as far inland as the surge force and local topography allow. In the case of Charlestown, Red Rum and Peddlers Run creeks are low-lying channels that would flood significantly inland compared to the expected flooding of North East River shoreline itself. The storm surge elevations were determined based on the FEMA flood insurance study for Cecil County (USACE, 2013).

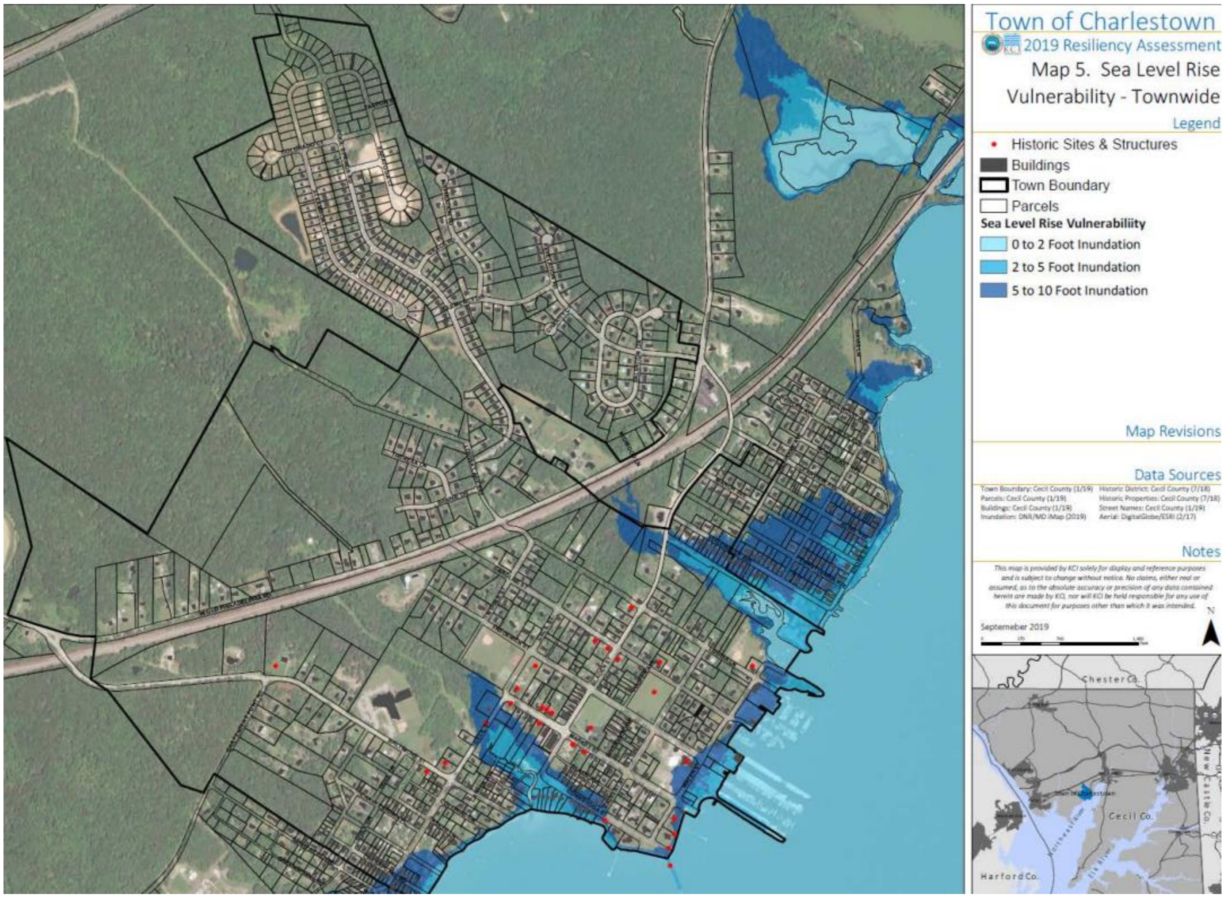
Figure 5: Hurricane Storm Surge Vulnerability (2019)
Source: 2019 Stormwater Vulnerability & Floodplain Management Assessment



SEA LEVEL RISE PROJECTION

Figure 6 illustrates expected sea level rise. Maryland's 2018 Sea Level Projections Guide (McClure et al, 2022) was used to estimate the average sea level rise heights above 2000 levels using the Baltimore Tide Gauge, which is closest to the study area. Low tolerance for flood risk was assumed as this project pertains to community assets and residential areas. The 2050 and 2080 values were added to the MHHW value to get future scenario sea level rise estimates. As shown in Figure 5, Hurricane Storm Surge, Red Rum and Peddlers Run Creeks are low-lying channels that would allow river water inland compared to much less expected flooding of the North East River shoreline.

Figure 6: Sea Level Rise Vulnerability (2019)



Source: 2019 Stormwater Vulnerability & Floodplain Management Assessment

PURPOSE AND SCOPE

The Charlestown WMP is a follow-up implementation strategy to the Town of Charlestown Stormwater Vulnerability & Floodplain Management Assessment (September 2019) and Cecil County Nuisance Flooding Plan (2020), with the intent to identify specific locations for stormwater BMP's that can reduce recurring and future flooding to less-than-significant and/or dangerous levels as much as possible with available current (2023) and future funding. About every 10 years, the Hydrologic and Hydraulic (H&H) modeling would need to be updated with updated weather and climate data, results reviewed, and stormwater BMP's, drainage system improvements, and other flood mitigation strategies revised as appropriate.

The scope of the grant-funded WMP was to begin with community outreach and then apply H&H modeling that simulates precipitation events recommended by the current scientific community. The use of more accurate, pertinent, and up-to-date input datasets is a key to the development of H&H models that can simulate existing and future flooding conditions. A data inventory was conducted to identify information that could assist with the development of the watershed flood model and flood impacts analysis. Appendix 2 lists the datasets that were identified and archived along with the data source and release date.

II. EXISTING CONDITIONS AND ISSUES

COMMUNITY INPUT

Community input began with creation of a WMP Steering Committee (Committee) in 2022, including a wide variety of stakeholders, including but not limited to, staff from the Town, Cecil County, Maryland Department of Environment (MDE), Maryland Department of Natural Resources (DNR), Cecil Land Trust (CLT), Elk and North East Rivers Watershed Association (ENERWA), and University of Maryland – Sea Grant Extension. Regular meetings were scheduled with the Steering Committee to provide project updates and seek feedback and consensus on project prioritization metrics and priority projects selected for concept. With the Committee's input, a community survey was created and distributed with utility bills with 74 responses shown in Figure 7. The survey responses and materials provided by respondents (i.e. photos and maps) were consolidated into a GIS format and used to validate the existing condition H&H model, as well as, help identify potential project locations. Examples of photos received are provided in Figures 8 to 10.

Figure 7: Charlestown Community Survey Respondents

FIGURE 8: Photo of flooding from Peddlers Creek at Route 7 culvert

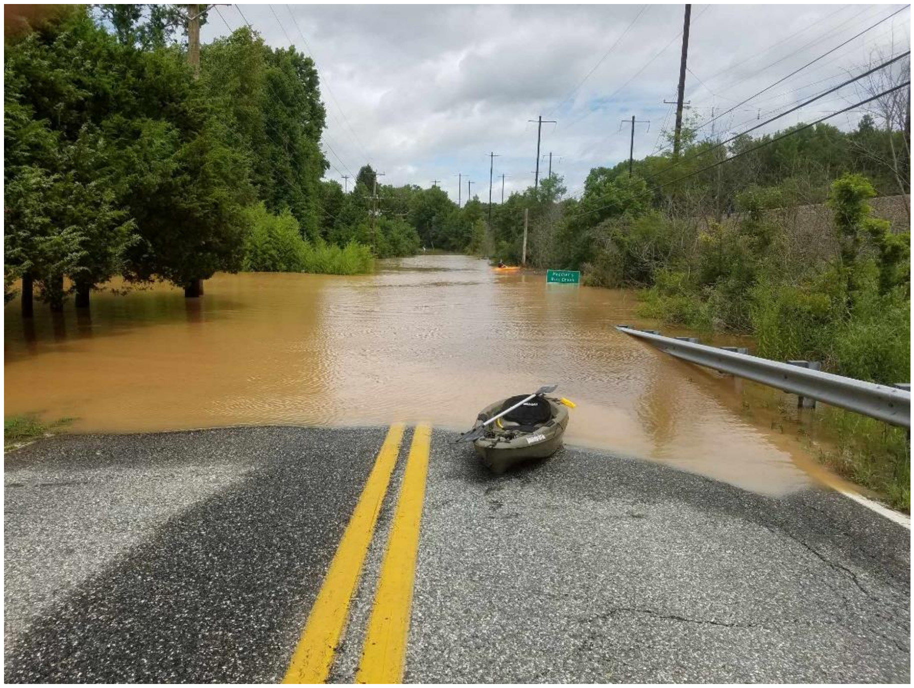


FIGURE 9: Photo of flooding in homeowner's backyard

FIGURE 10: Photo of backyard flooding

Although the level of detail in each survey response varied, the general trends are summarized as follows:

Flooding Issues
When asked if there are flooding issues on their property, the respondents reported:

- 43 out of 74 (58%) responded “yes”
- 31 out of 74 (42%) responded “no”

Flooding Frequency
When asked how often flooding was observed on their property, the respondents reported:

- 24 out of 74 (32%) responded only with “heavy rain”
- 12 out of 74 (16%) responded with “every rain”
- 2 out of 74 (3%) responded with high tides or storm surge
- 13 out of 74 (18%) responded that their property does not experience flooding

Flooding Depths
When asked to describe the typical depth, extent, and duration of flooding, the respondents reported:

- 9 out of 74 (12%) reported depths ranging from 0.5” to 2”

- 4 out of 74 (5%) reported depths ranging from 3” to 6”
- 15 out of 74 (20%) reported depths greater than 6”
- 18 of 74 (24%) responded not applicable or none

Causes of Flooding

When asked what the potential cause of the flooding was, the respondents reported:

- 22 of 74 (30%) reported flooding comes from a neighboring property
- 7 of 74 (9%) reported flooding is a result of heavy rain
- 6 of 74 (8%) reported flooding is a result of the property’s location within the landscape (e.g., located at the bottom of a hill)
- 14 of 74 (19%) reported flooding is due to poor drainage or lack of/damaged/inadequate drainage infrastructure
- 6 of 74 (8%) reported flooding is due to high tides, streams overflowing their bank, or storm surge
- 24 out of 74 (32%) responded not applicable or none

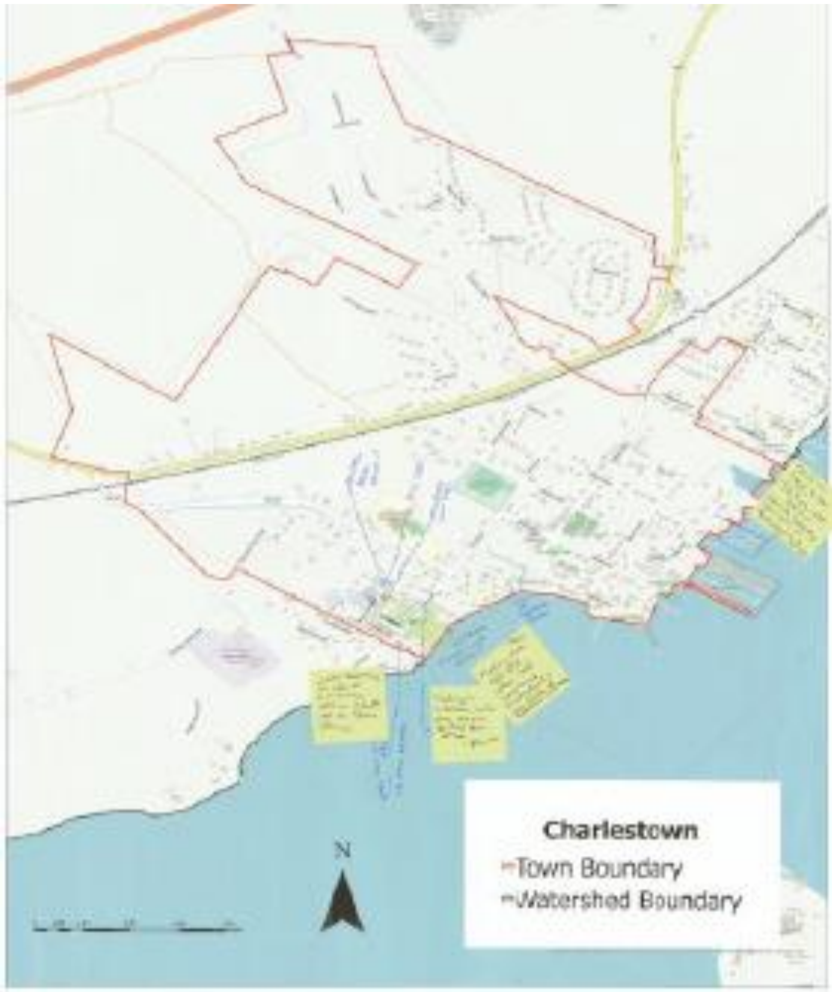
Figure 11: Dewberry Engineers and Town Staff presentation at Community Workshop #1.

Community Workshops

Two community workshops were hosted by the Town to solicit input from residents and provide project updates. The first meeting was held on November 16, 2022 and the second meeting was held on June 5, 2023.

Both Community Workshops were hybrid events with Town and Dewberry staff facilitating in-person and online attendees. During the workshops, the Town introduced the project and Dewberry provided an overview of the project approach and timeline. We summarized the desktop and data review collection process including how existing data and previous studies were being incorporated; provided an overview of the modeling approach and results; shared examples of potential mitigation strategies (including physical and regulatory approaches); facilitated breakout groups to discuss known flooding locations (Figure 12); and encouraged attendees to provide their perception of the benefits of watershed planning, the challenges to fixing flooding/watershed issues, and preferred mitigation strategies through a “dot” exercise. During the “dot” exercise, attendees were asked to select their top three (3) benefits of watershed planning, challenges to fixing flooding/watershed issues, and preferred mitigation strategies (Figures 13-15). Data on known flooding issues was digitized in GIS and used as part of the planning process to select project locations as discussed in Section IV, Alternatives (Figure 16).

FIGURE 12: Community Meeting Flooding Location Map



Known flooding issues were captured on large scale maps distributed throughout the meeting room using pens and post-it notes. Results were digitized into GIS.

FIGURE 13: Benefits 'Dot' Responses

Top five (5) "Benefits of Watershed Planning":

- Shoreline Protection
- Control Flood Risk
- Clear Water
- Property Values
- Quality of Life

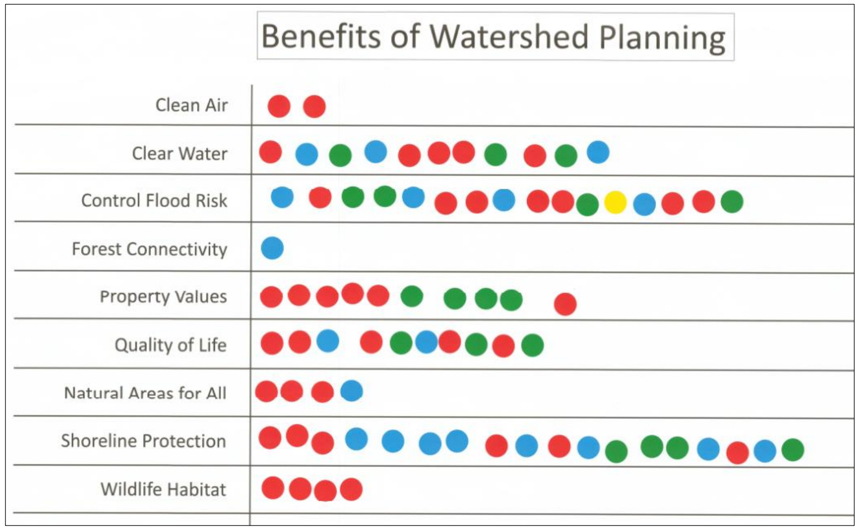


FIGURE 14: Challenges 'Dot' Responses

Top four (4) Challenges to "Fixing Flooding/ Watershed Issues":

- Private Property
- Funding
- Development
- Public Support

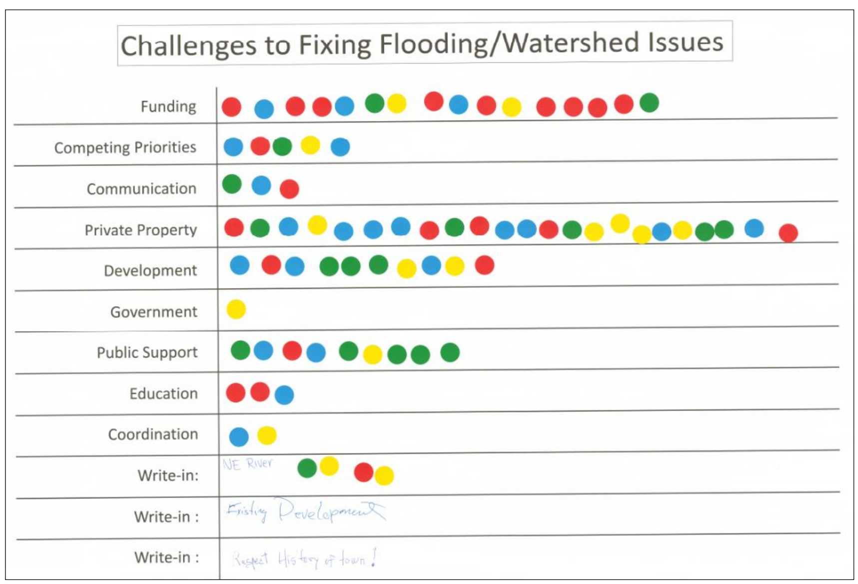
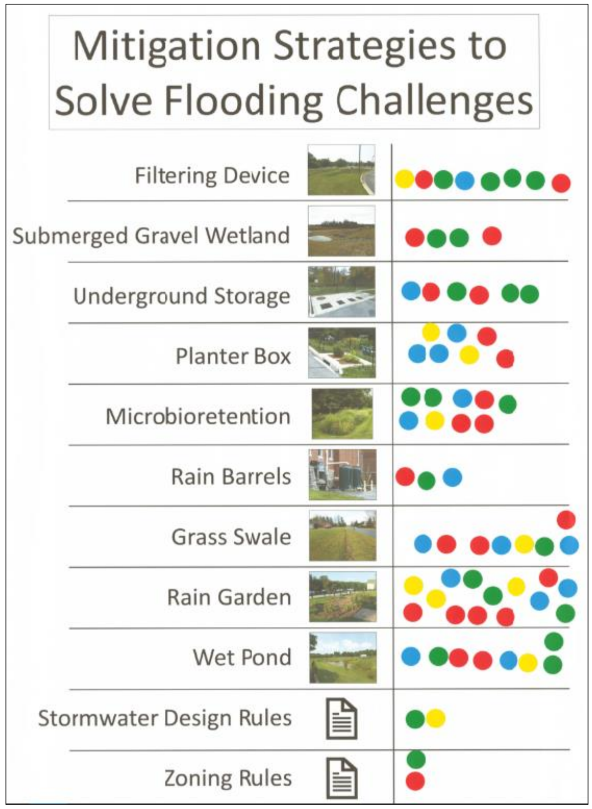


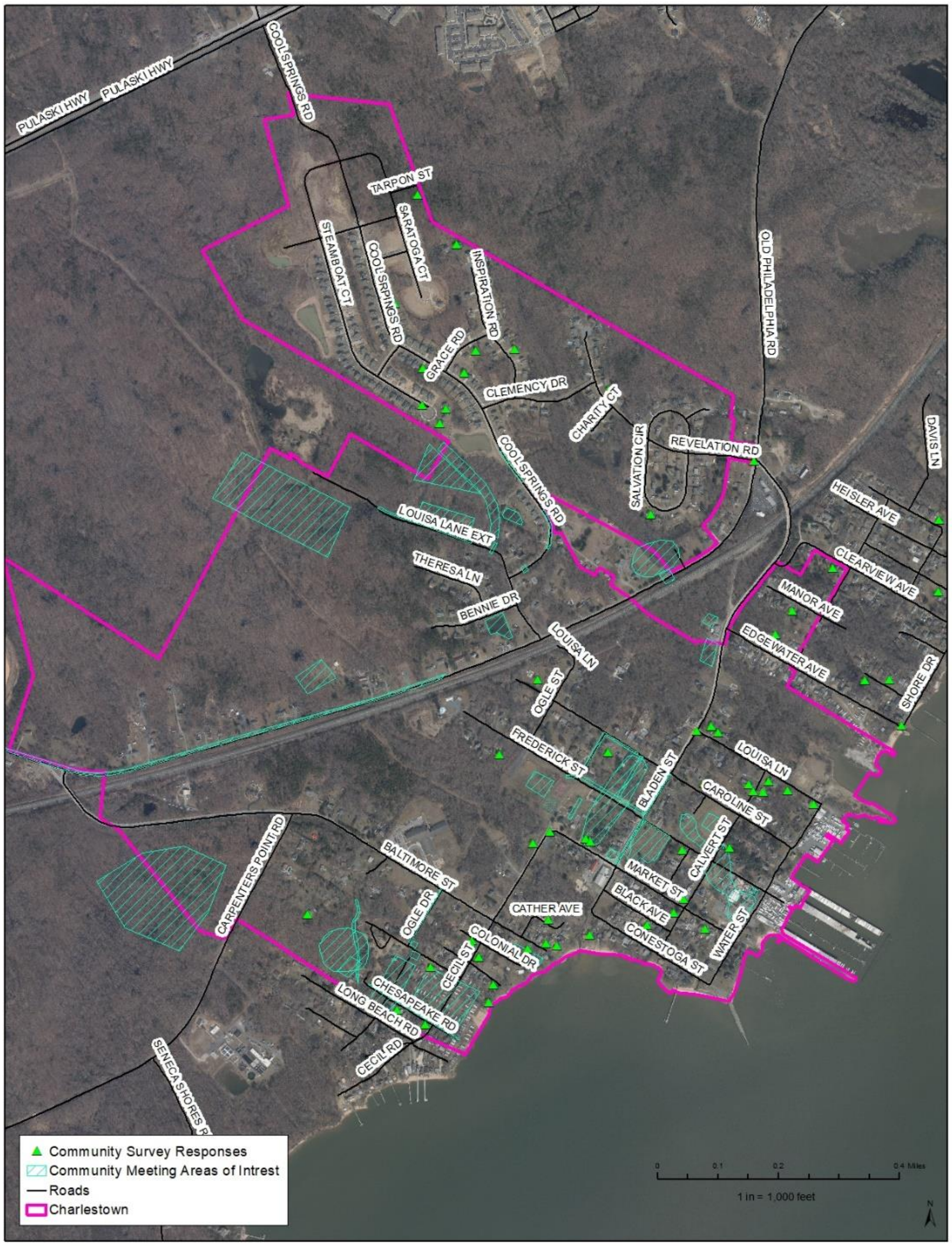
Figure 15: Strategies 'Dot' Responses



Top four (4) "Mitigation Strategies to Solve Flooding Challenges":

- Rain Gardens
- Micro-bioretentions
- Filtering Devices
- Wet Ponds

FIGURE 16: Digitized "Area of Interest" from Community Workshops #1 & #2



III. MODELING FLOOD RISK AND IMPACTS

The Charlestown Watershed Master Plan Technical Memo (December 2023), incorporated by reference in Appendix 3, provides complete modeling information.

Dewberry Engineers, Inc designed and conducted two-step hydrologic and hydraulic (H&H) analyses to locate and quantify flood risks in Charlestown. First, to understand how the watershed works with no stormwater drainage systems, a 2D rain-on-grid HEC-RAS model was used to simulate the combined overland stormwater (pluvial) and river/coastal flooding for the entire study watershed. Then, based on results from the HEC-RAS model, two-dimensional PCSWMM models were developed in three sub-drainage areas that included the existing Town stormwater drainage system. Resultant flood maps were analyzed to understand the efficacy of the existing stormwater drainage system and potential impact of flooding on buildings, roads, and critical infrastructure in the Town under current and future storm scenarios that include accounting for climate change and the storm surge associated with a hurricane event.

Model Scenarios and Input Data

Twelve storm scenarios were selected for modelling to show both existing and future flood conditions based on a variety of climate and occurrence factors. Model inputs are summarized below with more details provided in Appendix 3.

Time Period: Four time periods were selected to show how flooding currently affects the Town and how much it will change with future conditions.

- Current Period 2022
- Mid-Century 2050
- Mid-End Century 2080
- End-Century 2100

Storm Frequency and Duration: 10-year (10% annual exceedance probability) and 100-year (1% annual exceedance probability) design storm scenarios were selected to show how low and high frequency storms affect the Town. 25-year (4% annual exceedance probability) was also selected to model the existing stormwater drainage system. The storm duration chosen for all scenarios was 24-hours. This value is based off the watershed size as mentioned in the HEC-HMS Technical Reference Manual which suggests using a 24-hour storm for Maryland watersheds between 2 and 50 square miles. Additionally, much of the design of the Unites States stormwater drainage system plans are based on the 24-hour event.

GHG Emissions: Representative Concentration Pathway (RCP) 8.5 was used as the emissions scenario when determining future rainfall increases and projected sea level rise. RCP 8.5 represents the growing GHG emissions pathway, or the “worst-case” scenario, as opposed to the stabilized RCP 4.5 scenario. According to the Guidance for Using Maryland’s 2018 Sea Level Rise Predictions, experts believe actual emissions will be between RCP4.5 and RCP8.5 and using RCP8.5 “may be appropriate for projects with long timeframes, very low flood risk tolerance, and little or no adaptive capacity”.

The most important body regarding climate change science is the Intergovernmental Panel on Climate Change (IPCC). In August 2021, the IPCC published five "illustrative scenarios" with the designation SSP (*Shared socioeconomic pathways*). No probability labels are attached to them, but the probability of high emission scenarios such as RCP 8.5 and SSP 5-8.5 is seen as low and that the most likely scenarios are those in the middle, increases of about 2-3 degrees Centigrade (IPCC_AR6_WGI_Full_Report.pdf)

Tidal Conditions: Mean high high water (MHHW) and 10-year storm surge were chosen as the moderate and extreme tidal scenarios, respectively. MWWH refers to the average of the highest water height each day, while the 10-year storm surge refers to the 10% annual exceedance probability and describes the more extreme tide conditions.

Land Cover: Two data sources were used to describe the existing and future land cover for the model. The National Land Cover Dataset (NLCD) describes the 2019 or existing land use. The Integrated Climate and Land-Use Scenarios (ICLUS) describes the future estimated land use types based on the time period.

Table 1 outlines the twelve scenarios that were modelled based on the factors previously mentioned. Scenarios 1, 2, 4, 5, 8, and 9 describe moderate scenarios, with smaller storms and current sea levels. Scenarios 3, 6, 7, 10, and 11 represent extreme scenarios, with larger storms and storm surge tides. Scenarios 10 and 11 are similar to the Hurricane Isabel (September 17, 2003) caused moderate to severe damage along the Eastern Shore with a storm surge peaking at 8 feet (2.4 m) in the lower Chesapeake Bay and caused flooding of near-river properties at the north end of the Chesapeake Bay and along the North East River as the storm surge travelled into these more narrow and shallower areas.

Table 1: Storm scenarios selected for modelling.

Scenario	Time Period	Frequency (yr)	Duration (hr)	Tide	Land Use
1	2022	10	24	MHHW	NLCD 2019
2	2022	25	24	MHHW	NLCD 2019
3	2022	100	24	10yr surge	NLCD 2019
4	2050	10	24	MHHW	NLCD 2019
5	2050	10	24	MHHW	ICLUS 2050
6	2050	100	24	10yr surge	NLCD 2019
7	2050	100	24	10yr surge	ICLUS 2050
8	2080	10	24	MHHW	NLCD 2019
9	2080	10	24	MHHW	ICLUS 2080
10	2080	100	24	10yr surge	NLCD 2019
11	2080	100	24	10yr surge	ICLUS 2080
12	2100	100	24	MHHW	ICLUS 2100

Topography/Elevation Data

Existing Digital Elevation Model (DEM) topographic data were downloaded from the Cecil County website. The cell size is one meter.

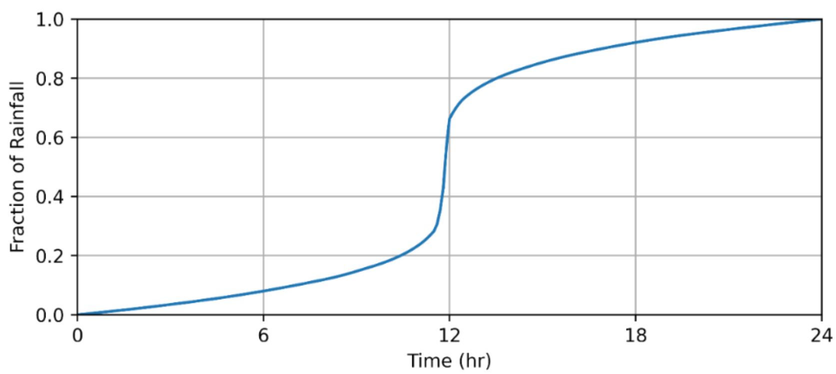
Rainfall

The flood model simulates stormwater flooding with a "rain-on-grid" modeling approach. The rain-on-grid approach adds or "rains" the appropriate amount of rainfall onto the surface of each grid cell at each model time step. During the model simulation, rainfall ponds and/or moves from model grid cell to grid cell based on the governing hydraulic equations which account for topography, differences in water surface elevation, and surface roughness. The rainfall timestep was set to six minutes, which was sufficiently short enough to capture the rise and fall of rainfall during the storm. Note that the rain-on-grid approach used here is substantially different than the approach used in traditional FEMA models, which only simulate the effect of changing river flows on flooding.

Existing Rainfall

The total rainfall (inches) was evaluated for three different storm scenarios – the 10-, 25-, and 100-year, 24-hour rain events – to be modeled as part of the existing conditions (2022) analysis. These scenarios were chosen to represent a range of potential extreme storm events. The NOAA Atlas-14 dataset was used to get cumulate rainfall totals across the study area. The rainfall by hour distribution is illustrated in Figure 17. A large fraction of rain falls during the middle of the storm between the 10th and 14th hours.

FIGURE 17: Cumulative rainfall during a 24-hour event used in the pluvial model



Future Rainfall

Rainfall increases for the mid-century and end-century scenarios were calculated using the Mid-Atlantic Regional Integrated Sciences and Assessments (MARISA) Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia. The rainfall increases are shown in Table 2. Rainfall is expected to increase between 16 and 18 percent compared to 2022 under the GHG emissions and climate change scenarios listed earlier.

Table 2: Rainfall increases for mid-century and end-of-century conditions

Time Period	Frequency (yr)	Rainfall Increase (%)
2050	10	11
	100	9
2080	10	16
	100	18

Source: https://midatlantic-idf.rcc-acis.org/

Tidal Elevations:

The eastern part of the study area is tidally influenced by the North East River and would be impacted by sea level rise (SLR). Mean high high water (MHHW) and 10-year storm surge were chosen as the moderate and extreme tidal scenarios, respectively.

MWWH refers to the average of the highest water height each day tidal. Maryland's 2018 Sea Level Projections guide was used to estimate the average sea level rise heights above 2000 levels using the Baltimore Tide Gauge, which is the closest to the study area. Low tolerance for flood risk was assumed as this project pertains to community assets and residential areas. The 2050 and 2080 values were added to the MHHW value to get future scenario sea level rise estimates.

Storm Surge:

The storm surge elevations were determined based on the FEMA flood insurance study for Cecil County. Table 3 shows the tidal elevations for each scenario. Note than by 2100, MHHW could be about six feet higher than in 2022.

Table 3: Tidal values for existing, mid-century and end-century conditions

Time Period	Tide Condition	Tidal Elevation (ft)
2022	MHHW	1.555
	10yr surge	5.57
2050	MHHW	3.625
	10yr surge	7.78
2080	MHHW	6.025
	10yr surge	10.27
2100	MHHW	7.815

Existing Land Cover (NLCD):

Manning's n values assigned to land use codes from the NLCD are provided in Table 4. The n value is determined from the values of the factors that affect the roughness of channels and flood plains. In densely vegetated flood plains, the major roughness is caused by trees, vines, and brush. Woody wetlands have the highest non-urban n value (0.0975) while high intensity urban development has the highest n value (0.16) leading to greater and more rapid runoff.

TABLE 4: MANNING'S N VALUES FOR NLCD LAND COVER

LAND USE CODE	LAND USE DESCRIPTION	MANNING'S N
11	Open Water	0.035
21	Developed, Open Space	0.04
22	Developed, Low Intensity	0.09
23	Developed, Medium Intensity	0.12
24	Developed, High Intensity	0.16
31	Barren Land Rock/Sand/Clay	0.0265
41	Deciduous Forest	0.15
42	Evergreen Forest	0.12
43	Mixed Forest	0.14
52	Shrub/Scrub	0.115
71	Grassland/Herbaceous	0.0375
81	Pasture/Hay	0.0375
82	Cultivated Crops	0.04
90	Woody Wetlands	0.0975
95	Emergent Herbaceous Wetlands	0.0625

Future Land Cover (ICLUS):

The 2050 and 2080 ICLUS datasets are based on the RCP 8.5 emissions scenario. Manning's n values assigned to land use codes from the ICLUS are provided in Table 5.

Table 5: Updates to the Demographic and Spatial Allocation Models to Produce Integrated Climate and Land Use Scenarios (ICLUS) Version 2

LAND USE VALUE	CLASS NAME	MANNING'S N
0	Natural Water	0.035
2	Wetlands	0.0975
4	Timber	0.15
5	Grazing	0.0375
7	Cropland	0.04
8	Mining, barren land	0.0265
9	Parks, golf courses	0.04
10	Exurban, low density	0.09
11	Exurban, high density	0.12
12	Suburban	0.09
13	Urban, low density	0.09
14	Urban, high density	0.16
15	Commercial	0.16

16	***Industrial***	***0.16***
17	***Institutional***	***0.16***
18	***Transportation***	***0.16***

Infiltration:

Rainfall infiltration or degree of pervious to impervious surface was modeled using the SCS curve number approach which assigns an infiltration factor to each type of land cover. More urbanized land uses tend to have higher SCS curve numbers and higher runoff while less urbanized land uses tend to have lower SCS curve number and less runoff.

MODEL RUN 1: HEC-RAS

The first of two Watershed-scale model runs used the U.S. Army Corps of Engineer Hydrologic Engineering Center River Analysis System (HEC-RAS Version) 6.3 2-dimensional (2D) unsteady flow model. This model run did not include the Town's underground stormwater system and shows what occurs based only on the rainfall scenario, land cover, and topography. Another interpretation is that the Town's stormwater infrastructure is all blocked. The model was manually adjusted to ensure that flows can pass through large bridges and major culverts. The flood model performance was evaluated by comparing the flows at various locations in the model to existing FEMA flood model and community survey data. All evaluations suggest that the model performed reasonably well. Additional evaluation information is included in Appendix 3.

Figures 18 and 19 illustrate the results of the HEC-RAS model run under the scenario of 1%/24-hour storm and existing tidal conditions. This run shows what 'nature wants to do' in a typical one to two-day storm if there were no storm drain system. Most flooding occurs as stormwater accumulates along the lower reaches of creeks and drainage channels that discharge into the North East River. The exceptions are the two 'backed-up' culverts along Route 7 that may reach 20 feet in depth according to the model and at several street crossing locations along Red Rum and Peddlers creeks. This run shows that even a 1%/24-hour storm event has the potential to isolate about half of the Town with flooded roads. If a similar rain event is coupled with storm surge and high tide, the town center could find itself split in half and the Charlestown Fire Station would be hard pressed to respond to most of its service area until the street flooding subsided.

Figure 18: HEC-RAS Model Run – Entire Town

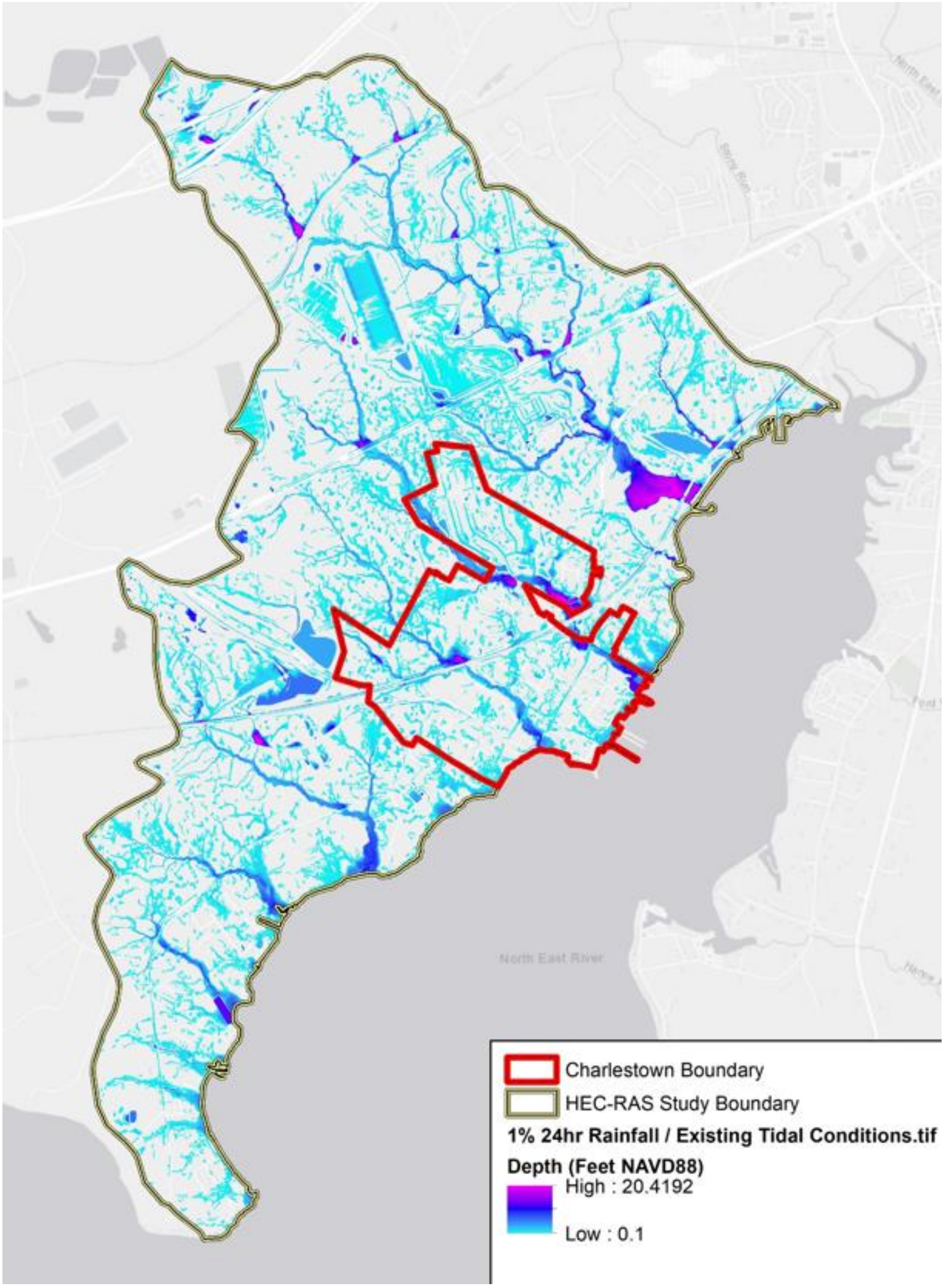
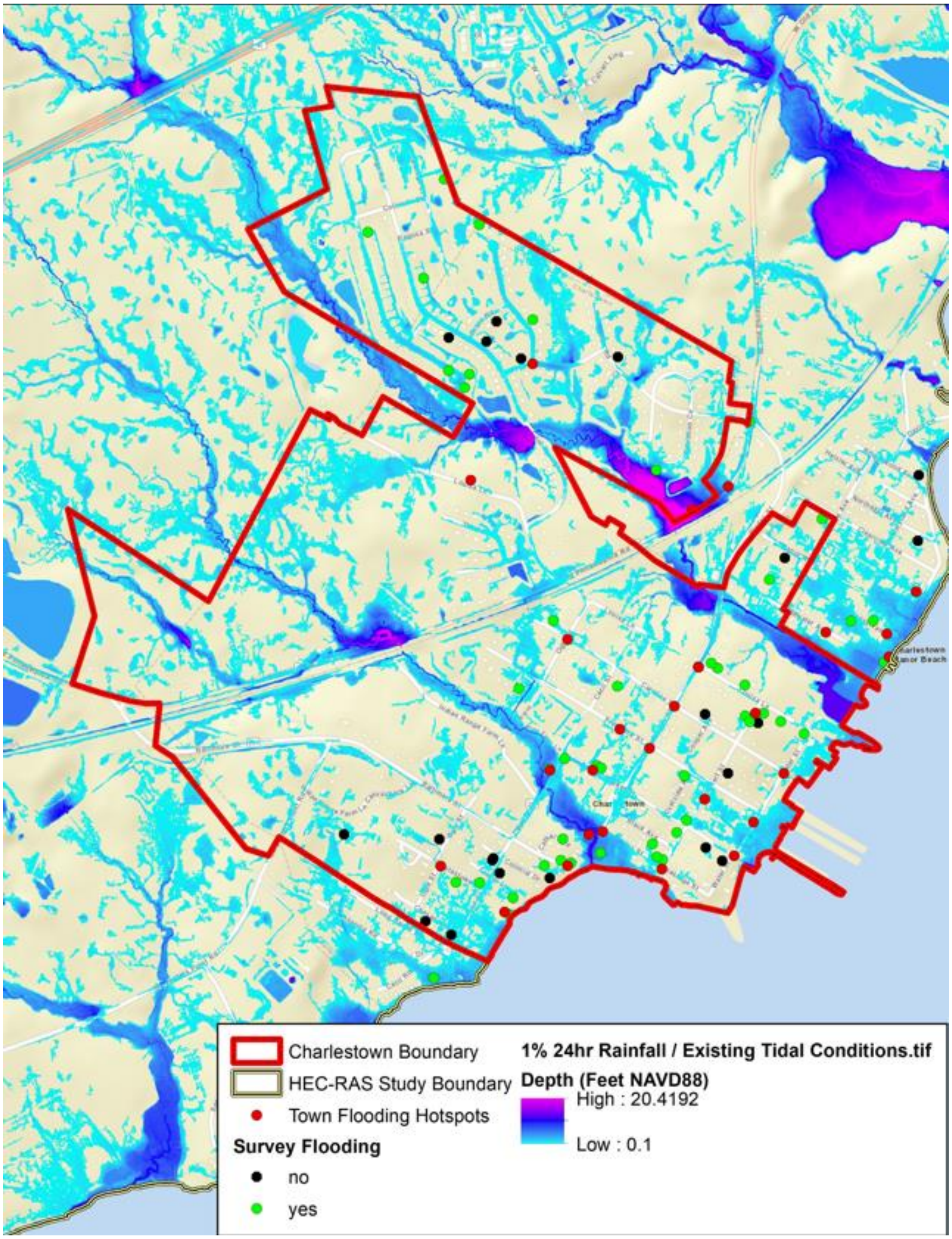


Figure 19: HEC-RAS Model Run – Central Charlestown



MODEL RUN 2: Storm Water Management Model (SWMM)

The community scale SWMM model run was conducted using U.S. EPA Stormwater Management Model (SWMM) which is used throughout the U.S. for planning, analysis, and design related to stormwater runoff, gray infrastructure, and stormwater control structures such as pipes and storm drains. The PCSWMM models includes the stormwater drainage network as fully functional.

Based on the results of the HEC-RAS model and community input listed earlier, three model areas were created:

(1) Red Rum Creek, located on the south part of the town of Charlestown along North East River,

(2) Peddlers Run Creek Downstream, the portion of Peddlers Creek downstream of W Old Philadelphia Rd (Rte. 7) and located on the east part of the town along North East River, and

(3) Peddlers Run Creek Upstream, the portion of Peddlers Creek upstream of W Old Philadelphia Rd (Rte. 7) and is located on the north part of the town, inland from the North East River.

Each area is approximately 0.25 to 0.5 square miles and includes residential areas of the Town.

Red Rum and Peddlers Downstream models include downstream boundary outfalls along the western bank of the North East River.

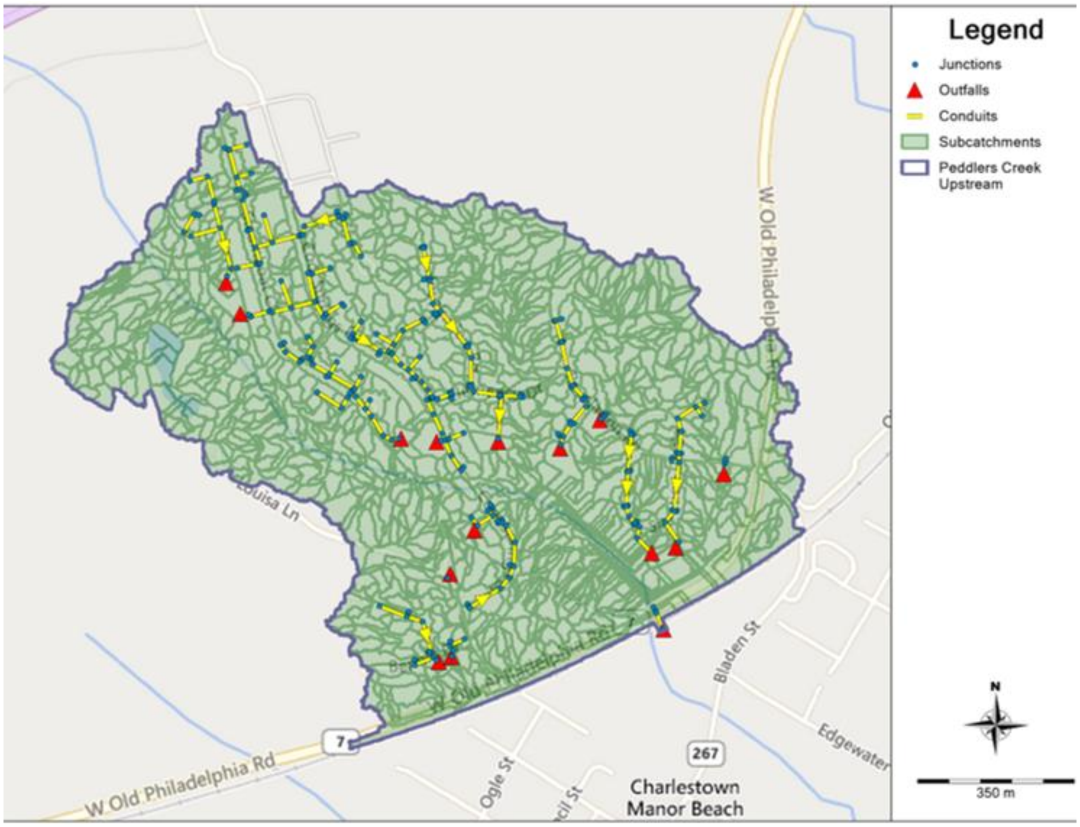
Red Rum and Peddlers Upstream models include inflows into model at the locations where streams enter the model boundaries. The flows were extracted as hydrographs from the HEC-RAS model at the respective locations. Peddlers Downstream model includes inflows from the Peddlers Upstream model. The outflow from the Peddlers Upstream PCSWMM model was extracted as a hydrograph for each scenario and entered into the Peddlers Creek Downstream model at the exit of the culvert along W Old Philadelphia Road, where the model boundary starts.

Existing Stormwater System

The PCSWMM model uses existing data to represent the performance of the stormwater drainage network including grass swales, BMPs, catch basins, pipes, manholes, and outfalls. This information comes from provided KCI GIS data files. Catch basins and manholes are represented as junctions in the models, and pipes and grass swales are represented by conduits. The models incorporate detailed design information about the stormwater infrastructure such as inlet size, pipe dimensions, and pipe inverts. Much of this data comes from the provided KCI data files, as well as a field survey to get inlet inverts. In cases where there were missing data gaps, reasonable assumptions were made based on best available engineering data.

Figure 20 shows the 1-D drainage network in the Peddlers Creek Upstream model area.

Figure 20: 1-D Stormwater network in Peddlers Creek Upstream PCSWMM model



MODEL EVALUATIONS

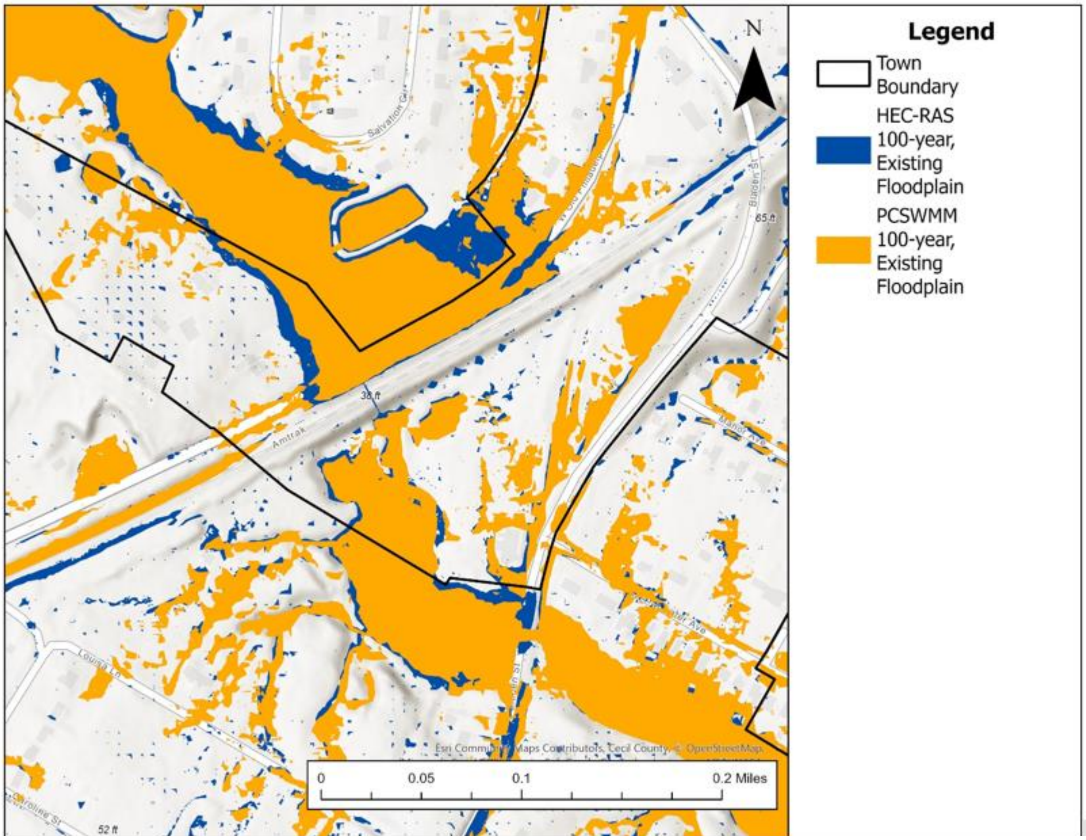
The flood model performance was evaluated by (1) comparing the flood inundations and depths to the HEC-RAS model results and (2) comparing the flooding results to the Community Survey and feedback received during Community Workshop #2. Both evaluations suggest that the HEC-RAS model performed reasonably well.

Model results for the PCSWMM models show similar locations of flooding to the HEC-RAS model and the FEMA floodplains; however, the flood inundations and depths in the PCSWMM models are slightly smaller overall. This is expected, as the PCSWMM models consider the runoff that is captured by the underground stormwater network, while the HEC-RAS models assume no runoff is captured into the stormwater network.

Figure 21 shows the inundation comparison for the 100-year, 24-hour, existing storm scenario, near W Old Philadelphia Road and Bladen Street. The overall inundations are similar, but since the PCSWMM models (Peddlers Creek Upstream and Downstream, in this example) incorporate the culverts and pipe network, flow is not as constricted at the raised roads and railroads as with the HEC-RAS model.

In addition to comparison with the HEC-RAS results, model results were validated by Community Survey results and community input at the Community Meeting #2 workshop.

Figure 21: Comparison of the HEC-RAS and PCSWMM model at Old Philadelphia Road



100 YEAR COMPOSITE FLOOD MAPS

The simulation results illustrate flooding impacts when the stormwater system does not work at all (HEC-RAS model results) and when the stormwater system works perfectly (PCSWMM model results). **The combination of results allows for the best assessment of the stormwater and coastal flood risks within the Town and is the basis for developing mitigation strategies.**

Each model simulation produces maps of the maximum flooding extent and the maximum flood depth across the study area for the twelve rainfall scenarios listed in Table 1. The maximum flood extent and depth was determined using the outputs of all model timesteps during the entire event. Therefore, the maximum extent and flood depth in one region of the model might not occur at the same time as in another region of the model. Figure 22 and Figure 23 show the composite flood maps for the 100-year, existing scenarios for each of the four models.

Figure 22: HEC-RAS 100-year existing conditions composite flood map

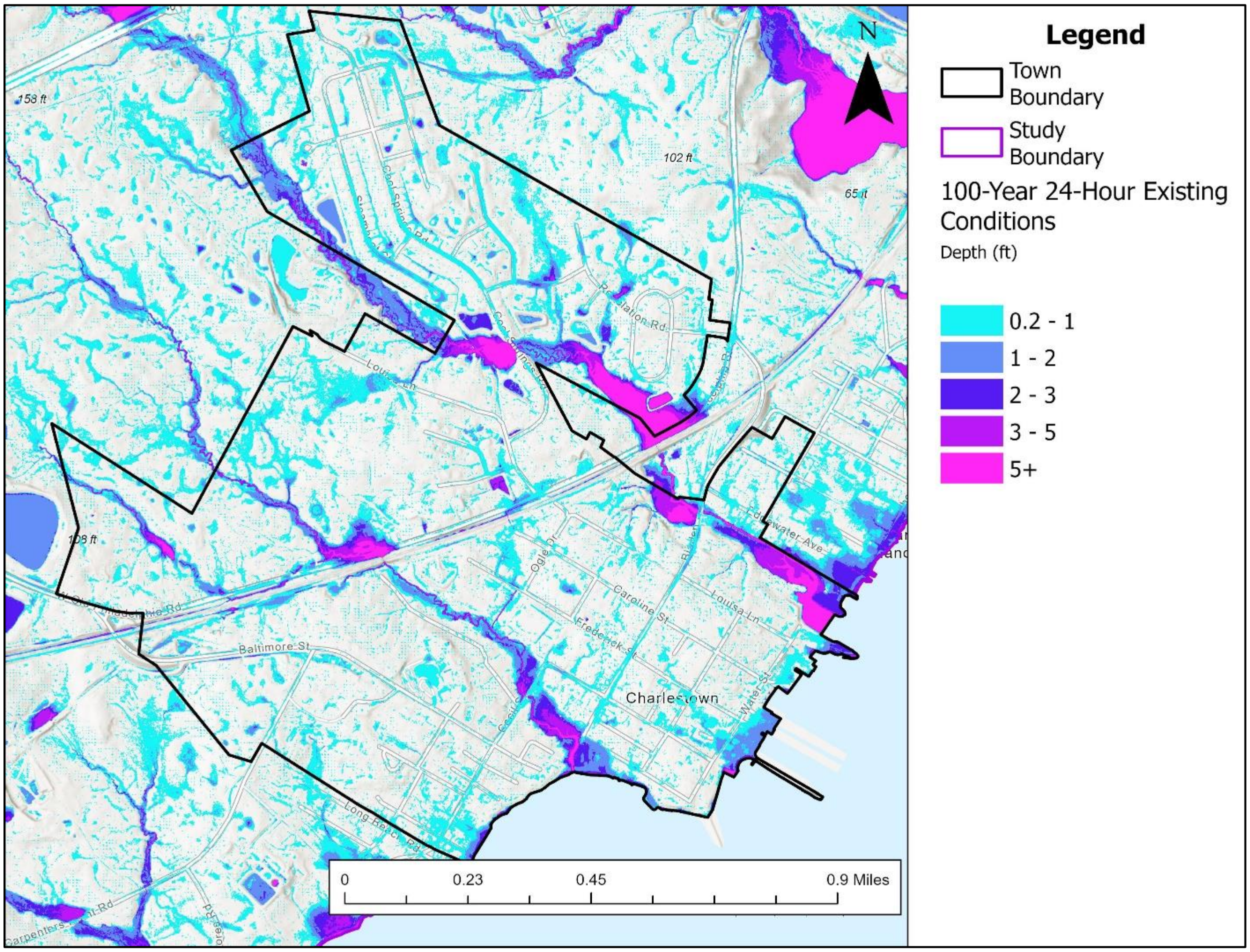
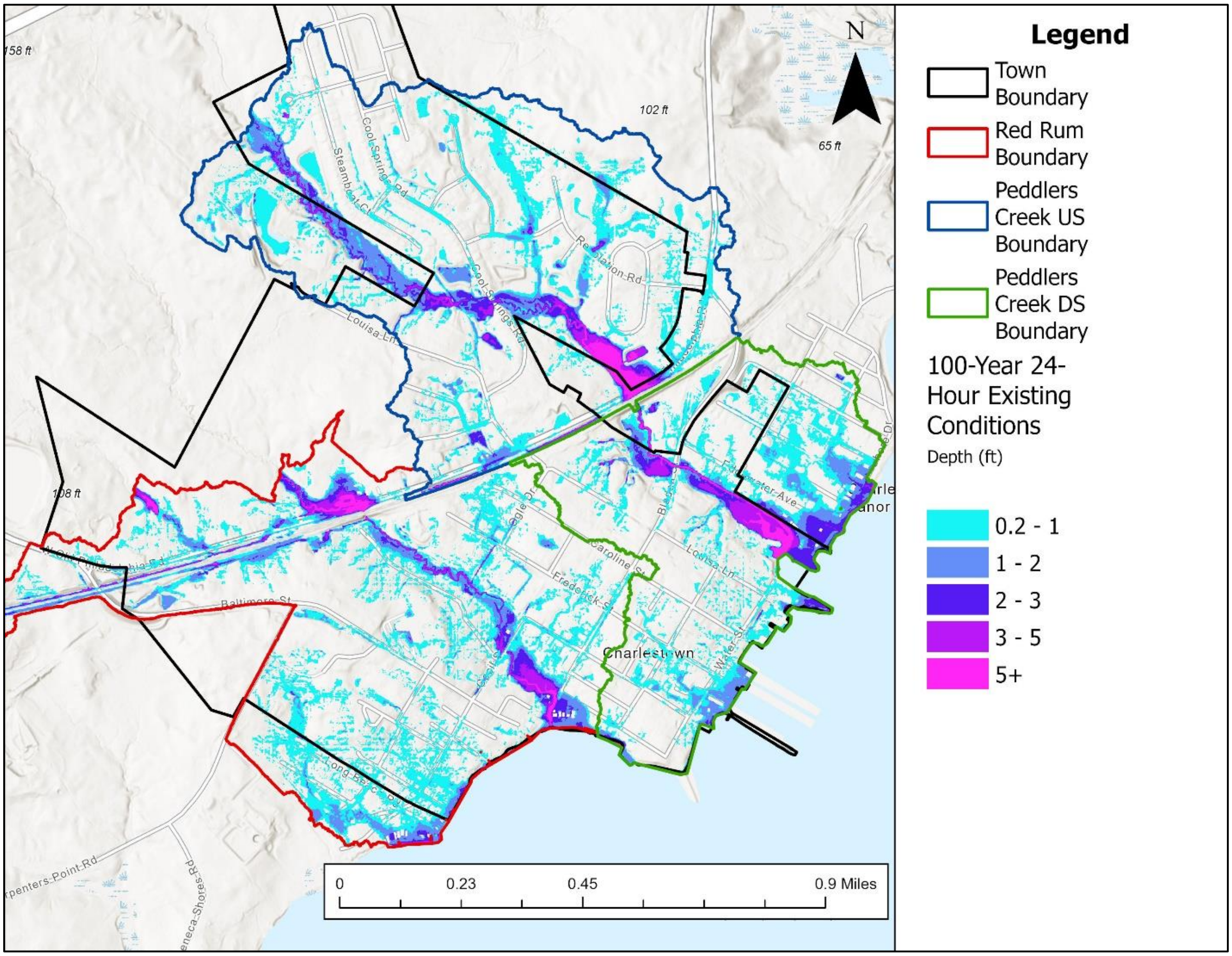


Figure 23: PCSWMM combined 100-year existing conditions composite flood map



IV. ALTERNATIVES AND PROJECTS

Alternative mitigations and strategies to reduce current flooding and avoid increased future flooding may be summarized in the eight 'R's shown below:

1) **Reduce** up-watershed incoming runoff.
2) **Redirect** runoff to another channel or into temporary storage.
3) **Retain** runoff and release after the peak flow period.
4) **Recharge** runoff into the ground via engineered recharge areas.
5) **Relocate** the at-risk vulnerable populations and property.
6) **Raise** structures above a flood-risk elevation.
7) **Regulate** activities and development in at-risk areas.
8) **Re-Educate** residents, visitors, and businesses regarding, flood risk and mitigations.

The final alternative is to 'do nothing' which is usually not an acceptable option unless there are circumstances that support waiting to take action such as the implementation of flood control projects by other agencies and/or in other areas. In Charlestown's situation, the Do Nothing alternative is not appropriate and a goal and objective of the WMP is to identify feasible implementable projects that result in reduced flood risk and damage both in the short and long run.

A range of project locations were identified, in collaboration with the Town staff using the mapped results from the Community Survey, locations of known flooding issues from the Community Workshops, and the above modeling results. Dewberry performed a GIS desktop review of each project location to document likely causes of flooding and mitigation strategies. The review assessed the feasibility of project implementation and whether the proposed project should be considered for concept development. The projects were also grouped by general location to assist with determining project dependencies.

A project was noted as having no concept potential if the mitigation strategy included only maintenance activities (e.g., inlet or pipe cleaning), the project was already slated to be addressed (e.g., the Town received grant funds to develop final designs for the Athletic Complex), the project would have a more localized impact (e.g., it would address flooding issues only on one private property), or the project is outside of the Town's jurisdiction (e.g., increasing the capacity of a culvert under a state-owned road).

The final list of potential projects is provided in Table 6 under five groupings:

A. Holloway Beach Community Storm Drain Improvements
B. Trinity Woods/FEMA Property
C. Fireman's Field/Wellwood Restaurant
D. Calvert Street/Conestoga Street
E. Charlestown ES pond

Table 6: Project List for Potential Concept Development

Holloway Beach Community Storm Drain Improvements		
RRC-005	Notes indicate blocked inlet at Chesapeake and Ogle. Evaluate inlet and storm drain capacity. Evaluate feasibility of constructing a facility in the vicinity of the inlet.	Storm drain installation and cleaning
RRC-016	Potential Beach Road ROW project; remove or block culverts under Ogle Street.	Storm drain installation
RRC-018	Overland runoff flows in direction of Ogle St flooding houses in area of Ogle St and Long Beach Rd	Regrade for positive drainage
RRC-004	Evaluate existing inlet and storm drain at SE corner of Ogle. May be able to incorporate storm drain cleaning here in conjunction with SD improvements at Chesapeake/Charlestown/Cecil.	Storm drain installation and cleaning
RRC-018	Chesapeake Road is not properly crowned; runoff is pooling on road instead of collecting in catch basins	Road resurfacing
RRC-009	Community survey noted flooding at 419 Charlestown Pl. Evaluate whether flow can be intercepted and directed to existing inlets.	Storm drain installation
RRC-011	Existing low sidewalk along Cecil St EB. Evaluate feasibility of installing curb inlets along the sidewalk to reduce flow running down Tasker Ln. Could it connect to inlet at 201 Cecil St?	Storm drain installation
RRC-007	There is an existing inlet located DS at 392 Chesapeake Rd. Evaluate whether additional inlets/SD can be placed along Cecil St to capture US flow and outfall into existing inlet.	Storm drain installation
RRC-017	Add additional inlets along Cecil between Beach Rd & Chesapeake: Evaluate storm drain capacity of pipe along Chesapeake between Cecil and the river; flooding likely due to surcharging during higher tide events combined with storm events; will need to determine project extent for the concept and include all other options as future recommendations.	Storm drain installation and cleaning; road resurfacing
Trinity Woods/FEMA Property		
PCU-002	Trinity Woods Detention Basin Retrofit 1. Combine with project at FEMA buyout property.	Pond retrofit
PCU-003	Trinity Woods Detention Basin Retrofit 2. Combine with project at FEMA buyout property.	Pond retrofit
PCU-004	Flood study previously performed; flooding is due to undersized culvert crossing state road & R/R. Evaluate feasibility of providing some storage on Town property. Potential to combine with two pond retrofits for additional storage.	Pond retrofit
Fireman’s Field/Wellwood Restaurant		
PCD-007	Evaluate feasibility of adding green stormwater infrastructure (bioswale, permeable pavers, etc.)	Green stormwater infrastructure
PCD-008	Replace & resize cross culvert on south side of Frederick St and crossing Calvert Street; regrade downstream swale where pipe discharges; add driveway culvert beneath Wellwood driveway entrance; evaluate feasibility of providing underground storage beneath Wellwood parking lot; plant trees in Fireman's field; add permeable paver walkway to promote use and provide outreach opportunities; and evaluate	Storm drain installation; green stormwater infrastructure

	opportunity to add storage in southeast corner of field at Frederick and Calvert intersection	
Calvert Street/Conestoga Street		
PCD-001	South side of Conestoga. Survey notes an existing inlet at corner of Conestoga & Calvert St that is not maintained. Evaluate condition of inlet and its outfall. Can another inlet be placed at low point in front of houses that noted flooding and connected to inlet?	Storm drain installation and cleaning
PCD-001B	North side of Conestoga. Survey notes an existing inlet at corner of Conestoga & Calvert St that isn't maintained. Evaluate condition of inlet and where it outfalls. Can another inlet be placed at low point in front of houses that noted flooding and connected to inlet?	Storm drain installation and cleaning
Charlestown ES pond		
RRC-010	Potential to retrofit existing school pond to capture more flow from Baltimore St and provide more storage? Evaluate all inflows and outfall of facility, and adjacent hydrography line.	Pond retrofit
RRC-003	Street view shows a type of landscaped pond. Investigate whether this was landscaped by the homeowners and for what purpose. Is there potential to retrofit for additional storage? Also check condition of culverts connecting each segment.	Pond retrofit

Five projects were identified that involve the Maryland State Highway Administration as the Town would not have authority to initiate projects without SHA permission. The five locations are listed in Table 7.

Table 7: Projects Involving the State Highway Administration.

RRC-015	Upsize culvert under MD 7	Storm drain improvements
RRC-002	Check condition and sizing of driveway culvert. Potential to add storage anywhere in this area? Also check condition of SHA culverts DS for any blockages/issues.	Storm drain improvements
PCD-002	Evaluate any opportunity for stream restoration or storage facility upstream of SHA culvert to reduce some impacts downstream.	Stream restoration/floodplain reconnection
PCD-009	Permeable sidewalk on Bladen St between Caroline St and Market St; potential location for new rain gardens?	Green stormwater infrastructure
RRC-001	Contours show high point here. Investigate reason for high point. Is there a potential to excavate to provide storage upstream of culvert? Also check condition of DS SHA culvert. Private property - may need permission to enter area.	Storm drain improvements

Six locations are in and around the Town's Athletic Complex for which a separate grant-funded project are listed in Table 8.

Table 8: Projects Involving the Athletic Complex

RRC-023	Potential location for new swale; located on Frederick St, between Bladen St and Cecil St	Storm drain installation/improvements
RRC-024	Potential location for new swale; located along Caroline St and Cecil St	Storm drain installation/improvements
RRC-025	Flooding at this location gets 12-15 feet wide; located between Market St and Frederick St; consider removing pipe & re-directing to Athletic Complex	Storm drain installation/improvements
RRC-022	General location of Bealle Alley; conservation grading?	Storm drain installation/improvements
RRC-012	Survey notes there is an existing inlet at corner of Cecil and Market	Storm drain cleaning
RRC-021	Athletic Complex & neighbors stream restoration & SWM BMPs design	Various

Additional locations were marked for minor storm drain improvements and related maintenance.

Project Prioritization

In order to prioritize the identified projects, Dewberry coordinated with Town staff to establish a 300-point weighted Project Prioritization Metrics (Table 9). Each prioritization metric/ranking component was assigned a weight and three-point numerical ratings were established. Table 9 provides a summary of the prioritization metrics, weights, and ratings. The projects were assigned a numerical rating for each prioritization metric. The value for each prioritization metric was calculated by multiplying the metric's weight by the assigned numerical rating for the project. The prioritization metric values were added together to obtain the Total Combined Score. Project locations receiving a higher score were considered to be better candidates than those receiving lower scores.

Table 9: Project Prioritization Matrix

RANKING COMPONENT	WEIGHT	CRITERIA 1-LOW 2-MODERATE 3-HIGH
Degree of Threat	15	Ranking Component Description: Evaluates the impact of flooding on the project location using the percentage of the area and depths from the PCSWMM model (as described below) Rating Descriptions: **Minor** = the proposed project area addresses flooding which causes minimal or no property damage, but possibly some public threat or inconvenience. Flood depths generally less than 6". **Moderate** = the proposed project area addresses flooding which causes some inundation of structures and roads near streams. The area may experience some evacuations of people and/or transfer of property to higher elevations. Flood depths generally between 6"-18". **Major** = the proposed project area addresses flooding which causes extensive inundation of structures and roads. The area may experience significant evacuations of people and/or transfer of property to higher elevations. Flood depths generally greater than 18".
Impact to Critical Infrastructure	12	Ranking Component Description: Evaluates whether the proposed project location is within 400 feet (upstream or downstream) of critical infrastructure. NOTE - this does not include roadways as that is evaluated under Town Access. Rating Descriptions:

		No = there is no critical infrastructure located within 400 feet of the proposed project location. **Yes** = there is critical infrastructure located within 400 feet of the proposed project location.
Town Access	20	Ranking Component Description: Evaluates whether the proposed project location addresses flooding which impedes town access based on how much of the road is flooding, depths from the PCSWMM model (as described below), and proximity to the road (<= 100 feet). Rating Descriptions: **Minor** = the proposed project addresses flooding which causes minimal impacts to town access. Flood depths addressed by the project are generally less than 6". **Moderate** = the proposed project addresses flooding which causes some inundation of primary access routes but roads are still passable by emergency vehicles. Flood depths addressed by the project are generally between 6" and 18". **Significant** = the proposed project addresses flooding which causes complete blockage of primary access routes. Roads are impassable. Flood depths addressed by the project are generally greater than 18".
Water Quality/Wildlife Habitat	10	Ranking Component Description: Evaluates whether there is potential to provide water quality and/or wildlife habitat within the project location. Rating Descriptions: Swales or pipes will have no habitat improvement unless setback distance from edge of pavement to building footprint is >30 feet.
Co-benefits	3	Ranking Component Description: Evaluates whether there is potential for co-benefits to be included as part of the project. Project co-benefits may include transportation considerations (e.g., traffic calming, pedestrian safety improvements), increasing tree canopy, improvements to neighborhood/property aesthetics, economic benefits (e.g., increases to property values, job creation). NOTE - water quality, wildlife habitat, and education/outreach co-benefits are incorporated into other ranking components and should not be considered here.
Design & Construction Requirements	9	Ranking Component Description: Evaluates whether the project will require contracted design and/or construction services. If swales or pipes were visible during field investigation then rating of 1 or 2, depending on potential project complexity (e.g., percent slope, wetlands present, etc.). 15% slope is considered steep.
Public Acceptance	5	Ranking Component Description: Based on feedback received on community surveys, during the Community Meetings, and during the Wade In. Rating Descriptions: **Low =** no surveys received or public comments provided adjacent to proposed project location **Moderate =** one survey received or public comment provided adjacent to proposed project location **High =** two or more surveys received or public comments provided adjacent to proposed project location
Public Visibility/Outreach Opportunity	4	Ranking Component Description: Evaluates how visible the project location is from public right-of-way, how many properties are adjacent to the proposed project location, and whether there are opportunities to incorporate education/outreach components. Rating Descriptions: **Low** = Proposed project location is not visible from public right-of-way, only one property adjacent to proposed project location, project will have minimal opportunities for education/outreach. **Moderate** = Proposed project location is somewhat visible from public right-of-way, proposed project location is adjacent to a couple of properties, there are some opportunities for education/outreach. **High** = Proposed project location is highly visible and/or in the public right-of

		way, several properties are adjacent to the proposed project location, there is significant opportunity for education/outreach.
Utility Conflicts	8	Ranking Component Description: Evaluates the potential for utility conflicts. Based on field visits, CecilMaps, street view (where available), etc.Rating Descriptions: **Extensive** = 2 or more utilities are located within the proposed project location; significant design and construction efforts may be required to move multiple utilities (i.e. sewer) **Minor** = Only 1 utility is located within the proposed project location and it will not require significant design and construction (i.e. cable) **None** = There are utility conflicts within the proposed project location.
ROW Requirements/Property Ownership	7	Ranking Component Description: Evaluates property ownership of the proposed project location. Ranking Descriptions: **Easement Required** = The proposed project location is on private property(ies) and the Town will be required to obtain an easement(s) from the current property owner(s) for project implementation **Temporary Construction Access Only** = The proposed project location is on Town-owned property but in order to access the site for construction, a temporary easement will need to be acquired
Local/State/Federal Permitting Requirements	7	Ranking Component Description: Evaluates the potential permitting required to implement projects within the proposed project location based on desktop analysis (e.g., forest, wetlands, floodplain, Critical Area impacts). Ranking Descriptions: **High** = extensive permitting requirements including full wetland/stream permitting, forest resource ordinance, NOI for construction requiring public comment, Critical Area permitting, etc. **Moderate** = significant permitting requirements including minor stream/wetland impacts, FRO, Critical Area, NOI for construction under the public comment threshold. **Low** = minor permitting requirements, likely just local permitting for grading and stormwater management review
	100	
TOTAL POSSIBLE WEIGHTED SCORE	**300**	

Project Concepts

Based on the weighted scoring, three (3) projects were selected for concept development:

- **The Holloway Beach Community Storm Drain Improvement Project:** The project encompasses two primary areas of concern identified through the Community Surveys, Community Workshops, and modeling effort: Chesapeake Road Storm Drain Improvements and Charlestown Place Drainage Improvements. A concept plan was developed for the Chesapeake Road Storm Drain Improvements which addresses flooding issues identified along Chesapeake Road, S. Ogle Street, and Cecil Street (Appendix 3A). If additional funding becomes available in the future, the drainage system along Charlestown Place, Cecil Street, and Beach Road should be evaluated further for retrofit opportunities.

- **The Trinity Woods/FEMA Property Project:** The project encompasses several opportunities in and around the Trinity Woods subdivision that were identified through the community surveys, community workshops, and modeling effort: Trinity Woods SWM #1/FEMA Property Project, Trinity Woods SWM #2 & #3 BMP Retrofits, Trinity Woods Upland Retrofits, and Peddlers Creek Stream Restoration/Floodplain Reconnection. A concept plan was developed for one approach for the Trinity Woods SWM #1/FEMA Property project with alternative restoration approaches discussed in the concept package (Appendix

3B). If additional funding becomes available, additional opportunities to provide water quantity and quality management should be evaluated further.

- **The Avalon Park Shoreline Stabilization Project:** The project includes the proposed removal of an existing, failing bulkhead and shoreline stabilization project which incorporates a walkable rock jetty, planted wetland areas, beach/kayak launch, planted upland areas, and permeable walkway (Appendix 3C). The project was identified and selected for concept development by the Town of Charlestown before the start of the Watershed Master Plan. As such, it was not included in the prioritization matrix (Table 10).

V. BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) refer to a set of guidelines and strategies that are considered effective and efficient in achieving optimal results in various fields, particularly in business, environmental conservation, and project management. These practices are designed to enhance performance, minimize risks, and promote sustainable and responsible approaches.

Best Management Practices (BMPs) for flood control are strategies and techniques designed to manage and mitigate the impacts of flooding. These practices aim to reduce the volume and velocity of stormwater runoff, control erosion, and minimize the risk of flooding in urban and rural areas. Here are some common flood control BMPs:

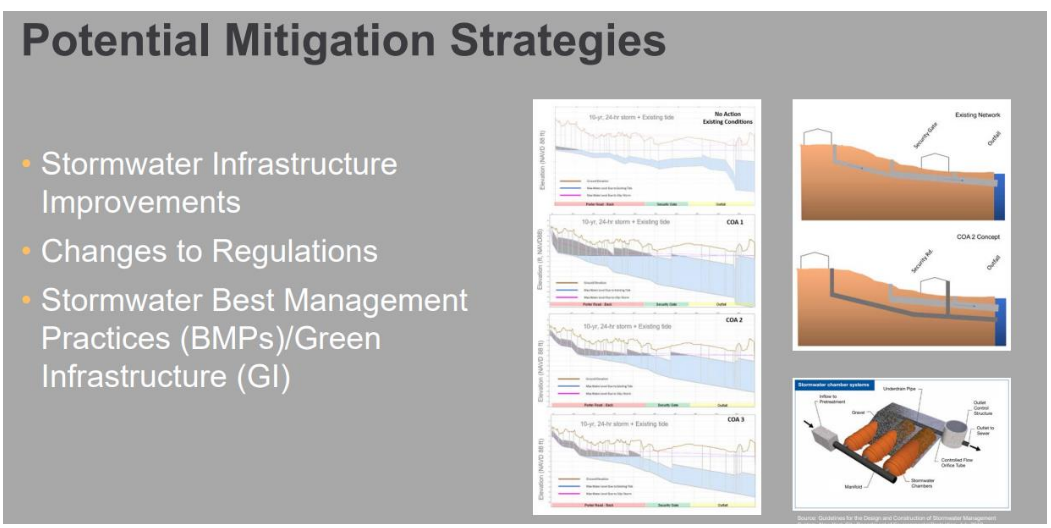
1. **Retention and Detention Basins:**
    - **Retention basins:** Designed to permanently hold a certain volume of water. They help in reducing peak flows during storms and allow for gradual infiltration.
    - **Detention basins:** Temporarily store stormwater and release it slowly, controlling the flow rate to prevent downstream flooding.
2. **Green Infrastructure:**
    - **Permeable Pavements:** Allow water to pass through, reducing runoff and promoting infiltration.
    - **Green Roofs:** Vegetated roofs absorb rainwater, reducing the volume of runoff.
    - **Rain Gardens:** Landscaped depressions that collect and absorb stormwater.
3. **Erosion Control:**
    - **Sediment Basins:** Capture sediment and prevent it from entering water bodies.
    - **Silt Fences:** Temporary barriers used to control sediment movement during construction activities.
    - **Riparian Buffer Zones:** Natural vegetation along water bodies that stabilize banks and prevent erosion.
4. **Channel Protection:**
    - **Gabion Baskets:** Wire baskets filled with rocks that protect against erosion along watercourses.
    - **Vegetative Cover:** Planting vegetation along riverbanks to stabilize soil and reduce erosion.

5. **Floodplain Management:**
    - **Floodplain Zoning:** Regulations that restrict development in flood-prone areas to minimize damage.
    - **Levees and Dams:** Artificial barriers that help confine and control floodwaters.
6. **Stormwater Management Practices:**
    - **Stormwater Ponds:** Artificial ponds designed to capture and treat stormwater runoff.
    - **Infiltration Trenches:** Underground trenches that allow stormwater to infiltrate into the soil.
    - **Swales:** Open channels designed to convey and manage stormwater.
7. **Land Use Planning and Regulations:**
    - **Setback Requirements:** Regulations specifying minimum distances between development and water bodies.
    - **Cluster Development:** Concentrating development in specific areas to preserve open space and reduce impervious surfaces.
8. **Public Education and Outreach:**
    - **Public Awareness Campaigns:** Informing the public about the importance of responsible stormwater management and flood control practices.

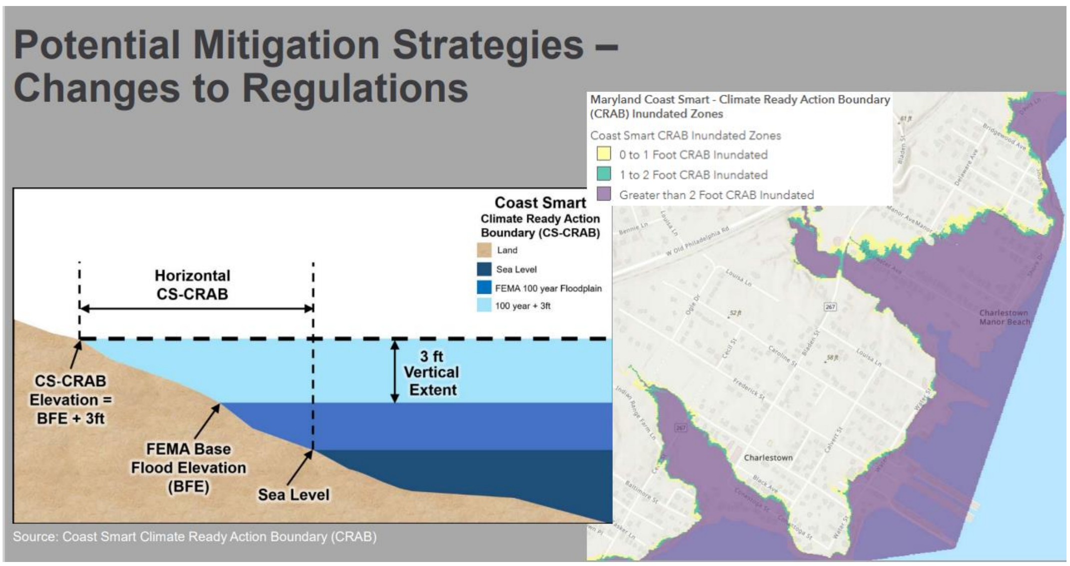
It's important to note that the effectiveness of BMPs often depends on site-specific conditions, and a combination of these practices are often employed to create a comprehensive flood control strategy. Additionally, ongoing maintenance and monitoring are crucial to ensure the continued effectiveness of these measures.

Below are examples of flood control BMP's that could be incorporated into projects identified in this WMP and future updates:

Figure 24: Examples of Mitigation Strategies




Potential Mitigation Strategies –
Stormwater Infrastructure
Improvements


Potential Mitigation Strategies –
Changes to Regulations
Coast Smart
Climate Ready Action
Boundary (CS-CRAB)
Land
Sea Level
FEMA 100 year Floodplain
100 year + 3ft
Horizontal
CS-CRAB
3 ft
Vertical
Extent
CS-CRAB
Elevation =
BFE + 3ft
FEMA Base
Flood Elevation
(BFE)
Sea Level
Source: Coast Smart Climate Ready Action Boundary (CRAB)
Maryland Coast Smart - Climate Ready Action Boundary
(CRAB) Inundated Zones
Coast Smart CRAB Inundated Zones
0 to 1 Foot CRAB Inundated
1 to 2 Foot CRAB Inundated
Greater than 2 Foot CRAB Inundated
Charlestown
Charlestown
Manor Beach


Potential Mitigation Strategies –
Stormwater BMPs/GI Practices
Filterra Planter Box
Microbioretention

Potential Mitigation Strategies – Stormwater BMPs/GI Practices


Rain Barrels/Cisterns


Grass Swale

Potential Mitigation Strategies – Stormwater BMPs/GI Practices

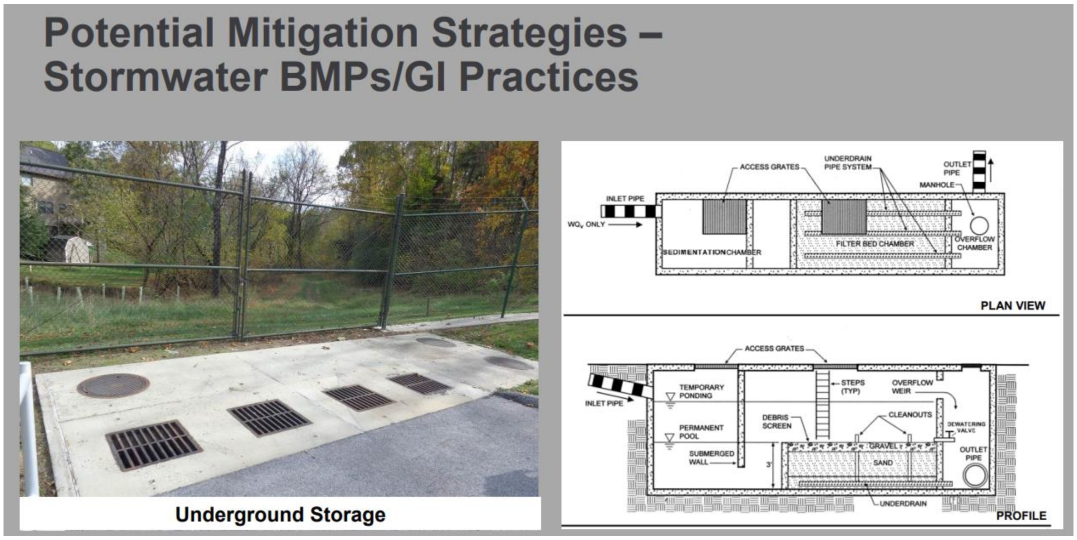

Rain Garden


Wet Pond

Potential Mitigation Strategies – Stormwater BMPs/GI Practices


Filtering Device


Submerged Gravel Wetland



VI. Implementation Strategies

Various action items to help protect, restore, and manage Charlestown's watershed are listed below, and are organized under five different themes. Town staff worked with the steering committee, public and community partners to identify and consider which agencies could support which action items, and whether that support would be through discussions, funding, or both. A list of acronyms for partners and funding sources is provided in Appendix 1.

Regulations

The Town is considering the adoption of new regulations to protect the Green Infrastructure Network in its watershed, as a tool to improve the management of both it's stormwater and drinking water systems. Development regulations for future floodplains can also help to improve these systems and minimize the risks of future flooding damage.

Action Items	Lead Agency	Partners and Support	Funding Options	Timeline
Protect the Green Infrastructure Network by creating a zoning overlay district that limits forest clearing, impacts to hydrology, lot coverage, and provides higher mitigation ratios.	Town Staff	DNR CAC, DNR FS, DNR WHS, ACB, PZC, County DLUDS	staff time	0-1 year

Develop regulations for FEMA's 500-year floodplain, MDE's Climate Ready Action Boundaries, or WMP flooding scenarios and determine the base flood elevations.	Town Staff	FEMA, MDE, DNR, MDP, PZC	PDM, HMGP, BRIC	1-3 years
Update the Town's stormwater ordinance to require mitigation standards for development activities under 5,000 square feet and provide more quantity control in priority areas.	Town Staff, Town Engineer	MDE, DNR, PZC	ARPA, DNR CR, Town CIP	0-1 year
Develop regulations for the Town's wellhead protection zones.	Town Staff	MDE, Town Engineer	MDE	1-3 years
Develop a stormwater utility fee to help pay for the ongoing improvement and maintenance of the Town's stormwater management and drainage system.	Town Staff, Town Engineer	MDE, UMSE	Town CIP	0-1 year
Update the Comprehensive Plan to integrate the WMP into the elements for Municipal Growth, Sensitive Areas, Water Resources, Land Use, and Transportation	Town Staff, Project Consultant	MDP, MDE, DNR CCS, Town Engineer	DNR CR, Town CIP	0-1 year

Planning and Program Development

The Town wants to explore the creation of local funding sources to offer new programs that preserve and restore priority areas within the watershed. Collaboration with community partners, including identification of outside funding sources, will be critical to increasing strategic protection programs and initiatives. Staff time will also be necessary for long term planning, coordination, and implementation.

Action Items	Lead Agency	Partners	Funds	Timeline
Collaborate on watershed management strategies across political boundaries and with community partners to help increase grant funding opportunities.	Town Staff	County DLUDS/DPW, UMSE, CLT	Town CIP, CBT WAGP, DNR CR	0-1 year
Develop a local cost share program or other mechanism to fund the preservation of the GI network.	Town Staff	DNR FS, SCD, ACB, UMSE, CLT	Town CIP	1-3 years
Identify roads with frequent flooding and develop appropriate mitigation strategies, including road elevation.	Town Staff, Town Engineer	MDOT, SHA, County DPW	HMA, PDM	0-1 year
Create a five-year Capital Improvement Plan for improving aging infrastructure.	Town Staff	PZC, MDP, MDHCD	Town CIP	1-3 years
Prepare a Source Water Protection Plan and incorporate a water conservation education program.	Town Staff	MDE, FEMA	BRIC	2-3 years
Develop criteria and update mapping of critical facilities, roads, water and sewer infrastructure.	Town Staff	MDE, ESRGC	Town CIP	1-3 years
Create incentives for private property owners to install BMP's.	Town Staff, Town Engineer	MDE, UMSE	Town CIP	0-1 year

Restoration

The WMP steering committee wants to re-create natural areas, relocate and protect structures and critical facilities where appropriate, and implement natural solutions to reduce vulnerability to flooding and associated soil and nutrient pollution using stormwater management best practices like rain gardens, rain barrels, conservation landscaping, and living shorelines. The design of future projects should also take into account the projected increased rainfall intensity, duration, and frequency.

Action Items	Lead Agency	Partners	Funds	Timeline
Use the University of Maryland Extension Smart Tool to track various stormwater management practices throughout Town.	Town Staff	County DPW, WSA, UMSE	CBT WAGP	1-3 years
Identify opportunities to reuse dredge material for living shoreline projects and determine candidate sites.	Town Staff	DNR CAC, USACOE, MDE, UMSE	CBT WAGP, DNR CR	1-3 years
Identify and acquire vacant lots in flood risk areas that can reduce flood impacts, and can be included within public open space systems.	Town Staff	DPR, DES, FEMA, ECG, LSHG, CLT	PDM, HMGP, FMA	0-1 years
Design ways for existing open space areas to better address flood hazards, such as holding water and collecting sediment and debris, and in the process, create local demonstration projects.	Town Staff	FEMA, MDE	CBT G3, CBT WAGP, BRIC, HGMP, FMA, DNR CR, NFWF	1-3 years
Identify areas of flood concern in close proximity to capital improvements and prioritize mitigation solutions for high-risk assets, incorporating nature-based solutions to the maximum extent practicable.	Town Staff	FEMA, CLT	Town CIP, CBT G3, PDM, HMGP, FMA, DNR CR	1-3 years

Improve management of habitat protection areas within utility corridors and on Town owned land.	Town Staff	DNR WHS, Exelon, Delmarva,	Town CIP, CBT WAGP, DNR CR	1-3 years
Establish forest conservation and restoration as a primary tool for stormwater management and maintain forest cover in current and future floodplains.	Town Staff	Town Engineer, MDE, DNR FS, UMSE, ACB	Staff time	0-1 year
Upgrade stormwater facilities in priority areas, including new tree planting projects.	Town Staff, Town Engineer	MDE, DNR FS, ACB	Town CIP, BRIC	0-1 year

Maintenance

The Town wants to improve the management of its drainage and stormwater control systems, to more effectively convey water from flood-prone areas. A better understanding of problem areas and improved documentation and tracking of maintenance activities will help.

Action Items	Lead Agency	Partners	Funds	Timeline
Conduct regular maintenance of drainage and stormwater control systems.	Town Staff	County DPW	Town CIP	0-1 year
Document nuisance flood locations capturing depth, extent, and duration and maintain records for dissemination.	Town Staff	County DPW/DES	Town CIP, CBT WAGP	0-1 year
Create a flood hazard profile and mitigation action strategy for each critical facility and town roadway vulnerable to nuisance flooding.	Town Staff	County DPW/DES	Town CIP, BRIC	1-3 years

Update the flooding models as BMP's are implemented.	Town Engineer	Town Staff	Town CIP	1-3 years

Educational Outreach

The WMP steering committee wants to communicate the cost savings of using natural solutions for flood mitigation and continue to publicize efforts and solicit feedback on WMP planning program modifications and improvements.

Action Items	Lead Agency	Partners	Funds	Timeline
Identify structures with flood risk and target outreach related to purchasing flood insurance and mitigating risk with design considerations for sill elevations, foundations, and utilities.	Town Staff	County DES/DLUDS, FEMA, MDE	Town CIP, DNR CR, PDM	1-3 years
Implement green infrastructure projects to create demonstration projects at our parks.	Town Staff	Cecil County Tourism Office, Colonial Charlestown, Town Engineer, Maintenance Staff, Charlestown Elementary School	Town CIP, DNR CR, PDM	0-1 year
Motivate private property owners to implement stormwater management practices and runoff retention, including rain barrels, rain gardens, and conservation landscaping with native plants.	Town Staff	County DPW, SCD, ENERWA, UMSE	Town CIP, DNR CR	0-1 year

VII. PLAN MAINTENANCE AND CONCLUSION

Plan Maintenance

Implementation and maintenance of the WMP is critical to the success of this planning process. Once adopted, plan maintenance will adhere to a schedule of developing an annual progress report on the action items identified in the section on Implementation Strategies. Members of the WMP steering committee will be invited to an annual meeting conducted by Town Staff to discuss collaborative efforts with community partners, monitor funding sources, and recommend any adjustments to lead and support agencies, funding sources, and timeframes for completion. Understanding local capacity will be a key part of the discussions and will revolve around new approaches getting projects into the ground, engaging different groups and new technical experts, and developing incentive programs.

The Town is responsible for preparing the annual progress report and will submit the document to the appropriate agencies for review and comment. The Town is also responsible for coordinating with other Agencies to integrate the appropriate implementation strategies into future updates of the Comprehensive Plan, Hazard Mitigation Plan, Stormwater Management Plan, Land Preservation, Parks, and Recreation Plan, and Strategic Plan. Finally, the plan must be updated every ten years and include any changes within the watershed, mapping assessments, flood modelling, and implementation strategies. This plan is anticipated for adoption in 2024, so the next plan update should occur in 2034.

Conclusion

This plan was developed over a 15-month time frame and began with data collection, identifying community issues, and conducting the flooding assessments. The steering committee met throughout the planning process to provide input and refinements along the way. Two community workshops were held to acquire additional feedback from the public and to develop priorities for the action items. The action items include updating regulations and existing programs to support the planning and implementation of the WMP, as well as, identifying partners to collaborate with on future land preservation, restoration, and educational activities. The implementation of the action items contained herein will go a long way towards ensuring the wise use of our resource lands when making future land use decisions.

APPENDIX 1

ACRONYMS USED THROUGHOUT THE PLAN

BMP	Best Management Practices
CRS	Community Rating System
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rating Map
GIS	Geographic Information Systems
H&H	Hydrologic and Hydraulic Study
HEC-RAS	Hydrologic Engineering Center River Analysis System
ICLUS	Integrated Climate and Land-Use Scenarios
IPCC	Intergovernmental Panel on Climate Change
MDE	Maryland Department of the Environment
MHHW	Mean High High Water
MHT	Maryland Historic Trust
MS4	Municipal Separate Storm Sewer System Permits
NFIP	National Flood Insurance Program
NHPA	National Historic Preservation Act
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
PCSWMM	Personnel Computer Storm Water Management Model
SWM	Stormwater Management
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers

IMPLEMENTATION STRATEGIES – GOVERNMENT AGENCIES AND COMMUNITY PARTNERS

ACB	Alliance for the Chesapeake Bay
AWI	Artesian Water Inc.
BGE	Baltimore Gas & Electric Company
CFDCB	Cecil County Forest District Conservancy Board
CLT	Cecil Land Trust
Delmarva	Delmarva Power
DES	Cecil County Department of Emergency Services
DNR CAC	Maryland Department of Natural Resources Critical Area Commission
DNR CCS	Maryland Department of Natural Resources Chesapeake & Coastal Service
DNR F	Maryland Department of Natural Resources Fisheries
DNR FS	Maryland Department of Natural Resources Forest Service
DNR WHS	Maryland Department of Natural Resources Wildlife & Heritage Service
DPR	Cecil County Department of Parks and Recreation
DPW	Cecil County Department of Public Works
ECG	East Coast Greenway

ESCAP	Eastern Shore Climate Adaptation Partnership
FEMA	Federal Emergency Management Agency
LSHG	Lower Susquehanna Heritage Greenway
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
SCD	Cecil County Soil Conservation District
SHA	Maryland State Highway Administration
UMSE	University of Maryland Extension Sea Grant
USACOE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WSA	Cecil County Watershed Stewards Academy

IMPLEMENTATION STRATEGIES – FUNDING SOURCES

CBT G3	Chesapeake Bay Trust Green Streets, Green Jobs, Green Towns Grant Program
CBT WAGP	Chesapeake Bay Trust Watershed Assistance Grant Program
Town CIP	Town Capital Improvement Program
DNR CR	Maryland Department of Natural Resources Community Resilience Grant Program
FMA	FEMA Flood Mitigation Assistance Grant Program
HMGP	FEMA Hazard Mitigation Assistance Grant Program
NFWF	National Fish and Wildlife Foundation Chesapeake Bay Stewardship Fund
PDM	FEMA Pre-Disaster Mitigation Grant Program
Staff Time	Personnel Hours required to develop program
VLT	Cecil County Video Lottery Terminal Grant Program

APPENDIX 2

DATA INVENTORY

No.	Data Set	Date/ Date Accessed	Source
Publicly Available Data			
1	Current Rainfall Data	2023	NOAA Atlas 14
2	Projected Rainfall Data	2023	MARISA
3	NOAA's Online Vertical Datum Transformation Tool	2023	Online Vertical Datum Transformation tool
4	NOAA's Relative Sea Level Trend	2023	Relative Sea Level Trend
5	Existing Land Use	2019	MRLC
6	Projected Land Use	2016	EPA ICLUS Version 2
7	Maryland CoastSmart Climate Ready Action Boundary (CS-CRAB)	2021	Maryland CoastSmart
8	USGS StreamStats	2023	StreamStats
9	USGS Gages	2023	USGS gage 01496080
10	Charlestown Stormwater Infrastructure	2019	Provided by Town of Charlestown; developed by KCI
11	HEC-HMS Technical Reference Manual		HEC-HMS Technical Reference Manual (army.mil)
12	HEC-RAS Hydraulic Reference Manual		HEC-RAS Hydraulic Reference Manual (army.mil)
Cecil County Data			
13	Digital Elevation Model (DEM)	2021	Cecil County Website
14	Cecil County Storm Drain System (Incomplete)	2022	Cecil County Website
15	FEMA 100-year Floodplain	2021	Cecil County Website
16	Buildings	2023	Cecil County Website
17	Hydrography (lines)	2021	Cecil County Website
18	Hydrography (polygons)	2021	Cecil County Website
19	Road Centerlines	2023	Cecil County Website
20	Soils	2010	Cecil County Website
Additional Data			
21	Guidance for Using Maryland's 2018 Sea Level Rise Projections	2022	MD_SLRGuidance
22	FEMA Region III Storm Surge Study, Coastal Storm Surge Analysis: Storm Surge Results, Intermediate Data Submittal No. 3	2013	Coastal Storm Surge Analysis
23	Town of Charlestown Stormwater Vulnerability & Floodplain Management Assessment	2019	Provided by Town of Charlestown
24	2020 Cecil County Nuisance Flooding Plan	2020	Provided by Town of Charlestown
25	Preparing for Increases in Extreme Precipitation Events in Local Planning and Policy on Maryland's Eastern Shore	2020	Extreme Precipitation Report
26	Mainstreaming Sea Level Rise Preparedness in Local Planning and Policy on Maryland's Eastern Shore	2019	Sea Level Rise Study
27	Cecil County Green Infrastructure Plan	2019	Green Infrastructure Plan
Data Generated During Charlestown WMP Project			
28	Community Survey Results	2023	Charlestown WMP

No.	*Data Set*	*Date/ Date Accessed*	*Source*
29	Flooding Areas of Interest	2023	Community Workshops #1 & #2
30	Potential Project Locations	2023	Charlestown WMP
31	HEC-RAS Floodplains - 10-, 25-, & 100-yr, 24-hr Existing - 10- & 100-yr, 24-hr 2050 w/ NLCD - 10- & 100-yr, 24-hr 2050 w/ ICLUS - 10- & 100-yr, 24-hr 2080 w/ NLCD - 10- & 100-yr, 24-hr 2080 w/ ICLUS - 100-yr, 24-hr 2100 w/ ICLUS		HEC-RAS model
32	PCSWMM Floodplains - 10-, 25-, & 100-yr, 24-hr Existing - 10- & 100-yr, 24-hr 2050 w/ NLCD - 10- & 100-yr, 24-hr 2050 w/ ICLUS - 10- & 100-yr, 24-hr 2080 w/ NLCD - 10- & 100-yr, 24-hr 2080 w/ ICLUS - 100-yr, 24-hr 2100 w/ ICLUS		PCSWMM models

APPENDIX 3

TECHNICAL MEMO

UNDER SEPARATE COVER