Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Table of Contents

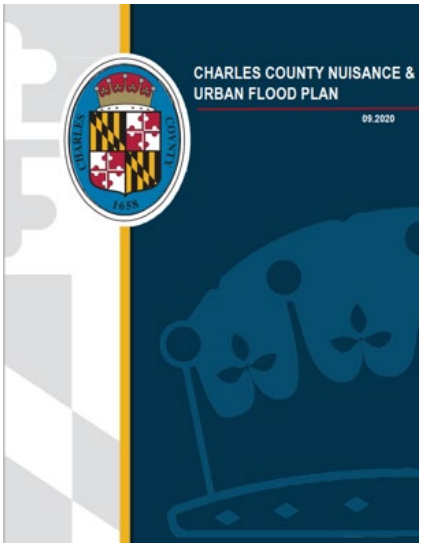
Mill Swamp & Pomonkey Creek Flood Analysis

Attachments

Section 1 - Purpose of Study and Context

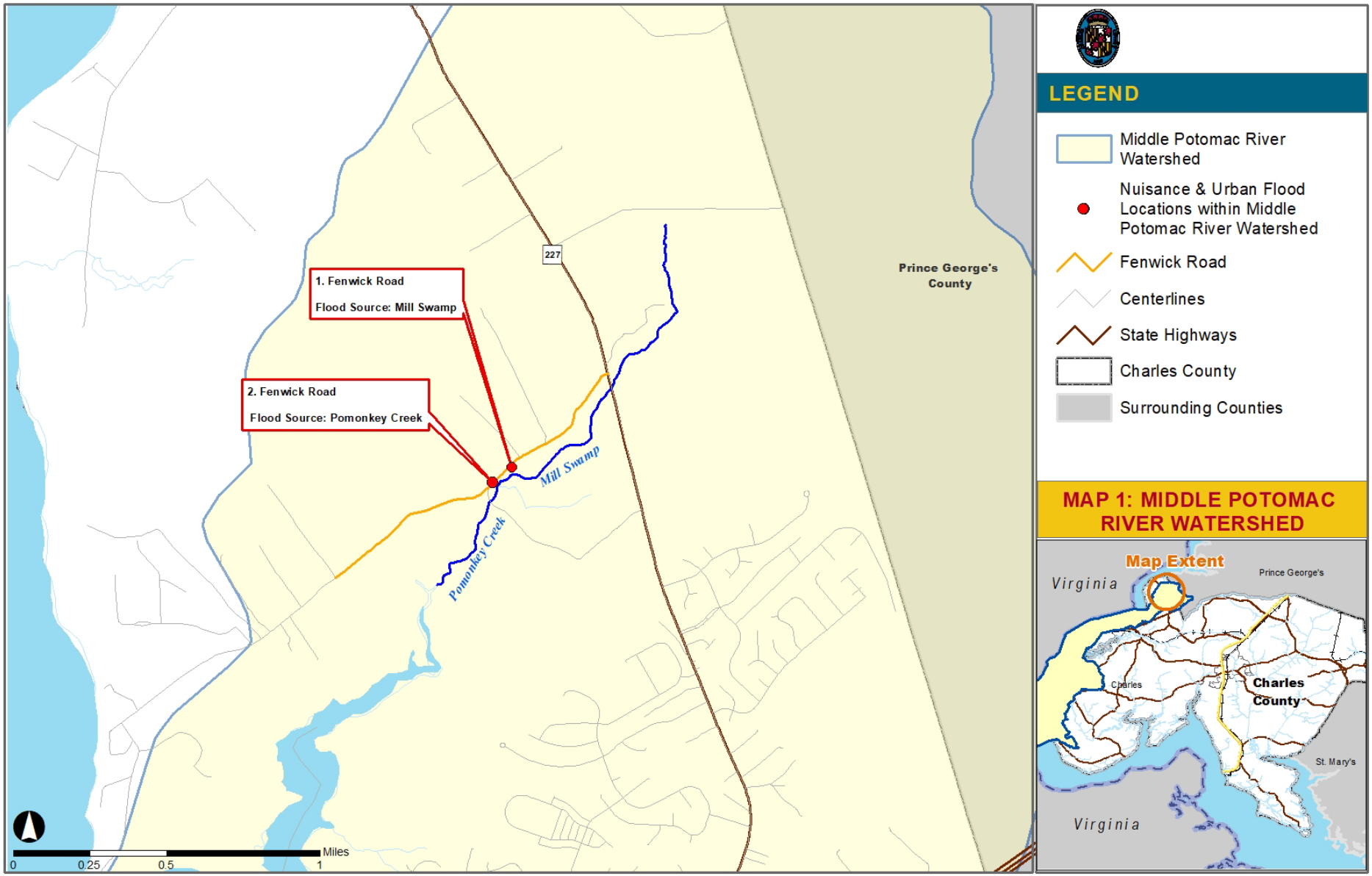
Charles County, Maryland is experiencing flooding with increasing frequency, including both nuisance and urban flooding. Nuisance flooding is associated with high tides that flow back through the stormwater system, increasing/raising the level of groundwater, and overtopping the banks and edge of waterways. Nuisance flooding is an indicator of rising water levels in the Chesapeake Bay and its tributaries. Areas that were previously dry now flood during high tides because the water elevation is high enough to lap over the banks of waterways and to enter stormwater systems through outfalls that were previously high enough to prevent backflow, while allowing outflow. Urban flooding is due to a variety of issues related to development: increased impervious surface, disruption of natural watershed flows and functions, undersized and aged stormwater infrastructure, and changing weather patterns which exacerbate the inadequacies of older stormwater systems and the fragmented watersheds. Urban flooding reflects decades of development that has outstripped the capacity of stormwater infrastructure and disrupted the natural flow and discharge of watersheds. Additionally, many stormwater systems are beyond their expected useful life and in need of repair and replacement. These challenges are compounded by what is becoming the new normal: an increase in the frequency and intensity of storms caused by higher global temperatures that increase evaporation in the ocean and atmosphere, creating more favorable conditions for heavier and more frequent precipitation.

Charles County Nuisance & Urban Flood Plan



Fifty Seven nuisance and urban flood locations were identified and prioritized for additional analysis and flood risk reduction solutions in the **2020 CHARLES COUNTY NUISANCE & URBAN FLOOD PLAN.** The purpose of this plan was to identify sources of nuisance and urban flooding, analyze flood hazards, and recommend actions to reduce flooding and increase community resiliency. The plan fulfills the requirements set forth in Maryland House Bill 1427 (2019), §3-1018(b) and (c), which requires that all local jurisdictions that experience nuisance flooding must develop a nuisance flood plan to address that flooding and update the plan every five years. To maintain the mandated update cycle, the plan was appended to become part of the County's 2023 Hazard Mitigation Plan Update, which must also be updated every five years.

As part of the nuisance flood plan implementation strategy the county has initiated independent watershed studies to address issues identified in the nuisance flood plan that will serve to build upon and expand this analysis to track localized flood events and mitigate localized flooding. Two locations along Fenwick Road are within the **Middle Potomac River Watershed** have been targeted for further analysis and will be addressed in this study. These locations are identified on the location map on the following page.


1. Fenwick Road
Flood Source: Mill Swamp
2. Fenwick Road
Flood Source: Pomonkey Creek
227
Prince George's County
Mill Swamp
Pomonkey Creek
0
0.25
0.5
1
Miles
LEGEND
Middle Potomac River Watershed
Nuisance & Urban Flood Locations within Middle Potomac River Watershed
Fenwick Road
Centerlines
State Highways
Charles County
Surrounding Counties
MAP 1: MIDDLE POTOMAC RIVER WATERSHED
Map Extent
Virginia
Prince George's
Charles
Charles County
St. Mary's
Virginia

The frequency and intensity of storms is increasing due to the changing climate that will continue to exacerbate flooding at these two locations. The stormwater infrastructure in these areas was not designed to convey the amount of runoff and tidal surge that is currently occurring and amounts that are predicted to occur in the future. As urbanization and the amount of impervious surface increase the capacity of the existing systems to accommodate both runoff and tidal fluctuations will be reduced. Impaired water quality in these locations is related to increased development pressures and previous stormwater practices that were not designed for future conditions. Without best management practices or green infrastructure in place to reduce the depth of floodwater and improve water quality, these areas will continue to experience flooding and degraded water quality and habitat in the affected tributaries.

Flood Study Objectives and Expected Outcomes

This flood analysis will be an important tool for future planning capital improvement projects. Principles, policies, and recommendations from County plans are integrated into the study to ensure that a mutually supportive resilience framework exists throughout all County planning efforts. The study concentrates on addressing 4 key objectives:

1. Analyze the cause(s) of flooding.
2. Identify solutions that eliminate flooding, improve water quality, and account for future precipitation volumes.
3. Develop conceptual designs to guide implementation of solutions at all three locations.

The stormwater improvements that are identified in this study will support the goals and policies articulated in the 2023 Charles County Hazard Mitigation Plan Update, the 2023 Charles County Nuisance and Urban Flood Plan, and the Charles County Comprehensive Plan (2016), Charles County Stormwater Management Ordinance and Drainage Ordinance, plus any relevant watershed improvement plans and studies as appropriate for addressing water quantity and quality within the study area.

The solutions identified in this study account for future conditions such as increased volumes of stormwater from more frequent, intense storms, future development in the project areas, and anticipated sea level rise in 2050 as well as in 2080. The solutions will also integrate a comprehensive approach that will support the implementation of nature-based infrastructure.

Changes in climate are making weather less predictable and generating bigger, stronger storms. Severe storms coupled with increased development in watersheds and an increase in impervious surfaces creates a volume of runoff that is greater than the design capacity of the existing infrastructure throughout the county.

Tools and Resources

This study utilized information gathered from the Charles County Nuisance & Urban Flood Plan, particularly data gathered about the flood characteristics during a field visit, engaging with County staff who served on the Plan's Stakeholder Group. As part of the ongoing planning process an update to the Nuisance Flood Plan Story Map was completed to include the results of this flood study. Information from Risk Map products, discharge points, and bridges and culverts layers and data contained within MDE's Flood Risk Application and County data resources were used to generate existing and future condition models for this project.

Partner Roles

The flood study was led by steering committee that is made up of staff from the Department of Emergency Services and Department of Planning and Growth Management. The steering committee will provide overall guidance for the project so that the identified solutions are ones supported by the County, and property owners. The steering committee consisted of the following members:

Mill Swamp Pomonkey Creek over Fenwick Road Flood Study Steering Committee

Name	Title	Department/Contractor
Michelle L. Lilly	Director, Charles County	Emergency Services
Gary Lewis	Emergency Management Specialist	Emergency Services
Kerry Kirkwood	Engineer I	Planning and Growth Management
Beth Groth	Climate Resilience and Sustainability Officer	Planning and Growth Management
Kelly Palmer	Floodplain Manager	Planning and Growth Management
Karen Wiggen	Planner III	Planning and Growth Management
Lynn Knaggs	Environmental Section Planning Supervisor	Planning and Growth Management
Stacy Schaefer	Executive Director	Resiliency Authority of Charles County
Andy Balchin	Chief	
Tiffany Saunders	Highway Engineer	Planning and Growth Management
Randy Crowder	Grading, Drainage & Stormwater Engineer	Planning and Growth Management
Brian Kagarise	Acting Chief	Department of Public Works
Alicia Afroilan	Engineering Program Manager	Planning and Growth Management
Jeremy Koser	Environmental Engineer	Johnson Mirmiran & Thompson
Kayla Rhue	Associate Engineer	MES
John Groeger	Senior Engineer	MES
Mark James	Project Manager	Michael Baker
Calt, Elizabeth	Civil Associate – Water	Michael Baker
Virginia Smith	Outreach	Smith Planning and Design

Section 2 - Planning Process

Steering Committee Meetings

A project management team meeting was coordinated by MES on May 11, 2023, to initiate project start up. During that call the team discussed members, timeline, data resources, and the need to establish a partnership with the Maryland State Highway Administration (SHA) to coordinate work in an adjacent wetland mitigation project.

The first steering committee meeting was held virtually on June 5, 2023. This meeting was scheduled to introduce key members of the contracting team, discuss project schedule, and contractor expectations. A request data was also made at this time and filled by County GIS resources. Agenda items included:

- Introductions
- Project Review and Suggestions
- Data Requests
- Schedule and Project Involvement (Stakeholders)
- Tracking Project to Match Grant
- Next Steps – Field Meeting

Data Use Agreements were signed for use of Planning and Growth Management's GIS data. Requested data was transferred and saved to a project teams location.

A second steering committee meeting was held in the field on August 4, 2023. Staff from Department of Emergency Services and Department of Planning and Growth Management along with consultants conducted a tour of the 2 locations along Fenwick Road where site information was gathered on existing conditions. The two locations where Pomonkey Creek and Mill Swamp flood Fenwick Road are depicted in Figure 1.

Figure 1. Left - Fenwick Road over Pomonkey Creek, looking west / Right - Fenwick Road at Mill Swamp floodplain, looking east.

Potential recommendations that were discussed during the field visit included:

- Investigate increasing capacity of existing culverts
- Elevate road to determined flood height
- Add rip rap and grade off roadway in areas of greatest impact
- Coordinate design options with adjacent proposed wetland improvements

Observed: culverts at low point and edge of property appears blocked and undersized large drainage alongside and behind private property believed to drain to low point. No significant erosion apparent.

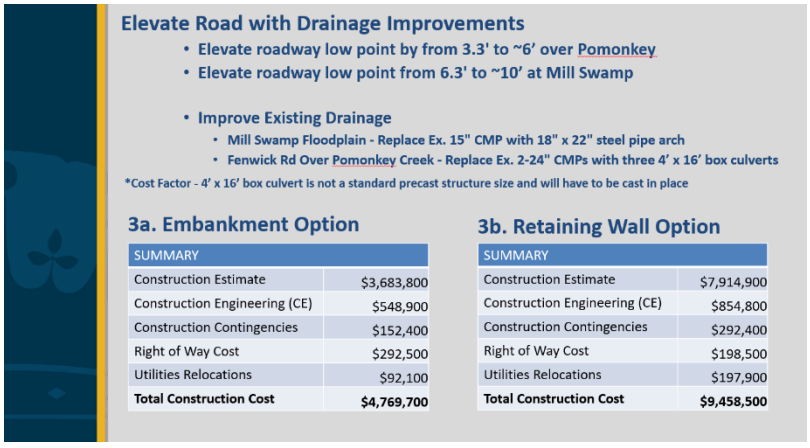
Capacity of system and vicinity to source is likely large part of this issue. Tidal level is just below road elevation.

During the April 5 steering committee meeting a project update provided details on the schedule and background to the study, project site review and considerations that were gathered during the field visit were presented. The steering committee were presented site specific data and relevant data resources that were used for model development. A hydrologic and hydraulic analysis was performed to determine the discharge/flows affecting the area and modeled to calculate the existing and future flood conditions. Modeling results for 10-year, 20-year, 50-year and 100-year storm events for current, 2050, and 2080 expected conditions were presented. Modeling data was compared to in field observations to identify areas of high risk for each site.

Members were presented 4 stormwater improvement alternatives to review and approve. Alternatives were developed using 100-year storm events for current conditions only. Alternatives selected for further analysis are shown in **bold**.

Alternative 1: No Build
Alternative 2: Improve Existing Drainage
Replace Ex. 15" CMP with a 18" x 22" steel pipe arch
Replace Ex. 2-24" CMPs with 6- 21" x 34" steel pipe arches
Alternative 3: Improve Existing Drainage
Replace Ex. 15" CMP with a 18" x 22" steel pipe arch
Replace Ex. 2-24" CMPs with 6- 8' x 2.5' box culverts
Alternative 4: Improve Existing Drainage and Raise Roadway Elevation
Replace Ex. 15" CMP with 18" x 22" steel pipe arch;
Raise roadway low point by from 3.3' to 6.1'
Replace Ex. 2-24" CMPs with 3-4' x 16' box culverts;
Raise roadway low point by 6.3' to 9.8'

Comments from the April 5 meeting were compiled and taken into consideration in the final design and presentation of the Mill Swamp Fenwick Road over Pomonkey Creek Flood Analysis.



The report findings and preferred proposed alternatives were presented to the steering committee during the July 22 meeting. The meeting included a project summary providing background to the study and items covered during the previous meeting, a review of the project schedule and publication on the County's Nuisance Flood Plan StoryMap. A review of the selected model was provided before details on the 3 design alternatives were provided. Costs and details of the drainage improvements plus road elevation with embankment and retaining wall were provided. Features of the bridge were presented but no costs were disclosed due to the significant environmental permitting and cost impacts.

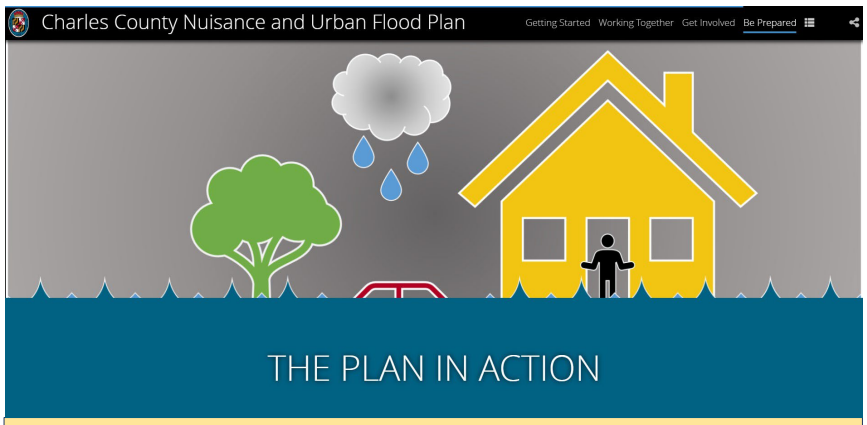
Reasons for the recommended design were presented and time was allowed for questions. One question regarding potential backwater and if it was a concern that the models considered. The Department of Emergency Service explained that our next step will be to apply for 2024 FEMA Building Resilient Infrastructure and Communities (BRIC) grant and Capital Services will need to determine what department will need to manage the project.

Jeremy Koser, from Johnson Mirmiran & Thompson gave a summary of the wetland bank project that is located on adjacent lands and recommended that the grant application include the wetland project as part of the project description. This will provide additional benefits to the project and enhance the County's chances of receiving the grant.

Material from all steering committee meetings are included in Attachment 1

Community Outreach and Project StoryMap

General project information will be conveyed through the County's social media, press releases, and updates to the Nuisance & Urban Flooding Plan ArcGIS StoryMap is a major communication vehicle for this and future watershed studies. The StoryMap that was developed for the Nuisance Flood Plan will be modified to include details and results of the Mill Swamp Fenwick Road over Pomonkey Creek Flood Analysis. This web-based application will continue to enable users to acquire information and engage in project development. Details on the County's Nuisance and Urban Flooding plan can be viewed at this location: https://www.charlescountymd.gov/services/emergency-services/emergency-preparedness/nuisance-and-urban-flooding



Nuisance and Urban Flooding ArcGIS StoryMap

https://maryland.maps.arcgis.com/apps/Cascade/index.html?appid=7bb024fa03ff46a58e07323e16bdb7f1

Section 3 – Target Flood Locations within Mill Swamp

Pomonkey Creek

A natural drainage path conveys stormwater from several private properties across Fenwick Road by means of two 15” corrugated metal pipes to Mill Swamp. The natural drainage path is not associated with any drainage easements and any required maintenance would be the responsibility of the property owners. During storm events, flooding conditions in Mill Swamp prevented Fenwick Road’s culvert pipes from being able to discharge as it would during normal rain events. This causes the flooding conditions along Fenwick Road

Residents along Fenwick Road have concerns about the ability for emergency vehicles to access houses during flood events. Fenwick Road has never been shut down by County Roads, but they do post high water warnings during heavy rain events. The area experiences nuisance flooding during heavy rain events and high tides.

During a post event inspection conducted by PGM in 2020 reported the following:

> All culvert pipes crossing Fenwick Road were open and appeared to be flowing. Sediment had built up along the edge of the asphalt in many areas preventing water in the roadway from entering the ditches. Roadside ditches and most of the driveway culverts along Fenwick Road were partially if not fully blocked with sediment. Flood conditions on Fenwick Road are caused by a combination of very heavy rain events and the roads proximity to the flood plains.

Mill Swamp Wetland Mitigation Bank

The Mill Swamp Mitigation Bank serves as a compensatory mitigation site for wetland losses due to development. Maryland Department of the Environment (MDE) held a public informational hearing for the proposed Mill Swamp Mitigation Bank application on April 24th, 2023. The project aims to restore, enhance, and preserve approximately 49 acres of aquatic resources for future compensatory mitigation. The proposal includes significant wetland and stream restoration efforts, with temporary impacts to various wetland and stream areas. You can find more details, including project documents, vicinity maps, and impact plates, on the official Maryland Department of the Environment page. Location and mitigation types are presented in Figure 2.

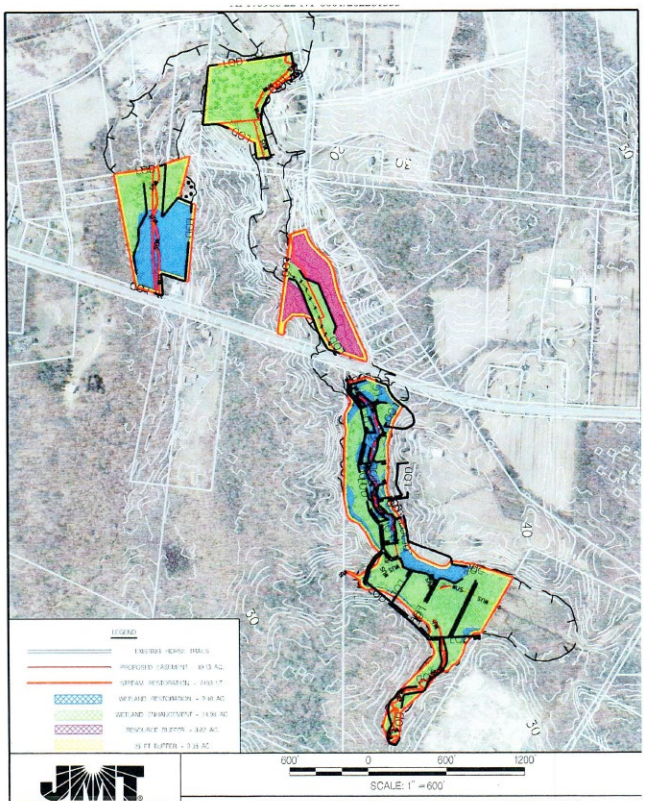


Figure 2. Mill Swamp Mitigation Bank Location Map

Potomac River Watershed Assessment – Pomonkey Creek & Mill Swamp

Between 2014 and 2017 the Charles County Department of Planning and Growth Management (PGM) completed a series of watershed assessments in response to requirements set forth by the Maryland Department of the Environment (MDE) in the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit. The watershed assessments provide the next step in the planning process specifically for the urban stormwater sector regulated by the County's NPDES permit. The watershed assessments, through desktop and field assessment, identify watershed and water quality conditions and identify and prioritize specific restoration solutions to meet the County's watershed restoration goals.

Pomonkey Creek and Mill Swamp Run are located in the Middle Potomac River watershed. The Middle Potomac River watershed spans the western limit of Charles County and is divided into two sections by the Mattawoman Creek. Land use in the Middle Potomac River watershed is mostly forested (73%), with the remaining area primarily devoted to developed land (17%).

Water quality sampling was performed on Pomonkey Creek for water quality and discharge measurements. Results of flow measurements are presented in Attachment 2.

As part of the watershed assessment field crews walked portions of the Mill Swamp Run. Figure 3 illustrates the stream reaches walked by field crews and the location of the representative sites for each reach. Representative sites were selected at locations representative of each stream segment. The general physical habitat condition was assessed at the representative sites using a modified version of the EPA's Rapid Bioassessment Protocols (Barbour et al., 1999). The assessment included qualitative ratings for ten habitat parameters as well as information on wetted width, pool, run, and riffle depths, and channel substrate (See Attachment 2).

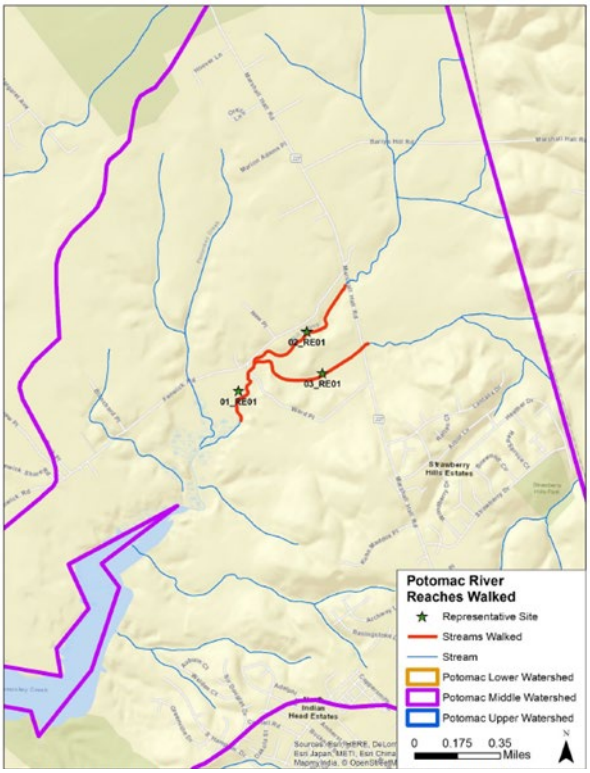


Figure 3. Location of Mill Swamp Run Field Investigations

Section 4 - Modeling Methodology

Hydrology

The site is located within the Mill Swamp Watershed. Fenwick Road traverses Pomonkey Creek and runs adjacent to Mill Swamp. A 2-D U.S. Army Core of Engineer's (USACE) Hydrologic Engineering Cetner (HEC) Riverine Analysis System (RAS) version 6.5 analysis was performed to estimate the flood elevation of Pomonkey Creek and Mill Swamp over Fenwick Road. USACE Hydrologic Modeling System (HMS) version 4.11 analysis was used to obtain the excess precipitation hyetograph to run the HEC-RAS 2D rain on grid (ROG) model.

Pomonkey Creek watershed drains approximately 8.96 mi^2 of land area. The landuse is predominantly forested land with some residential communities and agricultural areas. The soil type within the drainage area consists of mostly poorly drained type C and D soils. Drainage areas were developed for the site using StreamStats and available LiDAR data, soil information was obtained using NRCS Web Soils Survey, and land use information was obtained from the NLCD land use layer.

Four storm events for current conditions, 2050, and 2080 were investigated as part of this analysis. These analysis were completed for 10-year 20-year, 50-year, and 100-year anticipated flood levels, and the future projected land use conditions for years 2050 and 2080. Current rainfall data was obtained using NOAA Atlas 14 for Charles County. Future rainfall conditions were obtained using the RAND Corporation climate projections for Charles County, which incorporate regional atmospheric and topographic variability. High air emission scenarios were used (RCP 8.5) as a conservative approach. Table 1 summarizes the total precipitation for each event.

Table 1: Precipitation Volume

Scenario	Precipitation (In.)
Current	
10yr event	4.91
20yr event	6.15
50yr event	7.25
100yr event	8.48
2050 Predictions	
10yr event in 2050	5.35
20yr event in 2050	6.89
50yr event in 2050	8.27
100yr event in 2050	9.75
2080 Predictions	
10yr event in 2080	5.79
20yr event in 2080	7.32
50yr event in 2080	8.70
100yr event in 2080	10.26

NOAA Type D rainfall distribution was utilized within the HEC-HMS model. The NRCS TR-55 runoff model was utilized. Hydrologic input data is summarized in Table 2.

Table 2: Hydrologic Input Parameters

Drainage Area (mi^2)	% Impervious	Pervious Curve Number	Time of Concentration (min)	Peak Rate Factor*
8.96	6	73	417.4	284

*Peak Rate Factor for the DELMARVA peninsula

Project hydrologic parameters can be found in Attachment 3.

Hydraulics

An existing hydraulic analysis was performed using a 2-D HEC-RAS unsteady model. A concept-analysis was performed to estimate flood depths over Fenwick under the current conditions, 2050, and 2080 scenarios. HEC-RAS 2D models utilize a computation mesh over a user defined terrain file to define an elevation –volume relationship for each cell based on the terrain file. HEC-RAS 2D models can contain multiple computational meshes, each composed of irregular-shaped grids of up to eight-sided cells. The watershed drainage area extents were imported into HEC-RAS to develop the boundary used for the 2D computational mesh.

In this project, the Pomonkey Creek watershed is not highly developed in nature and is relatively flat; therefore, a maximum 200-ft resolution was deemed appropriate for a model of this size and resolution. This grid size is a balance between the level of detail, model size, and run time. Refinement regions are used within the mesh computation to produce a more detailed analysis within an enclosed region. Locations that would require refinement regions include highly urbanized areas, streams, and complex roadway systems. A refinement region was used along the Pomonkey Creek to define the floodplain where the grid size was reduced to a 75-ft resolution. Breaklines are defined along channels and high ground areas to direct the movement of water through the 2D domain. Breaklines were utilized along Fenwick Road and smaller local roads in the vicinity as well as along Mill Swamp and adjacent waterways. Breaklines were enforced at a resolution of 50 to 75-ft. The mesh is shown in Figure 1.

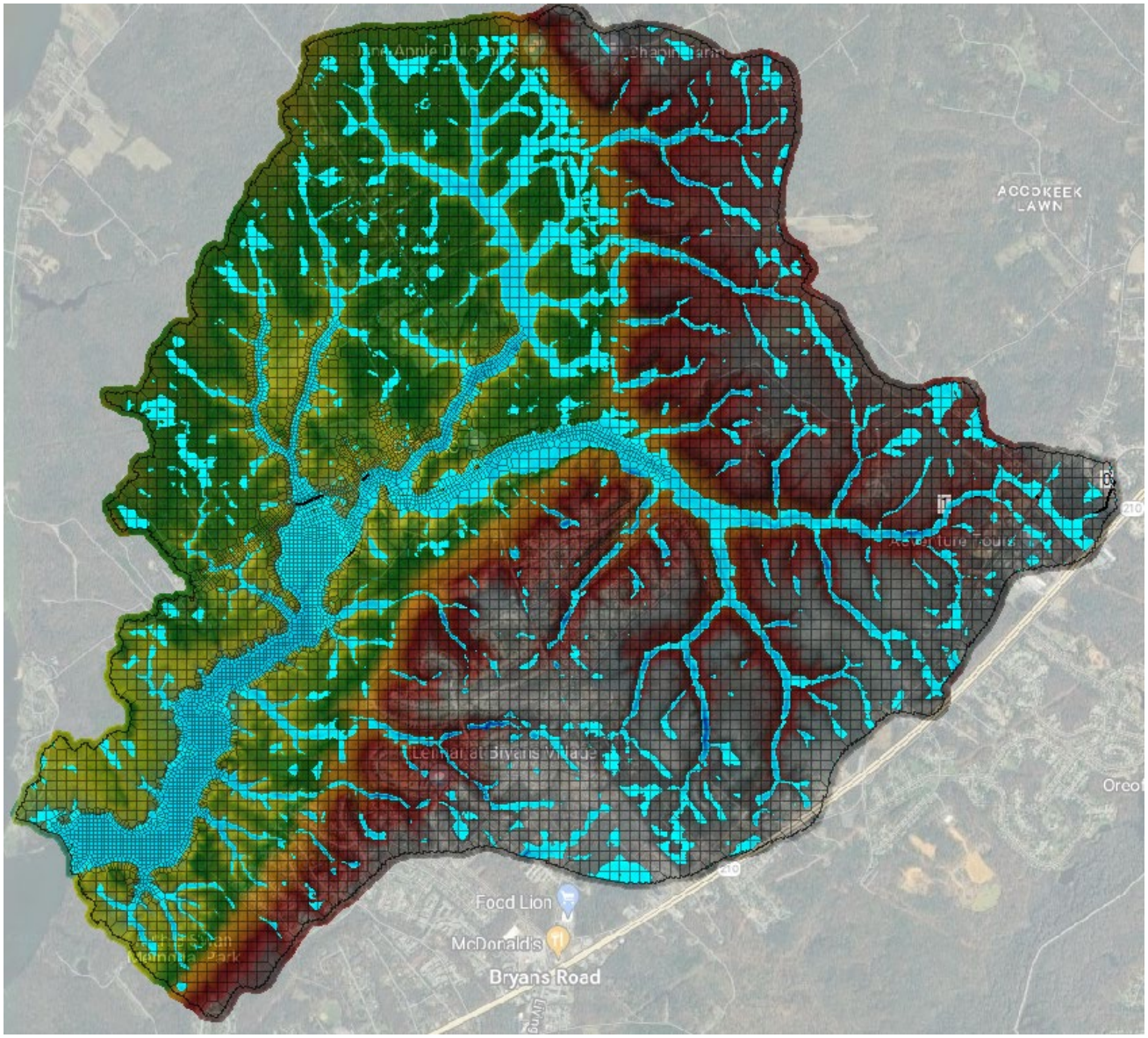


Figure 1: HEC-RAS 2D Domain and Mesh

The land use map was used to develop roughness coefficients for each land use type within the model. The landcover layer allows the user to develop a spatially varied land cover that can be associated with the geometry file created within the model. Table 3 summarizes the input used for each land use type. The models developed in this study are concept development and roughness coefficients were not calibrated during this phase.

Table 3: Manning's Roughness Coefficients for Land Cover

Scenario	Elevation (Ft)
Medium Density Residential	0.100
High Density Residential	0.120
Commercial	0.120
Institutional	0.120
Other Developed Lands	0.060
Agriculture	0.050
Forest	0.160
Water	0.035
Wetlands	0.100
Transportation	0.080
Very Low Density Residential	0.060
Industrial	0.120
Barren Land	0.030

Rain on grid files were developed using the .DSS output created by the HEC-HMS model. Infiltration was accounted for in the HEC-HMS model, so the excess precipitation was used in the HEC-HMS model to predict runoff flows and depth. A boundary condition line was placed at the confluence of the Pomonkey Creek and the Potomac River to model the tidal conditions. Tide data was obtained from USGS gage 8594900 at Washington DC. The downstream boundary conditions are summarized in Table 4.

Table 4: Downstream Boundary Conditions

Scenario	Elevation (Ft)
Current MHHW	1.77
MHHW + 2050 SLR	3.67
MHHW + 2080 SLR	4.97

The existing conditions were modeled to evaluate the flooding over Fenwick Road. Fenwick Road adjacent to Mill swamp caries a 15" CMP at a private property line between Ward Pl and New Pl and conveys runoff from adjacent properties under the existing roadway to Mill Swamp. Approximately 1500 feet southwest of this location Pomonkey Creek is conveyed under Fenwick Road by three 24-inch CMPs. All four existing culverts were modeled along Fenwick Road. The results of the existing model indicate that flooding over the roadway begins during the current 10-year storm event. As a result of the existing conditions, three alternatives were considered to mitigate the flooding over Fenwick Road as follows:

- No build:
  - This alternative does not address project needs and was not investigated further.
- Update drainage infrastructure:
  - Increasing the capacity of the existing CMP culverts does not address the depth of flooding over the roadway caused by tidal conditions and inland flooding.
- Raise the roadway profile:
  - Based on the existing conditions and the tidal influence, this is the only feasible alternative that will mitigate flooding over the roadway and provide a safe evacuation route for residents during storm events.
  - Raising the elevation of the roadway was investigated utilizing a bridge structure but was not modeled due to the bridge requirements resulting in higher than feasible roadway elevations.
  - An embankment alternative with updated culvert crossings was investigated and modeled as the selected alternative.

The flooding over the two low points along Fenwick Road are shown in Figures 2 and 3. The model results indicate the roadway elevation needs to be raised approximately 2.5' over Pomonkey Creek and 3.5' adjacent to Mill Swamp.

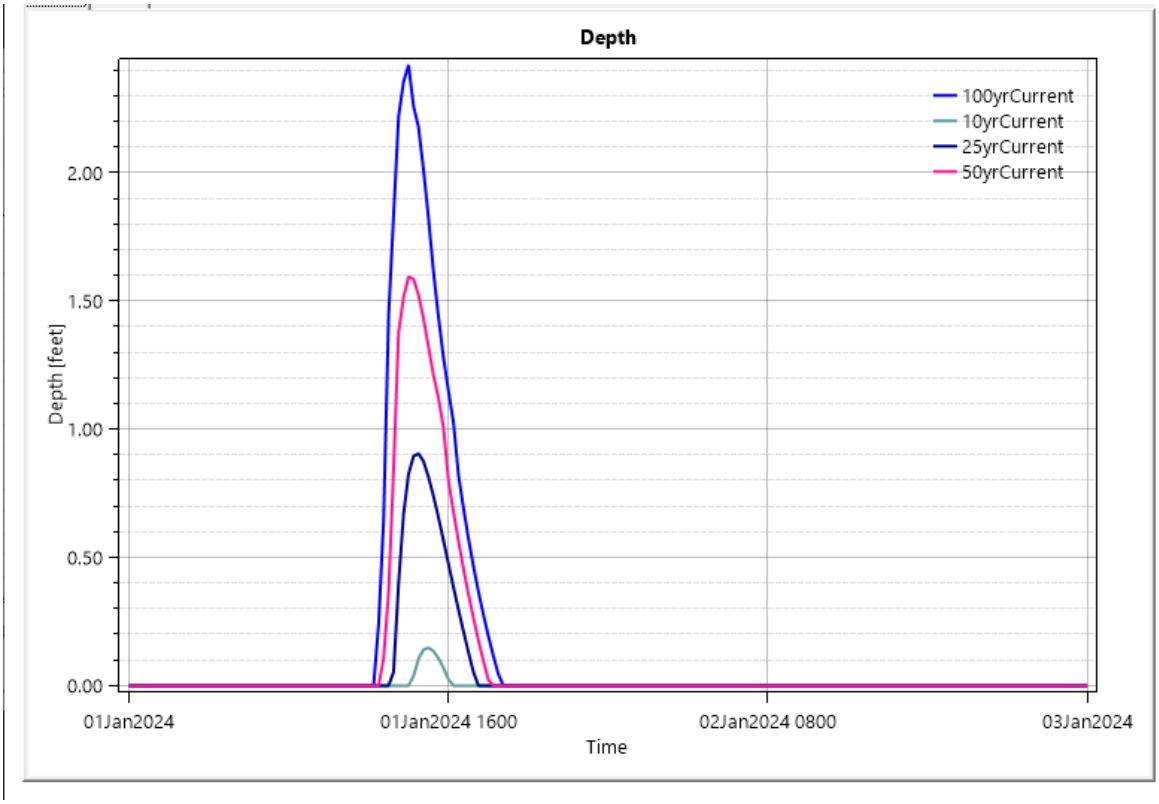


Figure 2: Pomonkey Creek Flooding over Fenwick Road

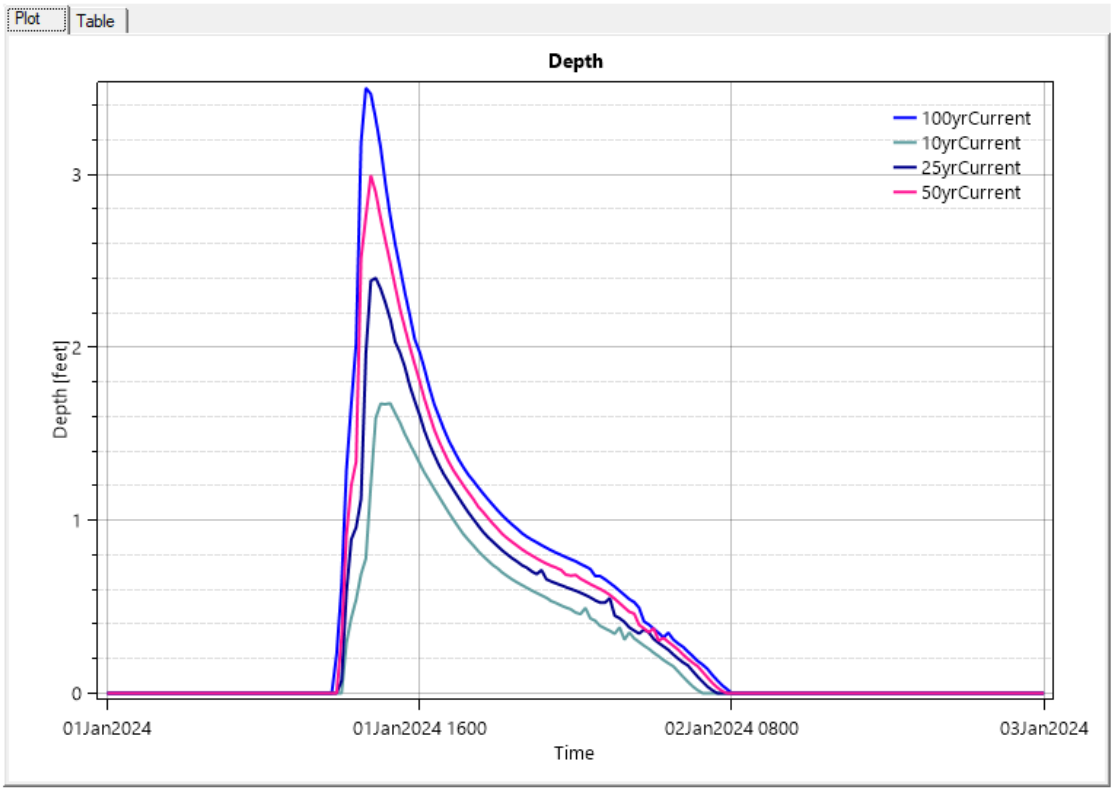


Figure 3: Mill Swamp Flooding along Fenwick Road

The proposed conditions were developed based on the current 100-year event depth of flooding over the roadway to establish a new roadway profile. A terrain modification was made to the existing terrain file to reflect the new elevation and the roadway weir elevation was increased within the 2D weir connection. Figure 4 shows the new roadway elevation. The elevation was raised approximately 2.5' over Pomonkey Creek and approximately 3.5' along Mill Swamp.

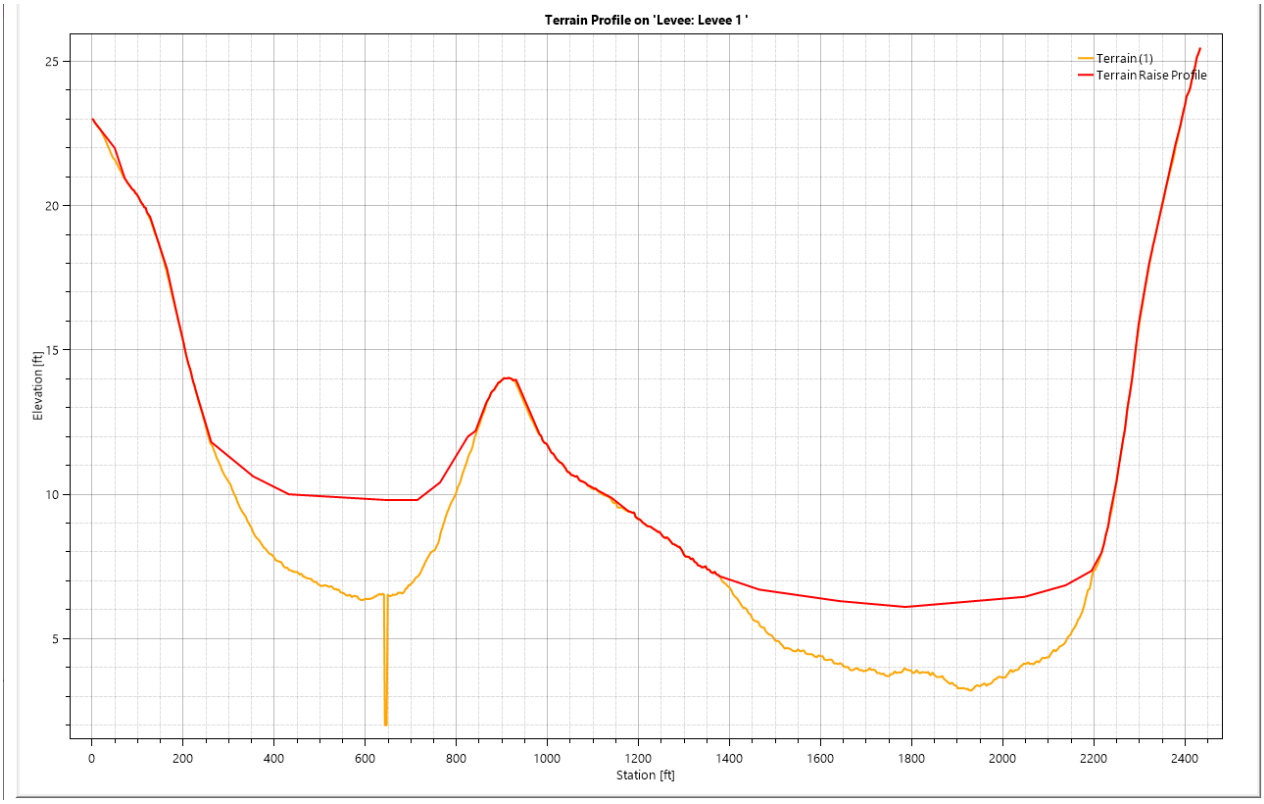


Figure 4: Existing Terrain vs Raised Profile

An 18” x 22” steel pipe arch is proposed under Fenwick Road that drains to Mill Swamp to accommodate conveyance from the upstream drainage, while minimizing backwater from Mill Swamp. A control gate may be investigated during later phases of this design to eliminate backwater from Mill Swamp during larger tidal events. Three 4’x16 box culverts are proposed under Fenwick Road to maintain conveyance both upstream and downstream to allow the flow to ebb during both tidal and fluvial events. Hydraulic analysis can be found in Attachment 4 and floodplain maps for current and future events 2050 & 2080 can be found in Attachment 5.

Section 5: Site Evaluation &Proposed Alternatives

Existing Condition:

A 15” CMP transverses Fenwick Road at a private property line between Ward Pl and New Pl and conveys runoff from adjacent properties under the existing roadway to Mill Swamp. Approximately 1500 feet southwest of this location Pomonkey Creek is conveyed under Fenwick Road by three 24-inch CMPs.

The selected alternative includes replacing the 15" CMP with an 18" x 22” steel pipe arch and raise the roadway low point from 3.5' to approximately 6’. Where Pomonkey Creek crosses Fenwick Road the recommended improvement involves replacing the three 24" CMPs with three 4’ x 16’ box culverts and raise the roadway low point from 6.5' to approximately 10’.

Proposed Alternatives:

Proposed alternatives were developed for the Pomonkey Creek project location. Aside from Alternative 1 – No Build, which does not address the purpose and need, the following distinct build alternatives were developed and analyzed.

Alternative 1: No Build
Does not address project needs.

- Fenwick Road continues to overtop during 10-year storm or greater.

Alternative 2: Improve Existing Drainage
Replace Ex. 15" CMP with a 18" x 22" steel pipe arch
Replace Ex. 2-24" CMPs with - 21" x 34" steel pipe arches

Advantages

- Increased conveyance and reduction in WSEL upstream of Fenwick Road.

Disadvantages

- Does not mitigate downstream flooding caused by backwater from Mill Swamp.
- Does not pass 10-year event.

Alternative 3: Improve Existing Drainage
Replace Ex. 15" CMP with a 18" x 22" steel pipe arch
Replace Ex. 2-24" CMPs with three - 4' x 16' box culverts

Advantages

- Increased conveyance and reduction in WSEL upstream of Fenwick Road.

Disadvantages

- Does not mitigate downstream flooding caused by backwater from Mill Swamp.
- Does not pass 10-year event.

Alternative 4: Improve Existing Drainage and Raise Roadway Elevation
Replace Ex. 15" CMP with 18" x 22" steel pipe arch; raise roadway low point by from 3.5' to 6’
Replace Ex. 2-24" CMPs with three 4’ x 16’ box culverts; raise roadway low point by 6.5' to 10’

- Increased profile prevents flooding during the 100-year current storm event.

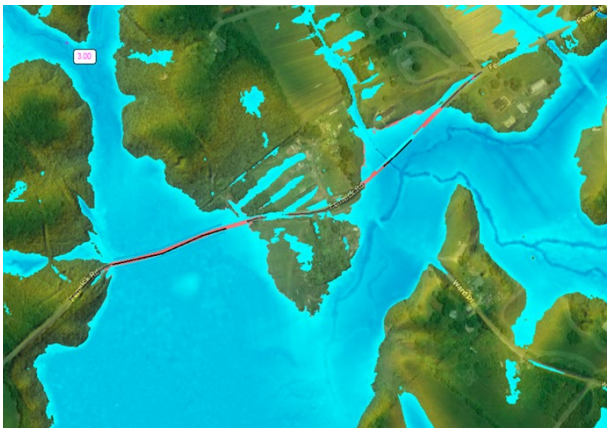
As presented in the Maryland Department of Transportation (MDOT), Office of Structures Guidelines and Procedures Memorandums All new and/or rehabilitated hydraulic structures on the State Highway system and on County Roads in Counties having the 100 year Federal Flood Insurance shall be designed so as not to cause any increase in the Water Surface Elevation of the "100 year Flood" for the waterway and its flood plain affected by the proposed construction; therefore, the design storm for the above indicated location shall be a "100 year Storm" for existing conditions as opposed to ultimate development as per existing zoning.

Section 6: Concept Development Recommendations for Target Flood Locations within Mill Swamp

The recommended PPA is Alternative 4: Improve Existing Drainage and elevate the Roadway Elevation. This option involves the following:

Replace the existing 15" CMP with 18" x 22" steel pipe arch and elevate the roadway low point from 3.3' to 6.1' where Mill Swamp meets Fenwick Road Replace two existing 24" CMPs with three 4' x 16' box culverts and raise the roadway low point from 6.3' to 9.8' where Pomonkey Creek crosses Fenwick Road. The increased profile will prevent flooding during the 100-year current storm event. Two road elevation methods and a bridge option were investigated as part of this study. Construction details and costs for each option are presented in Attachment 5. The total cost for the drainage improvements and roadway elevation will be $4,769,610.46 ($4.8million).

SUMMARY COST – EMBANKMENT OPTION	
Construction Estimate	$ 3,683,782.34
Construction Engineering (CE)	$ 548,883.57
Construction Contingencies	$ 152,400.00
Right of Way Cost	$ 292,450.00
Utilities Relocations	$ 92,094.56
Total Construction Cost	$ 4,769,610.46



100 year (Existing)
100 year (Elevated Profile)

Given the existing curved roadway and the close proximity of the right of way to the road, the embankment option is preferred over the retaining wall option for the following reasons:

Cost-Effectiveness:

- **Lower Construction Costs:** Embankments are generally less expensive to construct compared to retaining walls. The cost of an embankment includes roadway fill, pavement material, and drainage items, whereas retaining walls require additional materials such as concrete, steel, blunt-end protection items, and labor for installation.
- **Maintenance Costs:** Embankments typically incur lower long-term maintenance costs. Retaining walls may need periodic inspections and repairs due to structural stresses or damage.

Flexibility in Design:

- **Adaptability:** Embankments can be more easily adapted to the natural terrain and curved alignments. They can be shaped and graded to fit the specific contours and elevation changes of the site, making them more versatile for curvilinear roadways.

- **Slope Variation:** Embankments allow for gradual transitions in slope, which can be more aesthetically pleasing and easier to integrate with the surrounding landscape.

Space Efficiency:

- **Utilization of Available Space:** In areas with tight ROW, embankments can be designed to require only grading easements more effectively. By adjusting the slopes, designers can fit embankments within the constrained area without the need for extensive structural supports.
- **Sight Distance:** Retaining walls would need to be placed outside the horizontal sight distance for the current curves, necessitating the acquisition of additional ROW and construction easement.

Construction Simplicity:

- **Ease of Construction:** Building an embankment is generally a simpler process compared to constructing a retaining wall. It involves standard earthmoving equipment and techniques, reducing the complexity and duration of construction.
- **Foundation Preparation:** Embankments do not require the same level of foundation preparation as retaining walls, which often need deep foundations or extensive ground improvement to ensure stability.

Environmental and Aesthetic Benefits:

- **Natural Integration:** Embankments can be more naturally integrated into the landscape. They can be covered with vegetation, which helps in blending the road into its surroundings and provides environmental benefits such as erosion control and habitat creation.
- **Less Visual Impact:** Retaining walls can be visually intrusive, especially in scenic or natural areas. Embankments, with their gentle slopes and vegetative cover, have a softer visual impact.

Safety Considerations:

- **Impact Mitigation:** In the event of a vehicle leaving the roadway, embankments provide a more forgiving surface compared to the hard, vertical face of a retaining wall, potentially reducing the severity of accidents.
- **Sight Lines:** Embankments can be designed to maintain better sight lines around curves, enhancing road safety by improving visibility for drivers.

Considering these factors, embankments are preferred over retaining walls in scenarios involving curved roads and limited right of way, as they offer a more cost-effective, flexible, and environmentally friendly solution.

Attachment 1

Steering Committee Meeting Material

Flood Analysis
Mill Swamp Fenwick Road Over Pomonkey
August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Mill Swamp Flood Study Current & Future Conditions

April 5, 2024
11 AM - Virtual

1

Flood Analysis
Mill Swamp Fenwick Road Over Pomonkey
August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Agenda

- Project Update
  - Background
  - Schedule
  - StoryMap
- Relevant Data Sources
- Field Study Findings
- Model Development
- Current and Future Conditions
- Next Steps

2

Flood Analysis
Mill Swamp Fenwick Road Over Pomonkey
August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

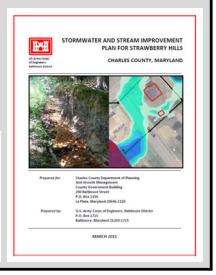
Project Update

3

Background

Scope Changes to Flood Study

- Initial Study included Strawberry Hills Neighborhood
- Conducted Field Study – Target Flooding Areas – Slope Runoff into Basements
- USACE Flood Study Recommendation are Scheduled
- Internal Discussion on Recommendation to Focus on Fenwick Road Flooding



4

Project Schedule

Initial Steps – Spring 2023

- Grant Award MOU / Contract Signing
- MDE Wetland Project Coordination

Internal Team Coordination – Summer 2023

- Kickoff Meeting
- Field Study
- Strawberry Hills Project Review & Deliberation

Flood Model Development – Spring 2024

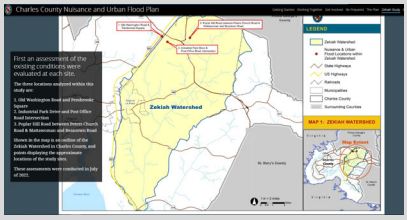
- Current Conditions
- Future Conditions 2050 & 2080
- Mitigation Measures

5

StoryMap

Methodology & Data Delivery

- Will incorporate findings of the study into the County's existing Nuisance Flood Study StoryMap
- Similar format to the Zekiah Urban Watershed Study – Pulldown Option from main menu



6

Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Relevant Data Sources

7

Nuisance Flood Plan

Data gathering process:

- Flood event data was obtained from the National Center for Environmental Information (NCEI)
- Additional information gathered by the Department of Emergency Services of known flood areas resulted in a listing of roadways and intersections.
- Twenty-seven nuisance and urban flood locations were identified. Additional information gathered during the flood identification site visits included a description per site and a site photograph.
- During the Nuisance and Urban Flooding Stakeholder Group meeting twenty new flood locations, sites were identified

8

Fenwick Road in the area of New Place

Description:

- Located in the northwestern portion of the county, Fenwick Road is in close proximity to Pomonkey Creek and Mill Swamp is also adjacent to Fenwick Road. Several low points along the roadway allows water to overtop the roadway. Also, the road is at the same level as the creek. High tides heavy rains and flooding can render the road impassable. This area of the road that floods is in a "bowl" and the excessive water is partly due to upstream developments and a limited outfall Flooding occurs along Fenwick Road between New Place and Ward Place.1

9

Mitigation Measures Medium Priority

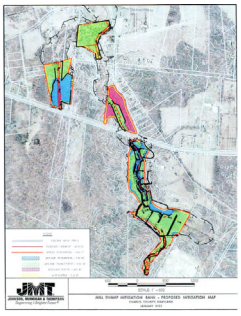
		PREPAREDNESS	RESPONSE	MITIGATION
HI MD LO				
1	Fenwick Road in the area of New Place	ADD SIGNAGE SIGN TYPE: Warning and Mass Notification Use CAD and Notification EAS and IPAWS Use During Major Incidents	Current response is reactive barricade following notification Of water on roadway Note: Evacuation Resistant Community	Assessment of Location Existing Programs Prioritization
	NUISANCE - Pomonkey Creek			

10

Adjacent Wetland Mitigaiton Bank

DNR Mitigation Bank

- 49 Acres
- Wetland Restoration / Enhancement / Preservation
- Compensation for Future Stream and Nontidal Wetland Impacts



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M0

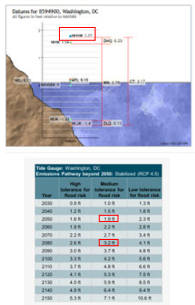
Hydraulic and Hydrology

Hydrology

- HEC-HMS Excess Precipitation
- Current Precipitation
- Future Precipitation
  - 2050
  - 2080

Hydraulics

- HEC-RAS 2D Watershed Model
- Boundary Conditions
  - Current: MHHW
  - 2050: MHHW + Projected SLR
  - 2080: MHHW+ Projected SLR



12

Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Field Study Findings

13

Mill Swamp over Fenwick Road

Known Issues:
- Flooding over Fenwick Road and Adjacent Property

Observed:
- Culvert at low point and edge of property appears blocked and undersized
- Large drainage along side and behind private property believed to drain to low point
- No significant erosion apparent
- Capacity of system and vicinity to source is likely large part of this issue

14

Fenwick Road over Pomonkey Creek

Known Issues:
- Flooding over Fenwick Road

Observed:
- Culverts at low point appears clear.
- Tidal level is just below road elevation
- No significant erosion apparent
- Limited through flow

15

Field Results

Potential Recommendations:

- Investigate increasing capacity of existing culverts
- Elevate road to determined design height
- Add rip rap and grade off roadway in areas of greatest impact
- Coordinate design options with adjacent proposed wetland improvements

16

Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

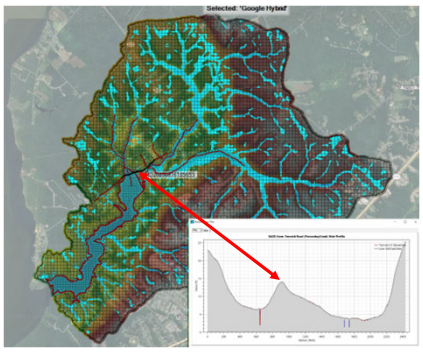
AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Model Development

17

Model

HEC-Ras
- Mill Swamp Watershed Model
- 2D Rain on Grid Mesh
- 200'x200' cell size
- Refinement regions and breaklines along major streams 75'x75' cell size
- Fenwick Road: 50'x50' cell size
- Terrain modification used at crossings and to model the raised roadway profile
- NLCD Landuse
- Maryland Statewide DEM



18

Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

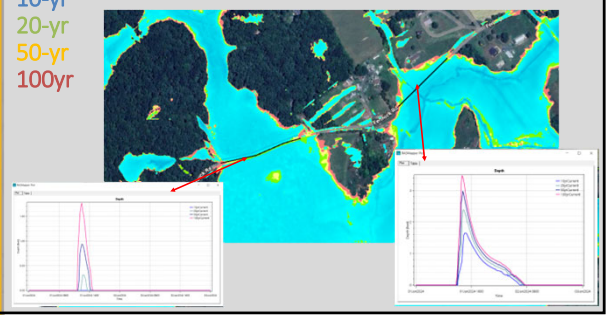
AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Current & Future Conditions

19

Current Conditions

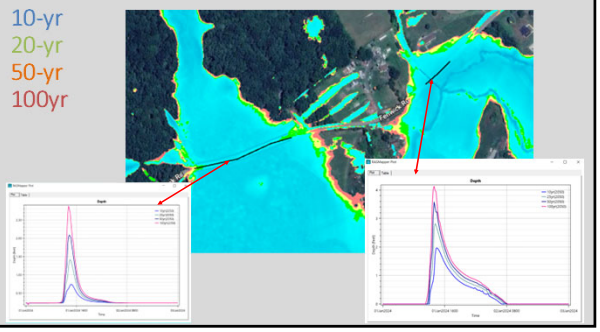
10-yr
20-yr
50-yr
100yr



20

2050 Future Conditions

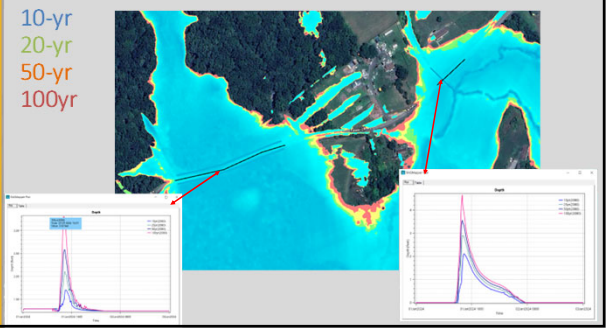
10-yr
20-yr
50-yr
100yr



21

2080 Future Conditions

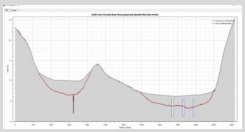
10-yr
20-yr
50-yr
100yr



22

Fenwick Road

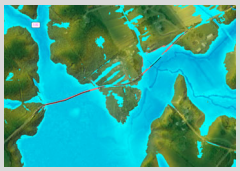
- Proposed Alternatives
  - Alternative 1: No Build
    - Does not address project need
  - Alternative 2: Improve Existing Drainage
    - Replace Ex. 15" CMP with a 18" x 22" steel pipe arch
    - Replace Ex. 2-24" CMPs with 6- 21" x 34" steel pipe arches
  - Alternative 3: Improve Existing Drainage
    - Replace Ex. 15" CMP with a 18" x 22" steel pipe arch
    - Replace Ex. 2-24" CMPs with 6- 8' x 2.5' box culverts
  - Alternative 4: Improve Existing Drainage and Raise Roadway Elevation
    - Replace Ex. 15" CMP with 18" x 22" steel pipe arch; raise roadway low point by from 3.3' to 6.1'
    - Replace Ex. 2-24" CMPs with 3-4' x 16' box culverts; raise roadway low point by 6.3' to 9.8'



23

Mitigation Measures Model Results

- Proposed Alternatives
  - Alternative 1: No Build
    - Fenwick Road overtops during 10-year storm
  - Alternative 2: Improve Existing Drainage
    - Increased conveyance and reduction in WSEL upstream of Fenwick Road. Does not mitigate downstream flooding caused by backwater from Mill Swamp. Does not pass 10-year event.
  - Alternative 3: Improve Existing Drainage
    - Increased conveyance and reduction in WSEL upstream of Fenwick Road. Does not mitigate downstream flooding caused by backwater from Mill Swamp. Does not pass 10-year event.
  - Alternative 4: Improve Existing Drainage and Raise Roadway Elevation
    - Increased profile prevents flooding during the 100-year current storm event



100 year (Existing)
100 year (Raised Profile)

24

Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Next Steps

- Hold Steering Committee Meeting to Present Vulnerability Analysis
- Refine Improvement Actions & Develop Implementation Schedule
- Modify StoryMap to Include Methodology & Findings of Study
- Compile Findings in Report and Present to County for Approval
- Develop FEMA Hazard Mitigation Grant Application

25

Flood Analysis
Mill Swamp Fenwick Road Over Pomonkey
August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Mill Swamp Flood Study Proposed Projects

July 22, 2024
11:30 AM - Virtual

1

Flood Analysis
Mill Swamp Fenwick Road Over Pomonkey
August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Introductions

2

Flood Analysis
Mill Swamp Fenwick Road Over Pomonkey
August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Agenda

- Project Update
  - Background
  - Schedule
  - StoryMap
- Model Updates
- Next Steps

3

Flood Analysis
Mill Swamp Fenwick Road Over Pomonkey
August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Project Update

4

Background

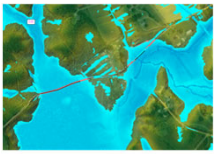
Modeling for 10, 20, 50, and 100 year storms for current conditions, 2050 and 2080.

Selected Alternative -Improve Existing Drainage and Raise Roadway Elevation

Increased profile prevents flooding during the 100-year current storm event

Fenwick Road at Swamp Mill:
Replace Ex. 15" CMP with 18" x 22" steel pipe arch;
Elevate roadway low point by from 3.3' to ~6'

Fenwick Road over Pomonkey Creek:
Replace Ex. 2-24" CMPs with 3-4' x 16' box culverts;
Elevate roadway low point from 6.3' to ~10'



100 year (Existing)
100 year (Raised Profile)

5

Project Schedule

Initial Steps – Spring 2023
- Grant Award MOU / Contract Signing
- MDE Wetland Project Coordination

Internal Team Coordination – Summer 2023
- Kickoff Meeting
- Field Study
- Strawberry Hills Project Review & Deliberation

Flood Model Development – Spring 2024
- Current Conditions
- Future Conditions 2050 & 2080
- Mitigation Measures

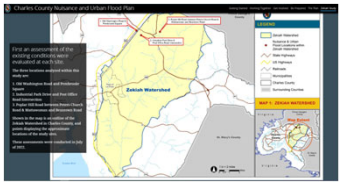
Proposed Projects –Summer 2024
- Road Elevation with Retaining Walls
- Road Elevation with Embankment
- Road Elevation with Bridge
- 2024 FEMA BRIC Application

6

Will incorporate findings of the study into the County's existing Nuisance Flood Study StoryMap

StoryMap

Similar format to the Zekiah Urban Watershed Study – Pulldown Option from main menu



7

Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Model Updates

8

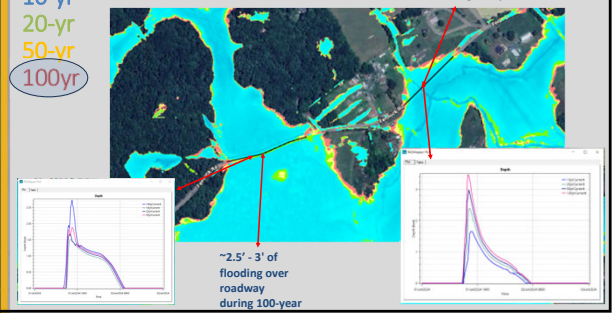
Alternatives

1. No build
   a. Does not address the project needs
2. Drainage Improvements
   a. Does not address the roadway overtopping
3. Raise Roadway Profile (Investigated three alternatives)
   a. Raise roadway profile using embankment fill and drainage improvements
   b. Raise roadway profile using retaining wall and drainage improvements
   c. Raise roadway profile using embankment fill and bridge over Pomonkey Creek with drainage improvements

9

Current Conditions

10-yr
20-yr
50-yr
100yr



~3.5' - 4' of flooding over roadway during 100-year

~2.5' - 3' of flooding over roadway during 100-year

10

Elevate Road with Drainage Improvements

- Elevate roadway low point by from 3.3' to ~6' over Pomonkey
- Elevate roadway low point from 6.3' to ~10' at Mill Swamp

- Improve Existing Drainage
  - Mill Swamp Floodplain - Replace Ex. 15" CMP with 18" x 22" steel pipe arch
  - Fenwick Rd Over Pomonkey Creek - Replace Ex. 2-24" CMPs with three 4' x 16' box culverts

*Cost Factor - 4' x 16' box culvert is not a standard precast structure size and will have to be cast in place

3a. Embankment Option

SUMMARY	
Construction Estimate	$3,683,800
Construction Engineering (CE)	$548,900
Construction Contingencies	$152,400
Right of Way Cost	$292,500
Utilities Relocations	$92,100
Total Construction Cost	**$4,769,700**

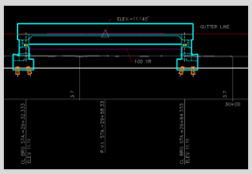
3b. Retaining Wall Option

SUMMARY	
Construction Estimate	$7,914,900
Construction Engineering (CE)	$854,800
Construction Contingencies	$292,400
Right of Way Cost	$198,500
Utilities Relocations	$197,900
Total Construction Cost	**$9,458,500**

11

3c. Bridge over Pomonkey Creek Option

- Investigated a single span bridge
  - Span length - 52' (c/c of bearing)
  - Clearing opening - 50'
  - Superstructure depth - 4'
  - Overall width of the bridge - 30' (out to out)
  - Evaluated concrete superstructure based on durability for the site conditions
  - Top of roadway elevation at centerline of roadway - EL. 11.145
    - Provides 1' freeboard from bottom of the superstructure to 100-yr flood elevation at El. 6.11.



As can be seen above, this option results in raising the roadway elevation by about 5' when compared to the culvert option. The bridge is expected to have significant environmental permitting and cost impacts. Therefore, this option was not modeled/investigated further.

12

Recommended Design Option

Drainage Improvements:

Replace Ex. 15" CMP with 18" x 22" steel pipe arch

Replace Ex. 2-24" CMPs with three 4' x 16' box culverts

- Increased conveyance and reduction in water surface elevation upstream of Fenwick Road
- Prevents flooding during the 100-year current storm event

Roadway Elevation - Embankment Option:

Elevate roadway low point by from 3.3' to ~6' over Pomonkey

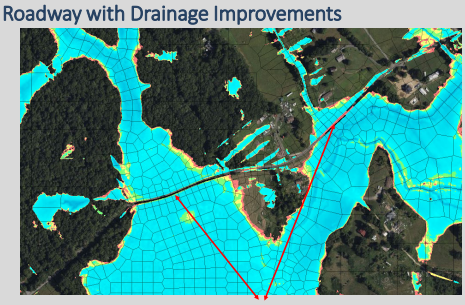
Elevate roadway low point from 6.3' to ~10' at Mill Swamp

- Lower Construction and Maintenance Costs
- Easily adapted to Natural Terrain
- Utilization of Available ROW Space and Sight Distance
- Ease of Construction and Foundation Preparation
- Environmental and Aesthetic Benefits
- Safety Considerations – more forgiving surface

13

Proposed Conditions:
Elevated Roadway with Drainage Improvements

10-yr
20-yr
50-yr
100yr



FLOODING OVER ROADWAY MITIGATED FOR 100-YEAR

14

Flood Analysis

Mill Swamp Fenwick Road Over Pomonkey

August 2024

CHARLES COUNTY, MARYLAND

AN ADDENDUM TO THE NUISANCE & URBAN FLOOD PLAN

Next Steps

- **Compile Findings in Report and Present to County for Approval**
- **Modify StoryMap to Include Methodology & Findings of Study**
- **Develop FEMA Hazard Mitigation Grant Application**

15

Attachment 2
Potomac River Watershed Assessment Results
Flow and Field Results

Potomac River Watershed Assessment- Water Quality Results

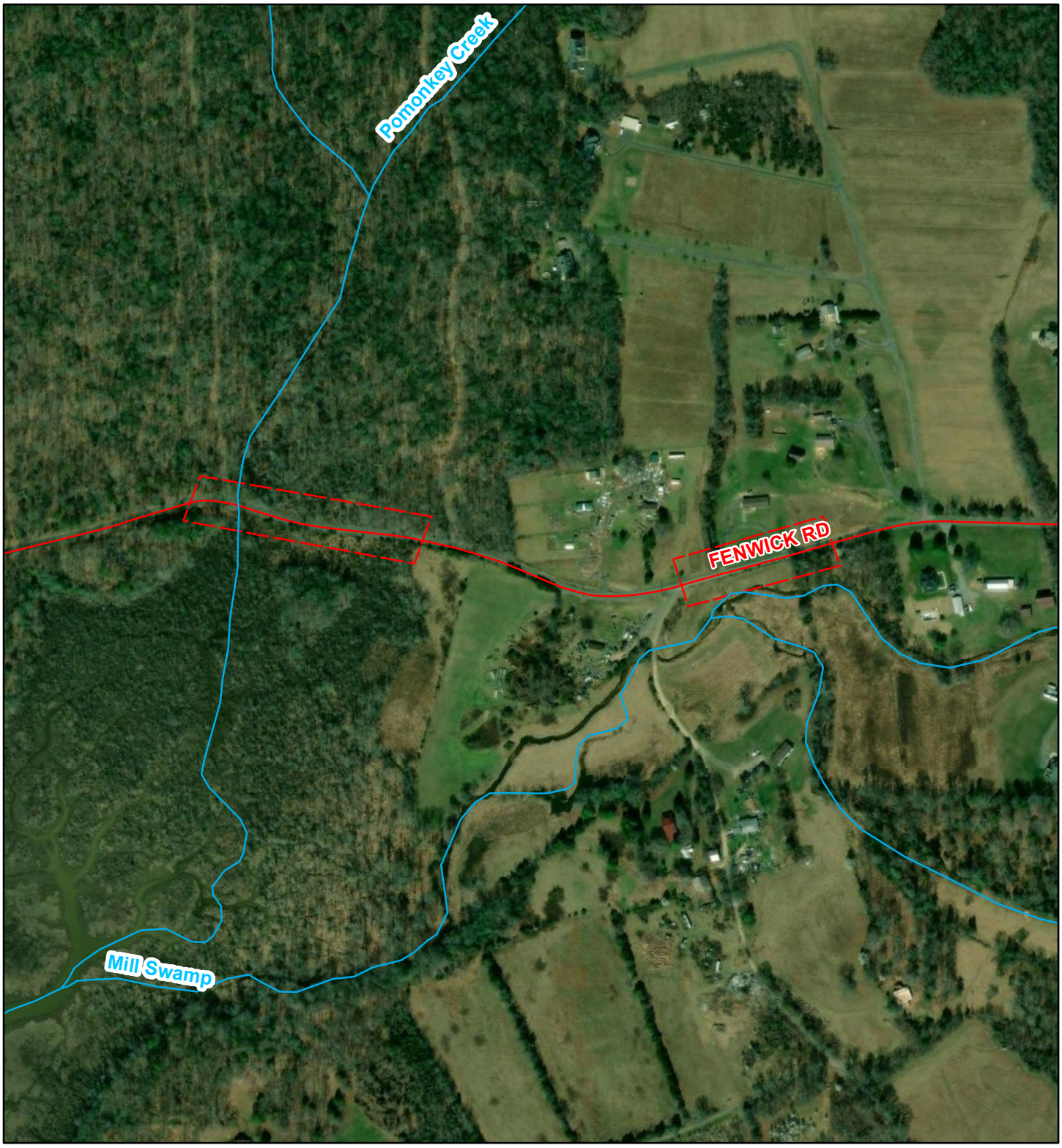
Station	Date	Area (Acres)	Discharge (cfs)	Discharge (Ls)	Temp (°C)	pH	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	Turbidity (NTU)	Optical Brightener (ppm)
PRM-4	3/13/2017	550.4	0.05	1.42	8.2	6.37	9.85	83.8	6.86	2.54

Station	Discharge (L/sec)	Ortho-P (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	E. Coli (MPN/100 ml)	Ortho-P (kg/H/day)	TKN (kg/H/day)	Nitrate-Nitrite (kg/H/day)	Total Nitrogen (kg/H/day)	Total Phosphorus (kg/H/day)
PRM-4	1.42	0.005	0.25	0.25	0.5	0.005	37.9	0.00000	0.00014	0.00014	0.00027	0.00000

Potomac River Watershed Assessment – Rapid Bioassessment Protocols Habitat Assessment Results

Site	Substrate	Embeddedness	Channel Alteration	Sediment Deposition	Velocity Depth	Flow	Vegetation	Bank Condition	Riparian Vegetation	Riffle Width (IN)	Run Width (IN)	Pool Width (IN)	Riffle Depth (IN)	Run Depth (IN)	Pool Depth (IN)	Bottom Type
01_RE01	POOR	POOR	OPTIMAL	POOR	POOR	OPTIMAL	MARGINAL	MARGINAL	POOR	120	120	120	36	36	36	SILT
02_RE01	MARGINAL	MARGINAL	OPTIMAL	MARGINAL	MARGINAL	OPTIMAL	SUBOPTIMAL	SUBOPTIMAL	MARGINAL	48	48	48	6	10	20	SILT
03_RE01	SUBOPTIMAL	SUBOPTIMAL	OPTIMAL	SUBOPTIMAL	SUBOPTIMAL	SUBOPTIMAL	SUBOPTIMAL	SUBOPTIMAL	SUBOPTIMAL	96	96	96	5	8	18	GRAVEL

Attachment 3
Hydrologic Backup



Legend

- Fenwick Road
- Streams
- Roadway Low Points

N

0 250 500 1,000 Feet

Figure 1
Project Location Map

Fenwick Road Over
Pomonkey Creek

Bryans Road, MD

Michael Baker
INTERNATIONAL

Legend

- Fenwick Road
- Streams
- Watershed Area
- Fenwick Road Low Points

N

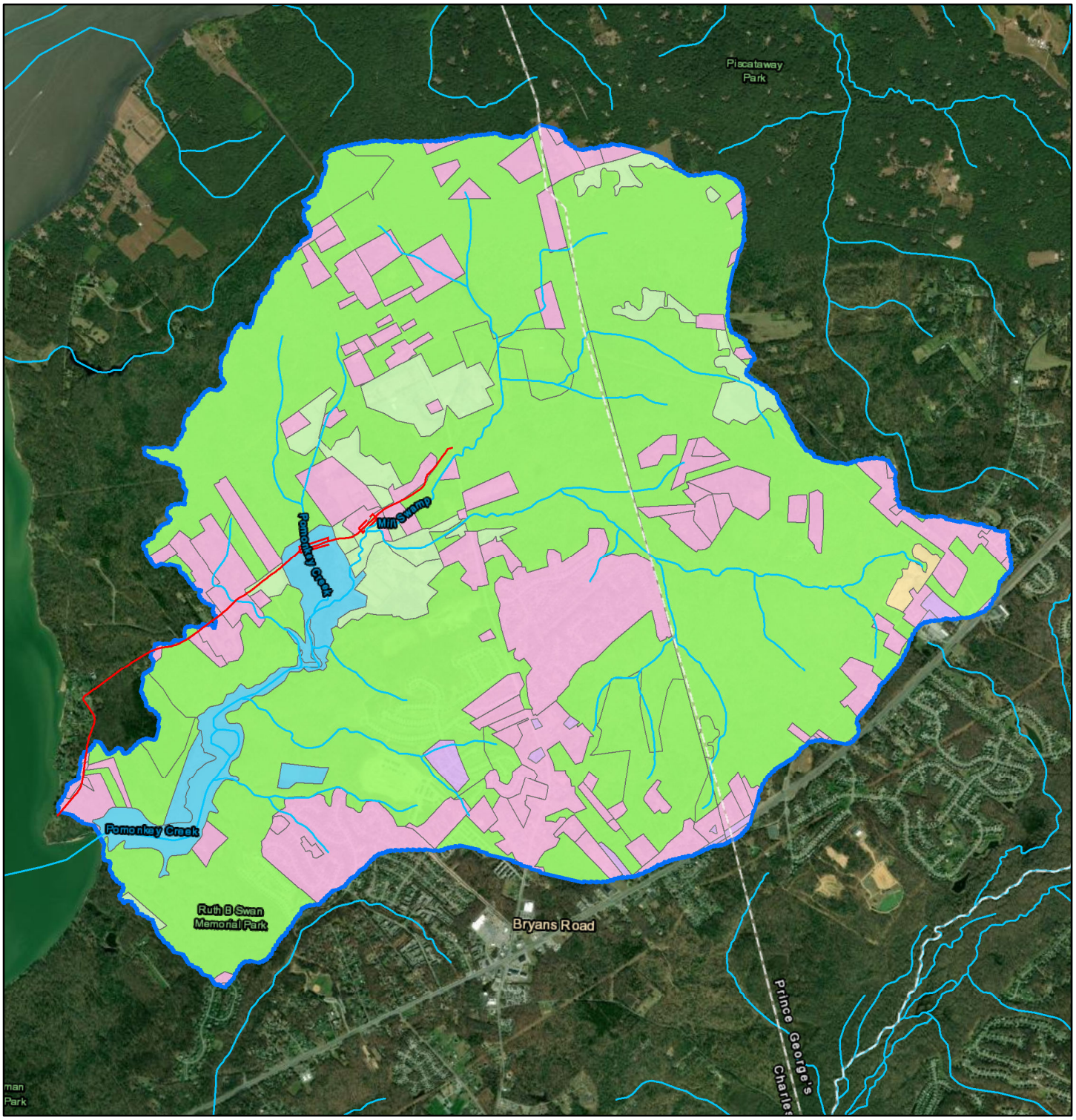
0 0.25 0.5 1 Miles

Figure 2
Watershed Map

Fenwick Road Over
Pomonkey Creek

Bryans Road, MD

Michael Baker
INTERNATIONAL



Legend

- Fenwick Road
- Streams
- Watershed Area
- Fenwick Road Low Points

Land Use

- Agriculture
- Barren Land
- Developed
- Forest
- Residential
- Water/Wetlands

N

0 0.25 0.5 1 Miles

Figure 3
Landuse Map

Fenwick Road Over
Pomonkey Creek

Bryans Road, MD

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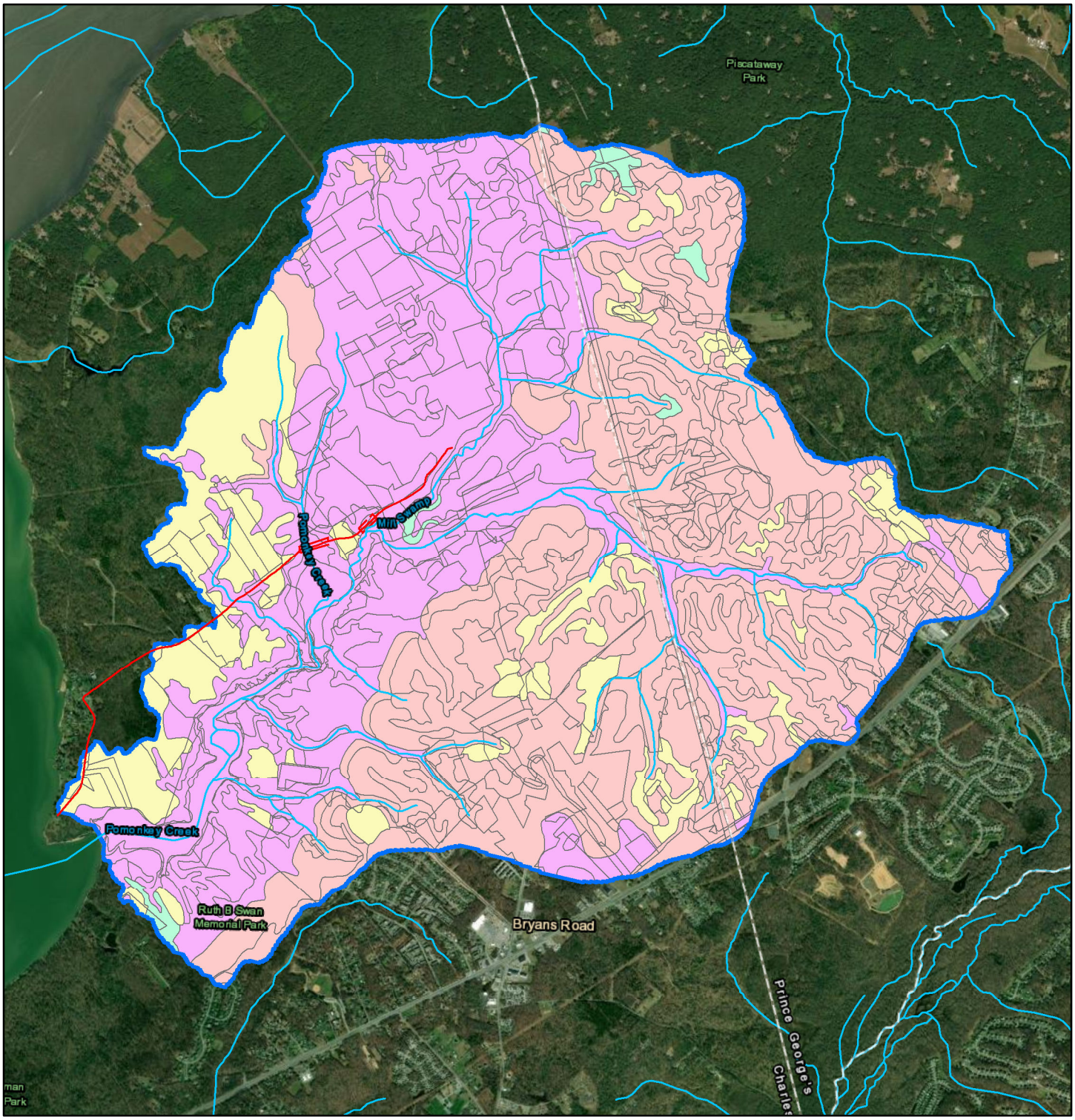

Legend

- Fenwick Road
- Streams
- Watershed Area
- Fenwick Road Low Points

Hydrologic Soil Group

- A
- B
- C
- D

N

0 0.25 0.5 1 Miles

Figure 4
Soils Map

Fenwick Road Over
Pomonkey Creek

Bryans Road, MD

Michael Baker
INTERNATIONAL

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Project: Pomonkey Creek, Maryland

Time of Concentration Calculations

Computed By: ***EDC*** Date: **2/7/24**

Checked By: ***HTL*** Date: **7/18/24**

DA 1

Sheet Flow:

Surface Description (Table 15-1)	Woods		
Manning's Roughness coeff., n	0.4	(see Table 15-1)	
Flow Length, L (Table 15-2) (<=100)	100	ft	
Two-yr, 24-hr rainfall, P2	3.18	inches	NOAA ATLAS 14
Land Slope, s	0.003	ft/ft	
Tt =(0.007 * (n*L)$^{0.8}$) / ($P_2^{0.5}$ * $s^{0.4}$)	0.77	hr =	46.0 min

Shallow Concentrated Flow:

Surface Description (Figure 15-4)	Woods		
Flow Length, L	4110	ft	
Watercourse slope, s	0.013	ft/ft	
Average Velocity, V (Figure 15-4)	0.27	ft/s	
Tt = L / (3600 * V)	4.23	hr =	253.7 min

Channel Flow:

Cross Sectional Flow Area, a	60	sq ft	
Wetted Perimeter, Pw	26	ft	
Hydraulic radius, r = a/Pw	2.31	ft	
Channel Slope, s	0.005	ft/ft	
Manning's Roughness coeff., n	0.05		
V = 1.49 * r2/3 * s1/2 / n	3.70	ft/s	
Flow Length, L	26151	ft	
Tt = L / (3600 * V)	1.96	hr	117.7 min

Total Watershed or subarea Tc	6.96	hr =	417.4 min

Table 15–1 Manning's roughness coefficients for sheet flow (flow depth generally ≤ 0.1 ft)

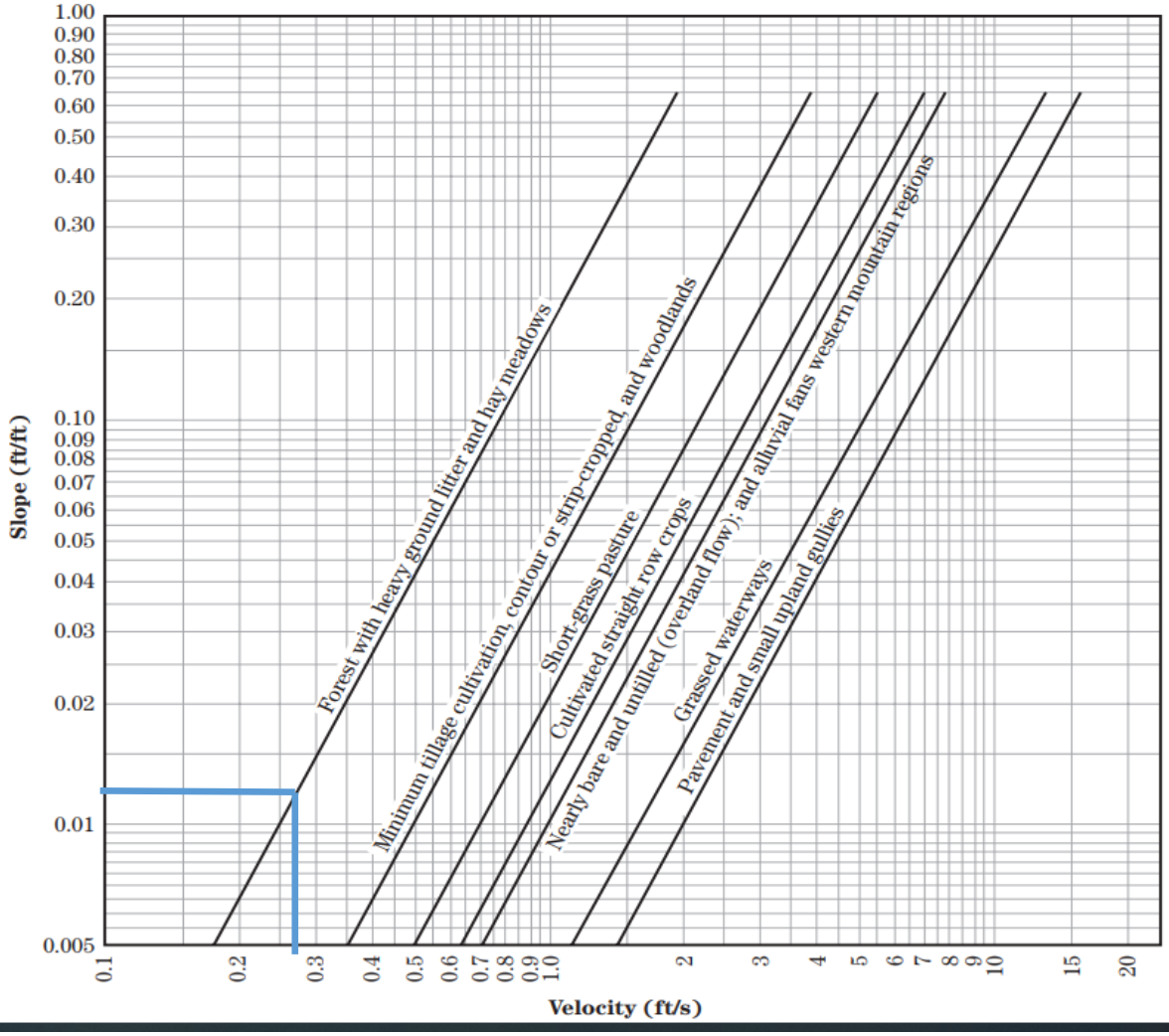
Surface description	n [1]
Smooth surface (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short-grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The Manning's n values are a composite of information compiled by Engman (1986).
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Table 15–2 Maximum sheet flow lengths using the McCuen-Spiess limitation criterion

Cover type	n values	Slope (ft/ft)	Length (ft)
Range	0.13	0.01	77
Grass	0.41	0.01	24
Woods	0.80	0.01	12.5
Range	0.13	0.05	172
Grass	0.41	0.05	55
Woods	0.80	0.05	28

Figure 15–4 Velocity versus slope for shallow concentrated flow



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Pokomoke Watershed Curve Number										
LANDUSE	DESCRIPTION	Curve Number (HSG A)	Area (ac)	Curve Number (HSG B)	Area (ac)	Curve Number (HSG C)	Area (ac)	Curve Number (HSG D)	Area (ac)	COMPOSITE CN
11	RESIDENTIAL, SINGLE UNIT, LOW DENSITY,20%	54	71.670	70	2.464	80	239.622	85	119.045	77
12	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY,25%	61	66.885	75	-	83	260.181	87	34.237	79
13	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	77	-	85	-	90	-	92	5.567	92
14	COMMERCIAL/SERVICES	89	-	92	-	94	10.866	95	2.494	94
15	INDUSTRIAL	81	-	88	-	91	1.674	93	0.000	91
16	ALTERED LANDS	77	-	86	-	91	2.228	94	0.000	91
18	OTHER AGRICULTURE	39	-	61	-	74	15.677	80	0.179	74
21	CROPLAND AND PASTURELAND	49	23.767	69	11.281	79	53.530	84	178.954	79
22	CROPLAND AND PASTURELAND	49	0.864	69	2.010	79	-	84	37.864	83
41	DECIDUOUS FOREST (10-50% CROWN CLOSURE)	36	387.625	60	27.876	73	1682.761	79	1378.135	71
42	CONIFEROUS FOREST (10-50% CROWN CLOSURE)	36	32.348	60	-	73	113.739	79	54.451	69
43	MIXED FOREST (>50% CONIFEROUS WITH 10-50% CROWN CLOSURE)	36	48.487	60	-	73	80.066	79	48.643	65
44	DECIDUOUS BRUSH/SHRUBLAND	35	32.686	56	-	70	-	77	13.169	47
50	ARTIFICIAL LAKES	100	0.791	100	-	100	-	100	112.561	100
60	DECIDUOUS WOODED WETLANDS	88	4.388	89	-	93	-	96	93.267	95
73	UPLAND RIGHTS-OF-WAY UNDEVELOPED	72	-	82	-	87	17.927	89	0.519	87
80	TRANSPORTATION/COMMUNICATION/UTILITIES	30	-	55	-	70	2.665	77	3.091	74
191	RESIDENTIAL, SINGLE UNIT, LOW DENSITY	51	3.087	68	1.970	79	27.585	84	64.101	81
192	MIXED FOREST (>50% DECIDUOUS WITH 10-50% CROWN CLOSURE)	36	75.745	60	5.014	73	136.830	79	143.940	67
Total (ac)		**5735**								
Pervious CN		**73**								

Project: Pomonkey_Creek_
Simulation Run: 10yrCurrent
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:14

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	671.84	01Jan2024, 19:54	0.95

Subbasin: Subbasin-1

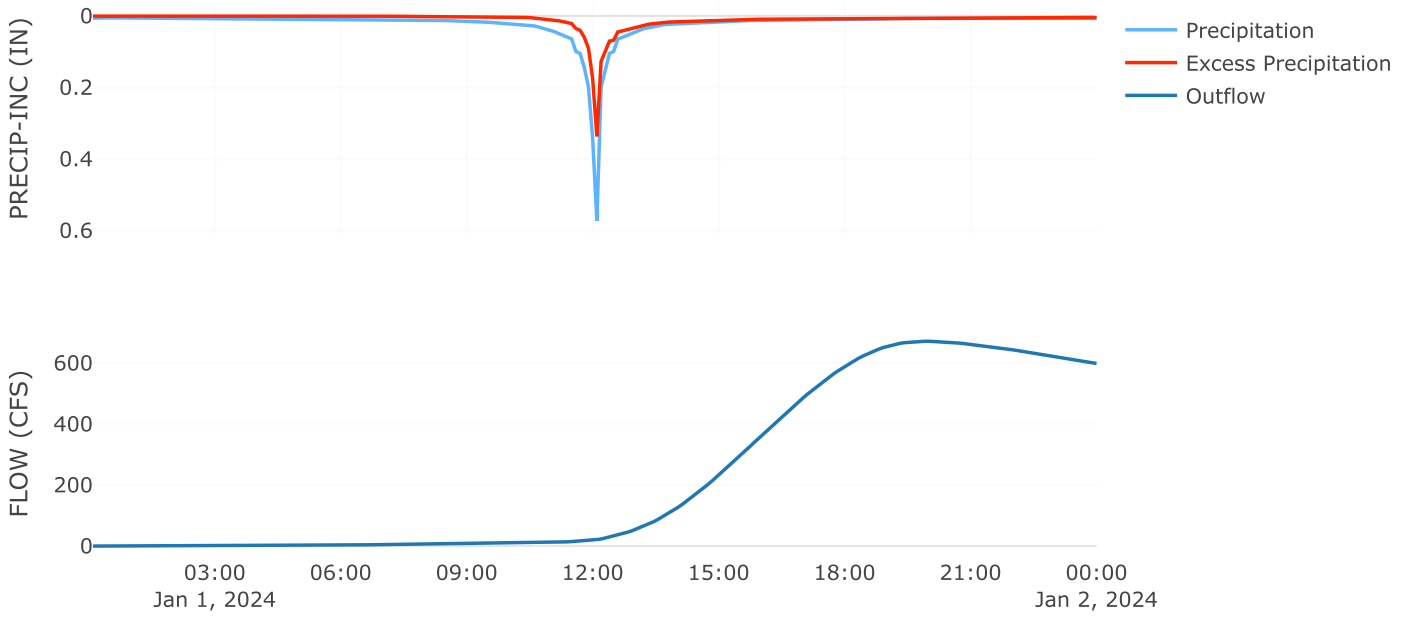
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

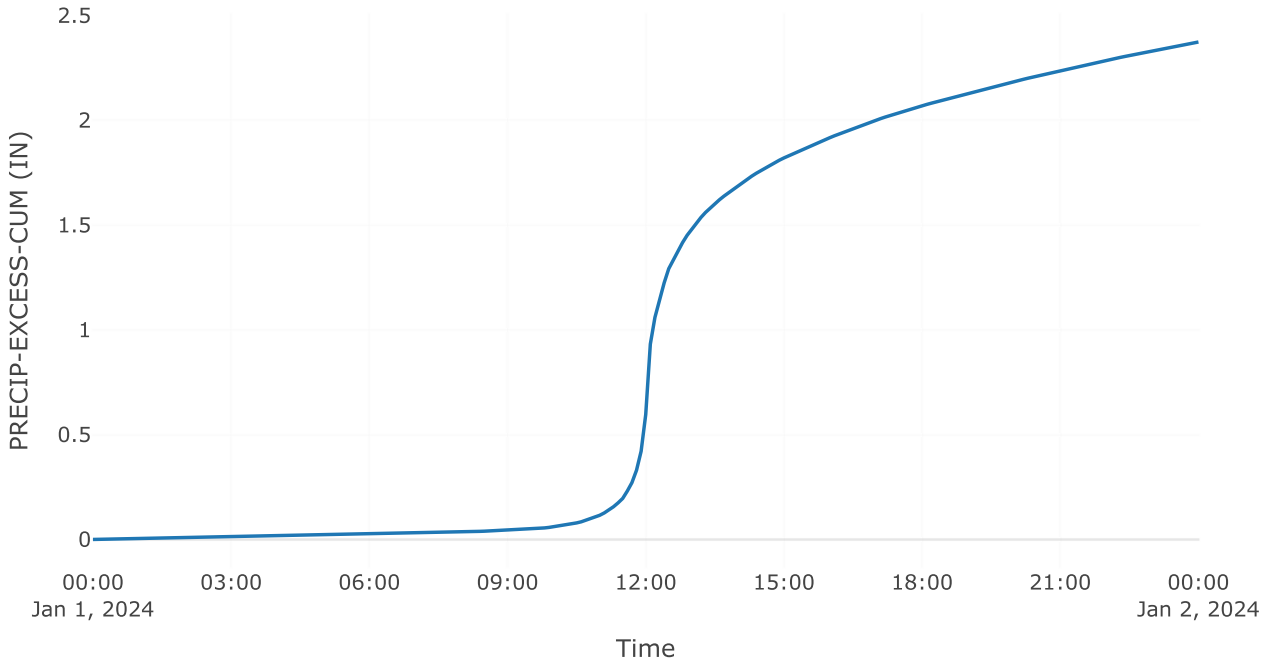
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	671.84
Time of Peak Discharge	01Jan2024, 19:54
Volume (IN)	0.95
Precipitation Volume (AC - FT)	2346.33
Loss Volume (AC - FT)	1211.87
Excess Volume (AC - FT)	1134.45
Direct Runoff Volume (AC - FT)	453.66
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 10yr2050
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:14

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	775.31	01Jan2024, 19:54	1.1

Subbasin: Subbasin-1

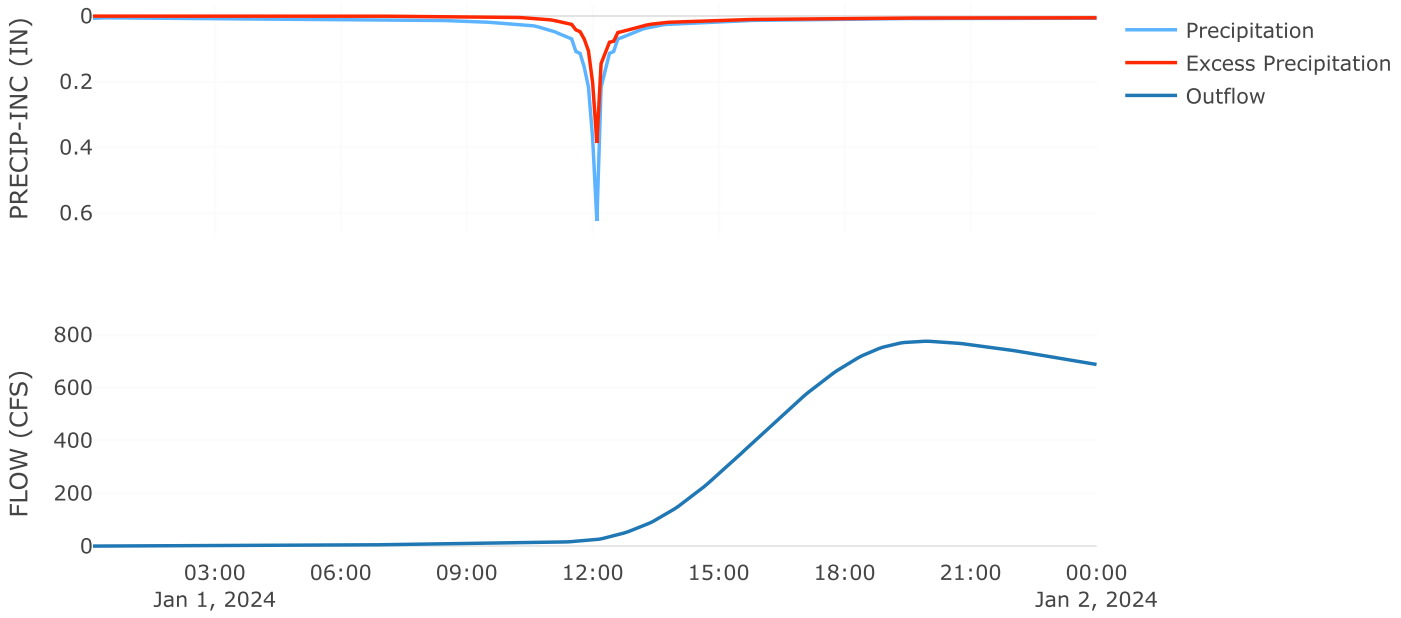
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

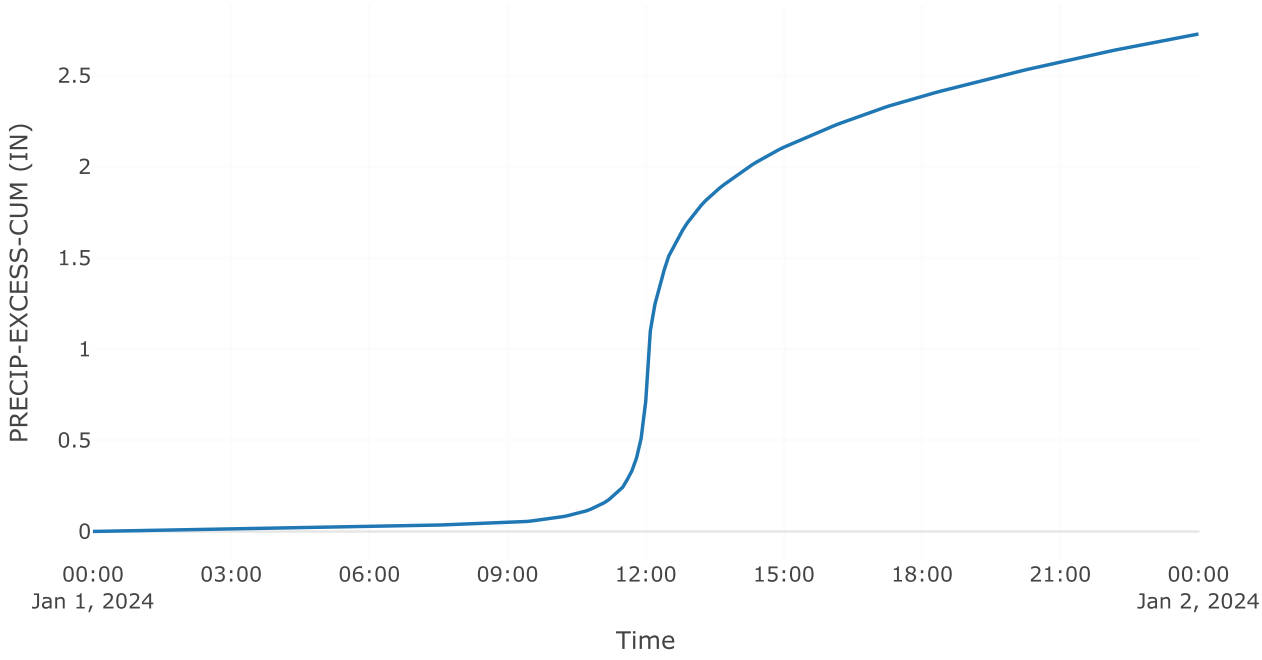
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	775.31
Time of Peak Discharge	01Jan2024, 19:54
Volume (IN)	1.1
Precipitation Volume (AC - FT)	2556.59
Loss Volume (AC - FT)	1253.19
Excess Volume (AC - FT)	1303.39
Direct Runoff Volume (AC - FT)	524.45
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 10yr2080
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:14

Subbasin: Subbasin-1

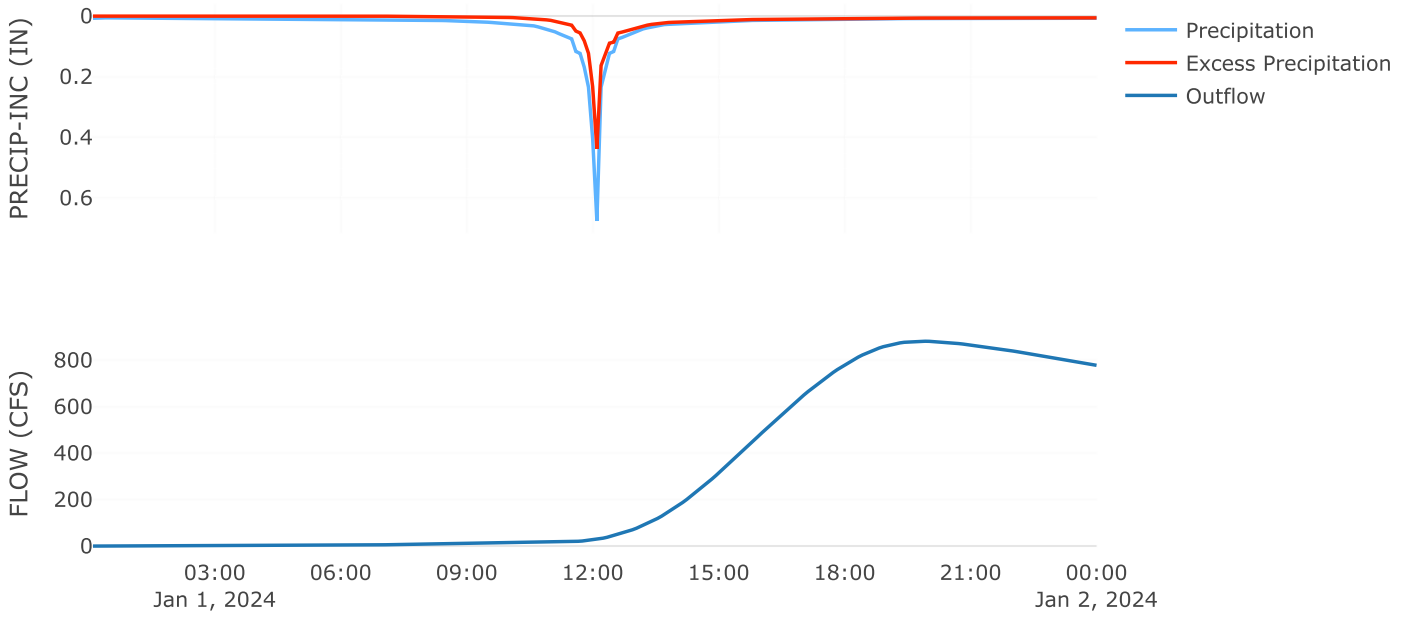
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

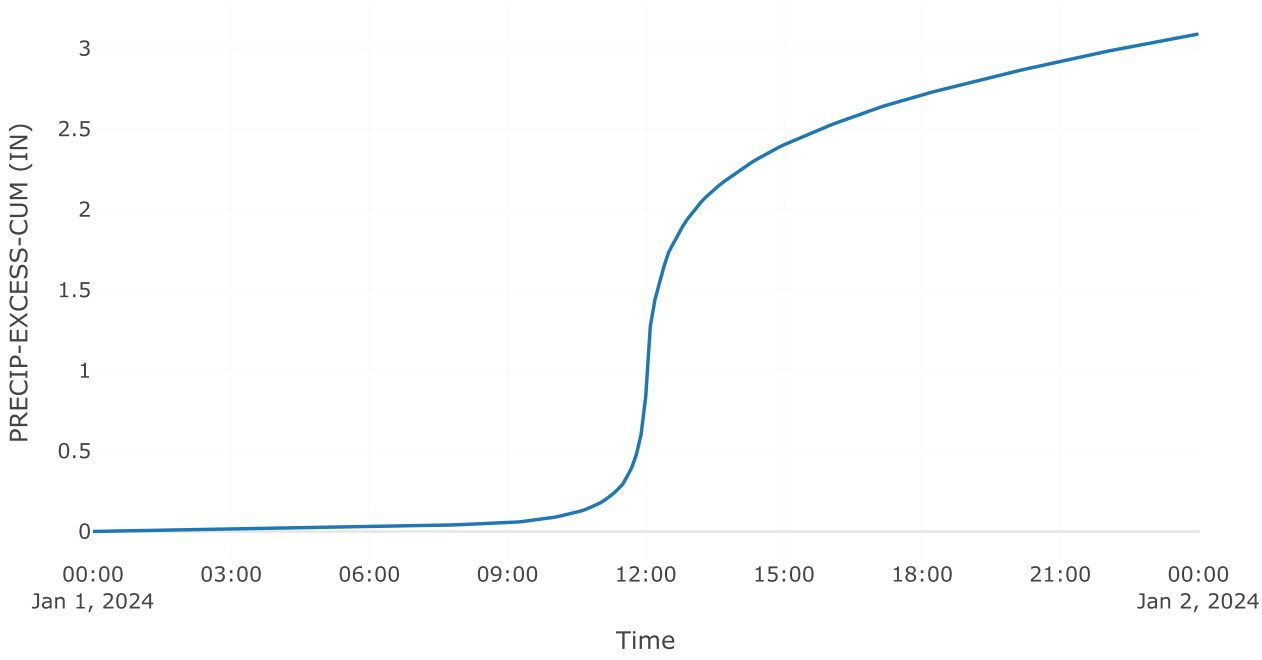
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	881.5
Time of Peak Discharge	01Jan2024, 19:48
Volume (IN)	1.25
Precipitation Volume (AC - FT)	2766.85
Loss Volume (AC - FT)	1290.36
Excess Volume (AC - FT)	1476.49
Direct Runoff Volume (AC - FT)	597.43
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 25yrCurrent
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:16

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	970.23	01Jan2024, 19:48	1.38

Subbasin: Subbasin-1

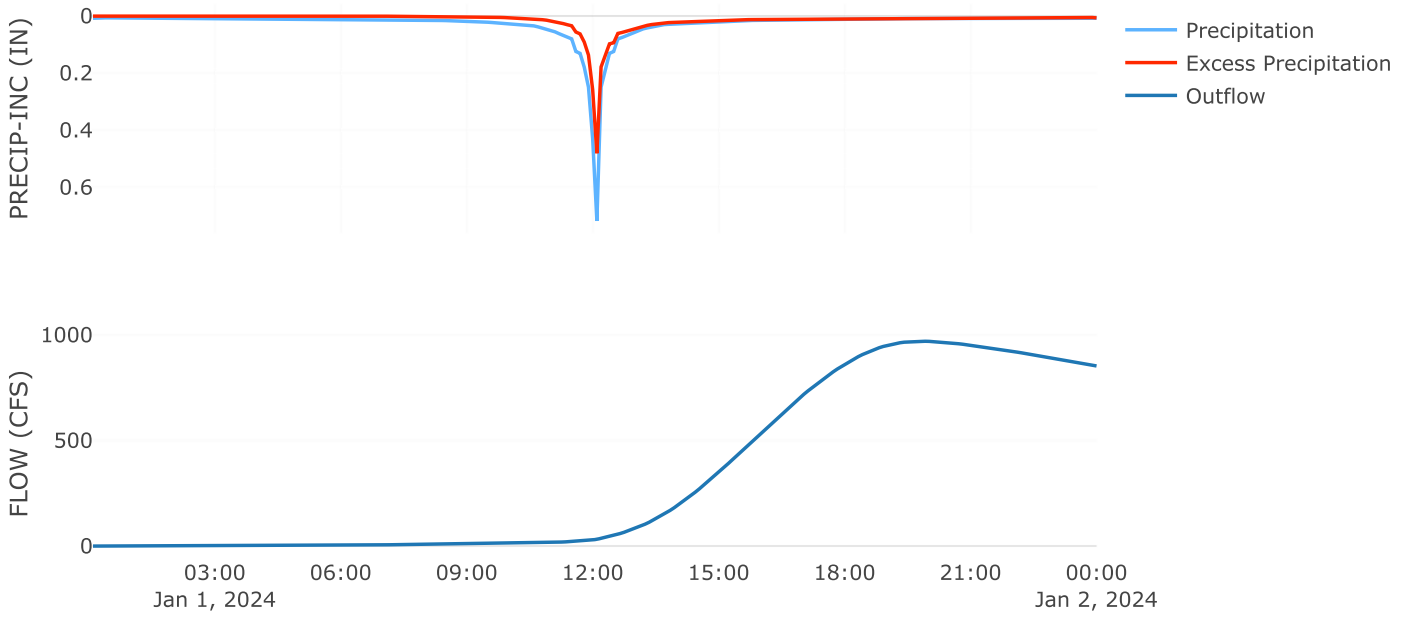
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

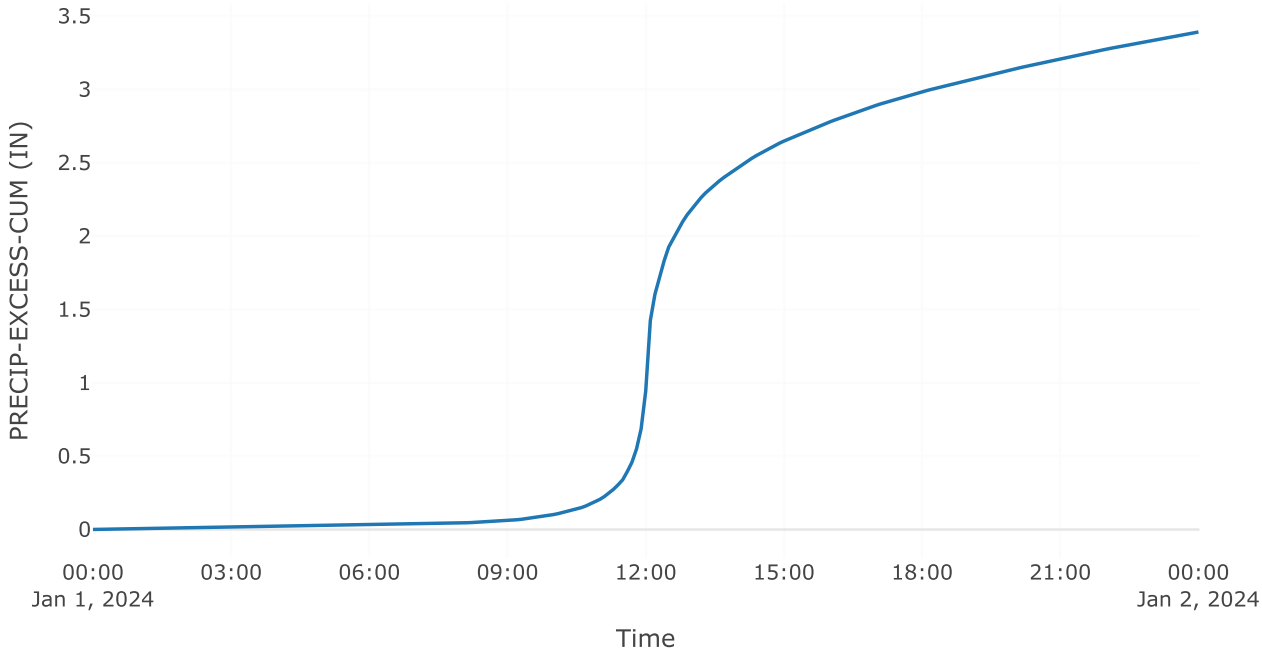
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	970.23
Time of Peak Discharge	01Jan2024, 19:48
Volume (IN)	1.38
Precipitation Volume (AC - FT)	2938.88
Loss Volume (AC - FT)	1318.1
Excess Volume (AC - FT)	1620.78
Direct Runoff Volume (AC - FT)	658.57
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 25yr2050
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:16

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	1156.72	01Jan2024, 19:48	1.65

Subbasin: Subbasin-1

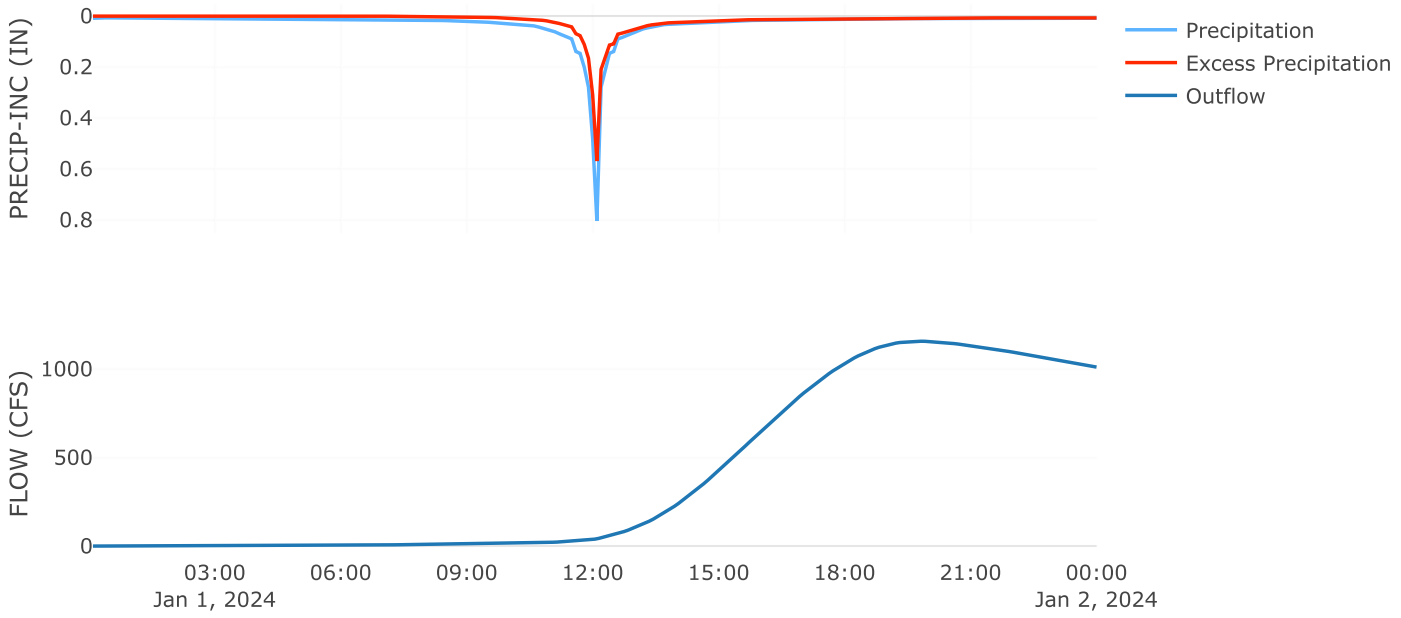
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

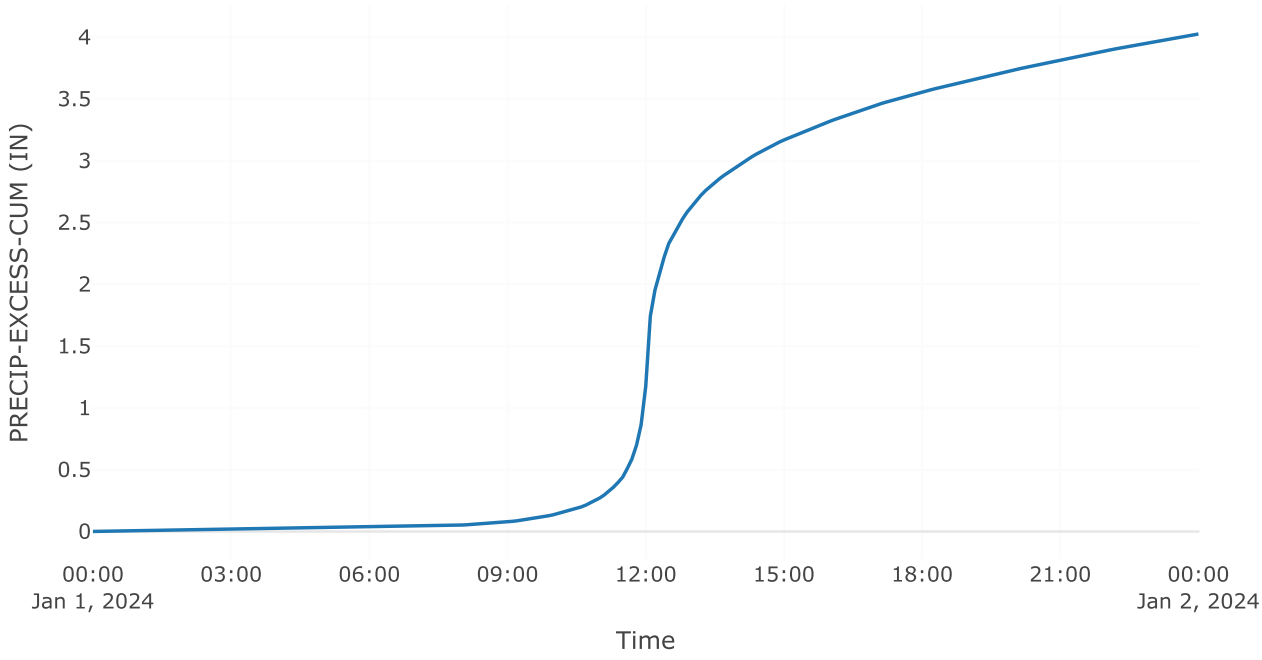
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	1156.72
Time of Peak Discharge	01Jan2024, 19:48
Volume (IN)	1.65
Precipitation Volume (AC - FT)	3292.5
Loss Volume (AC - FT)	1368.75
Excess Volume (AC - FT)	1923.75
Direct Runoff Volume (AC - FT)	787.76
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 25yr2080
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:16

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	1267.22	01Jan2024, 19:42	1.81

Subbasin: Subbasin-1

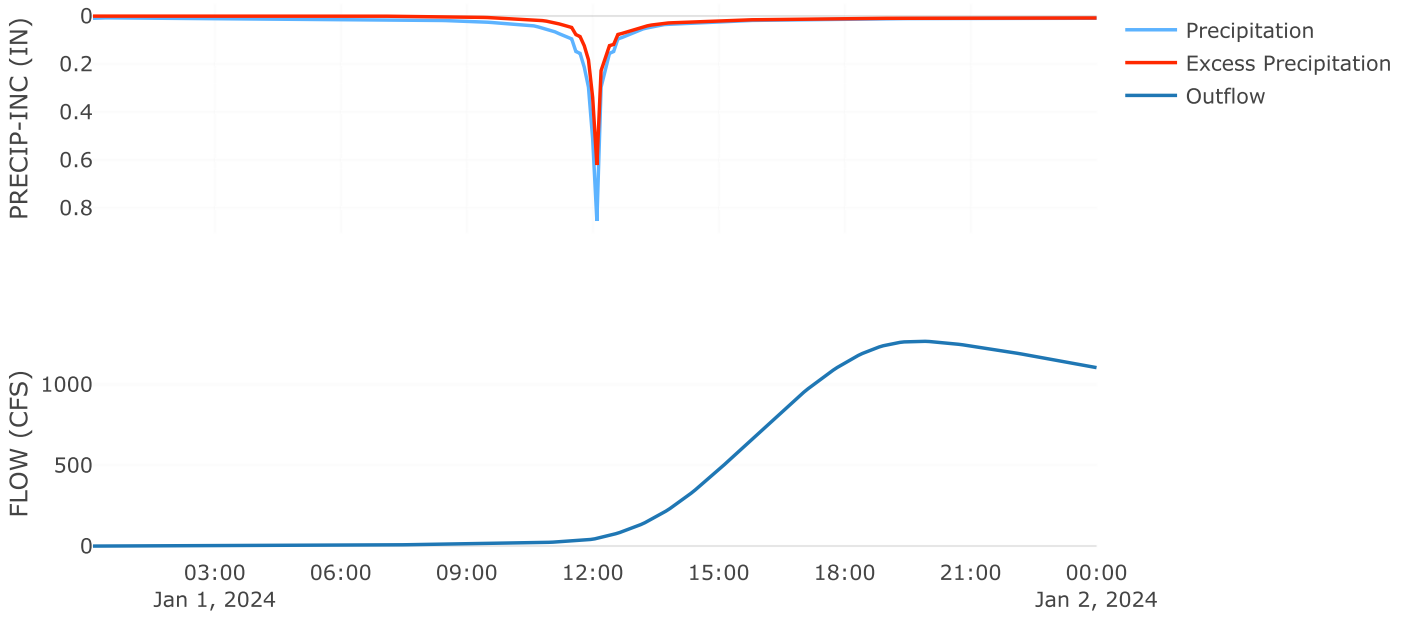
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

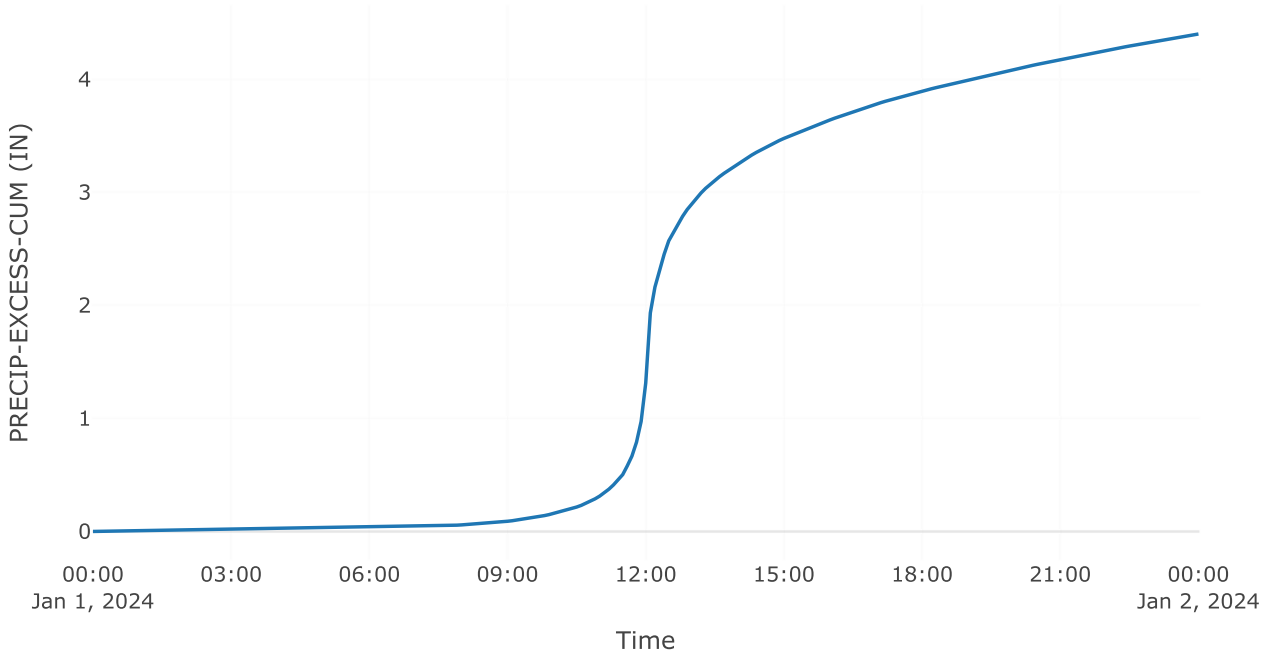
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	1267.22
Time of Peak Discharge	01Jan2024, 19:42
Volume (IN)	1.81
Precipitation Volume (AC - FT)	3497.98
Loss Volume (AC - FT)	1394.83
Excess Volume (AC - FT)	2103.16
Direct Runoff Volume (AC - FT)	864.7
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 50yrCurrent
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:16

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	1249.13	01Jan2024, 19:48	1.78

Subbasin: Subbasin-1

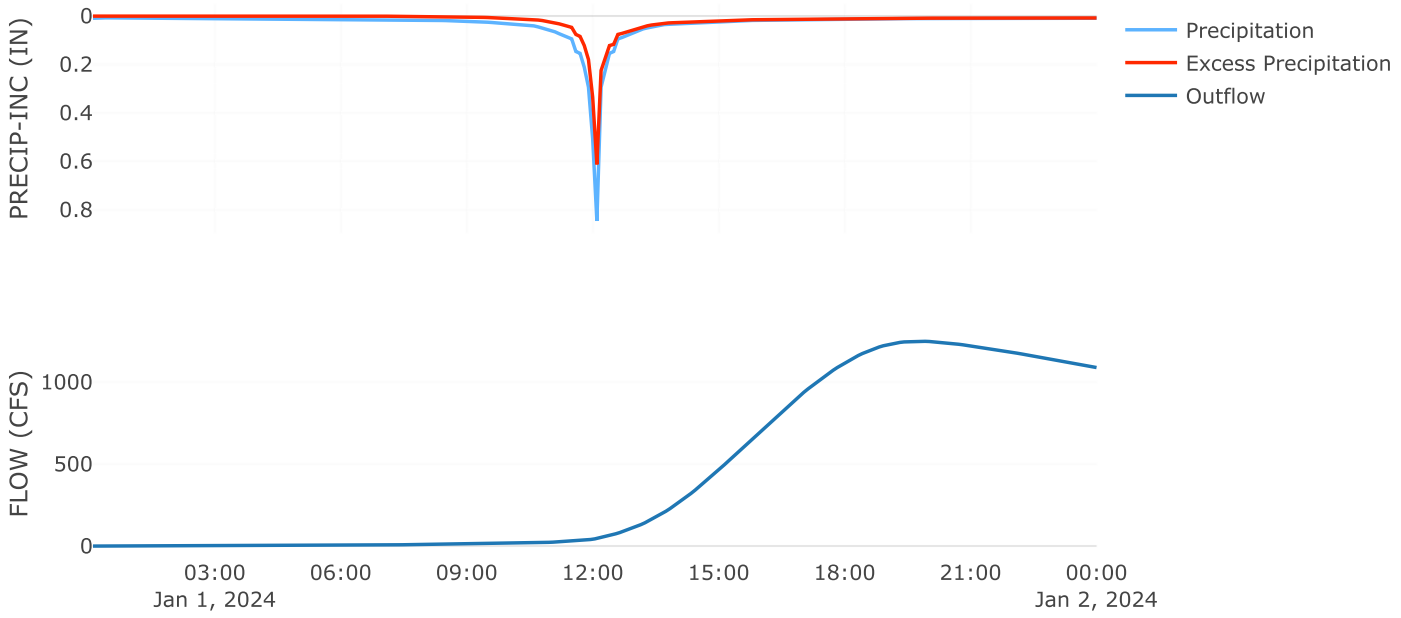
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

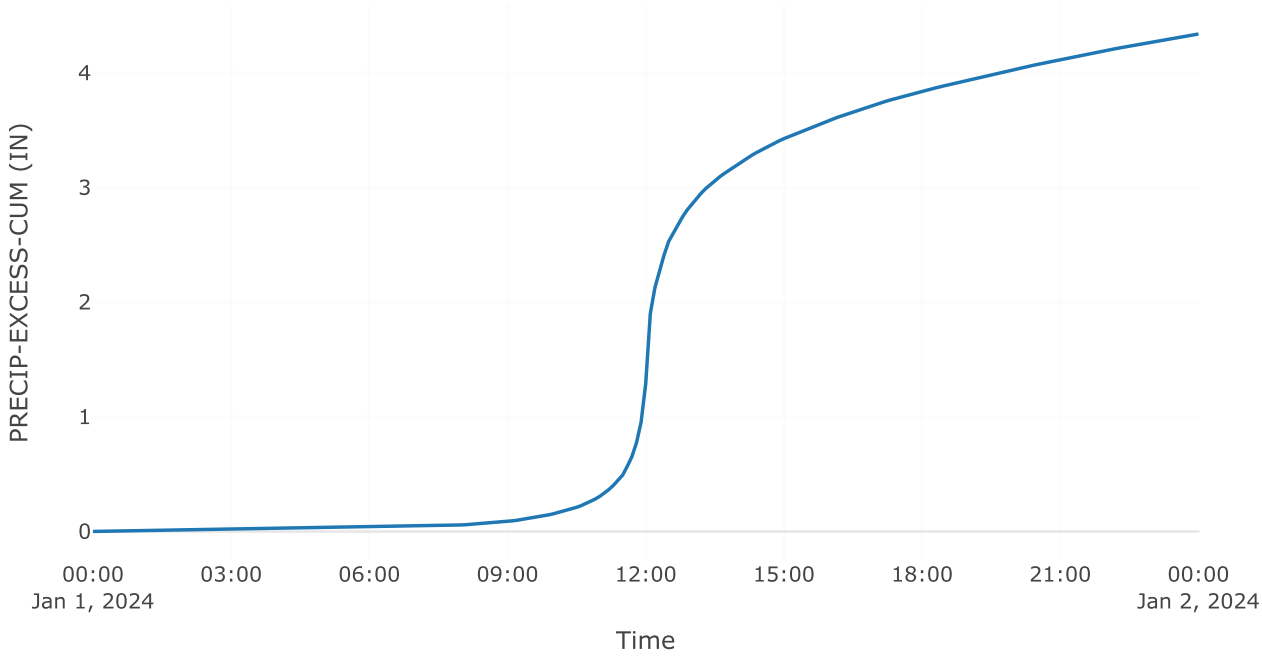
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	1249.13
Time of Peak Discharge	01Jan2024, 19:48
Volume (IN)	1.78
Precipitation Volume (AC - FT)	3464.53
Loss Volume (AC - FT)	1390.73
Excess Volume (AC - FT)	2073.8
Direct Runoff Volume (AC - FT)	852.09
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 50yr2050
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:16

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	1516.11	01Jan2024, 19:42	2.17

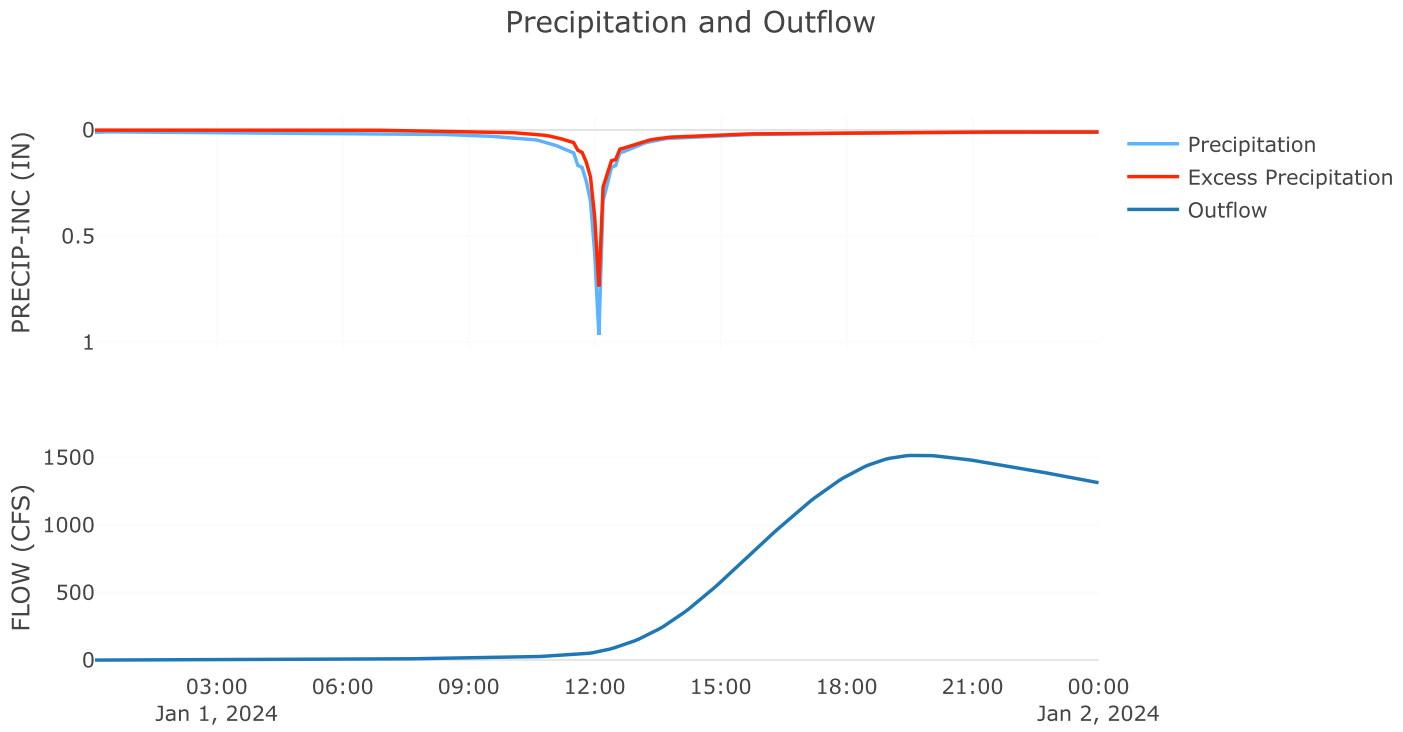
Subbasin: Subbasin-1

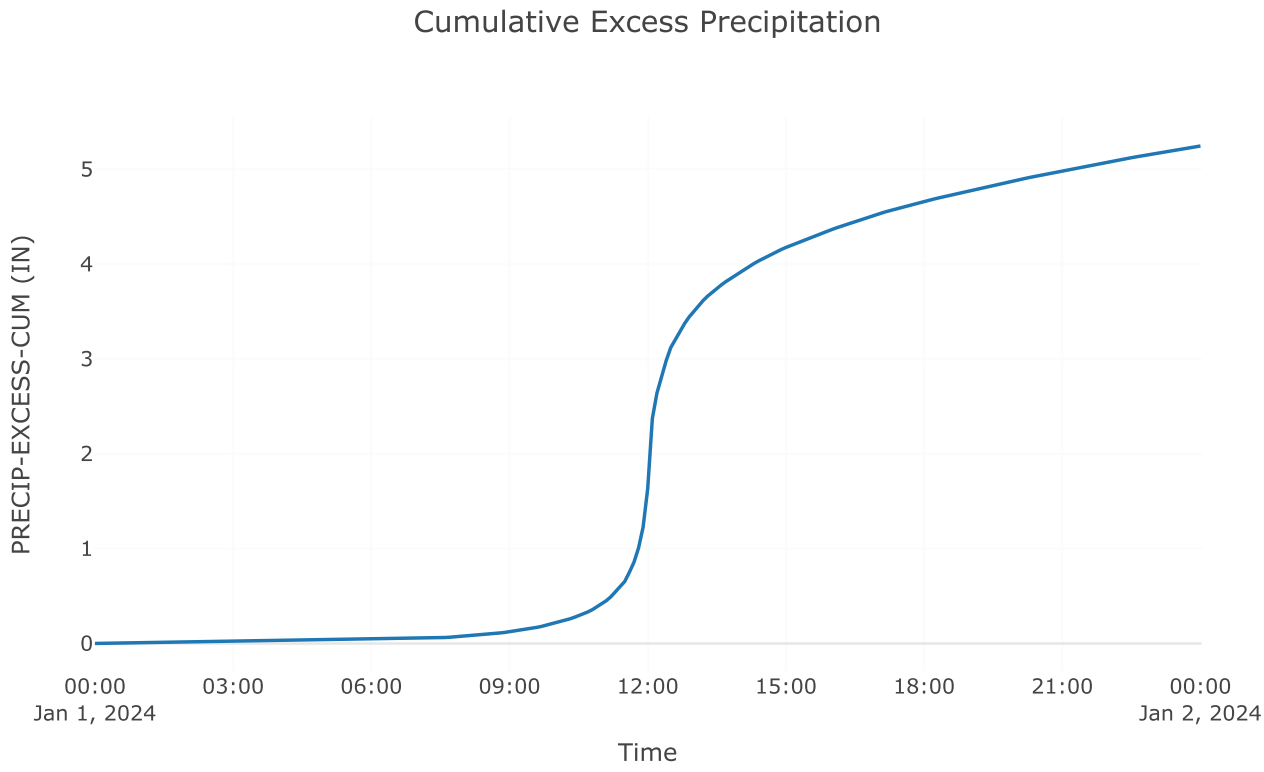
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	1516.11
Time of Peak Discharge	01Jan2024, 19:42
Volume (IN)	2.17
Precipitation Volume (AC - FT)	3951.96
Loss Volume (AC - FT)	1445.37
Excess Volume (AC - FT)	2506.59
Direct Runoff Volume (AC - FT)	1038.77
Baseflow Volume (AC - FT)	0


Precipitation and Outflow
PRECIP-INC (IN)
0
0.5
1
Precipitation
Excess Precipitation
Outflow
FLOW (CFS)
1500
1000
500
0
03:00
Jan 1, 2024
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2024


Cumulative Excess Precipitation
PRECIP-EXCESS-CUM (IN)
5
4
3
2
1
0
00:00
Jan 1, 2024
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2024
Time

Project: Pomonkey_Creek_
Simulation Run: 50yr2080
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:17

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	1630.46	01Jan2024, 19:42	2.34

Subbasin: Subbasin-1

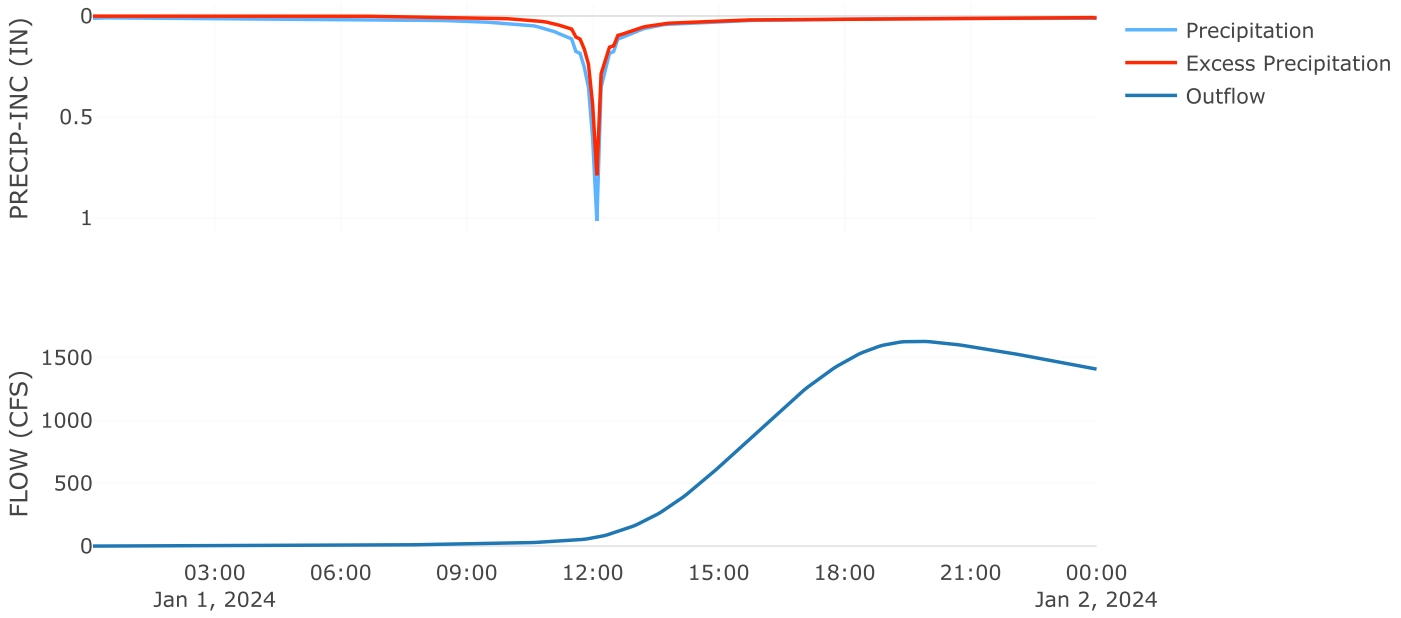
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

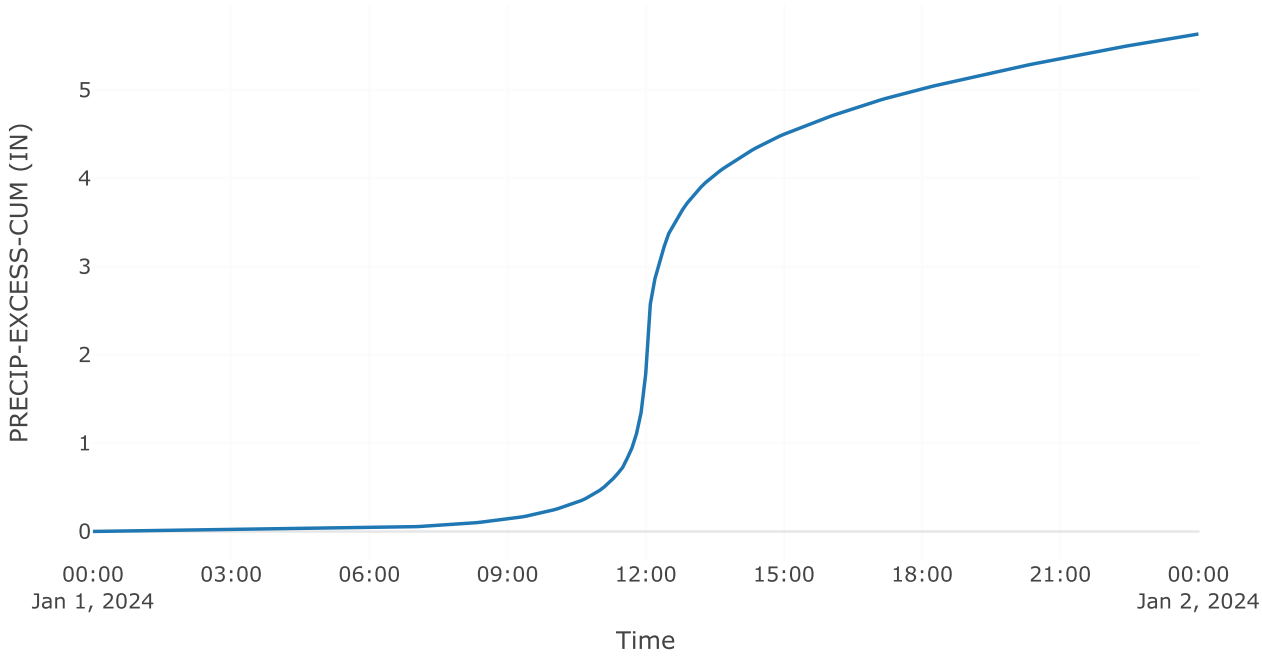
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	1630.46
Time of Peak Discharge	01Jan2024, 19:42
Volume (IN)	2.34
Precipitation Volume (AC - FT)	4157.44
Loss Volume (AC - FT)	1465.54
Excess Volume (AC - FT)	2691.9
Direct Runoff Volume (AC - FT)	1119.16
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 100yrCurrent
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:15

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	1571.84	01Jan2024, 19:42	2.26

Subbasin: Subbasin-1

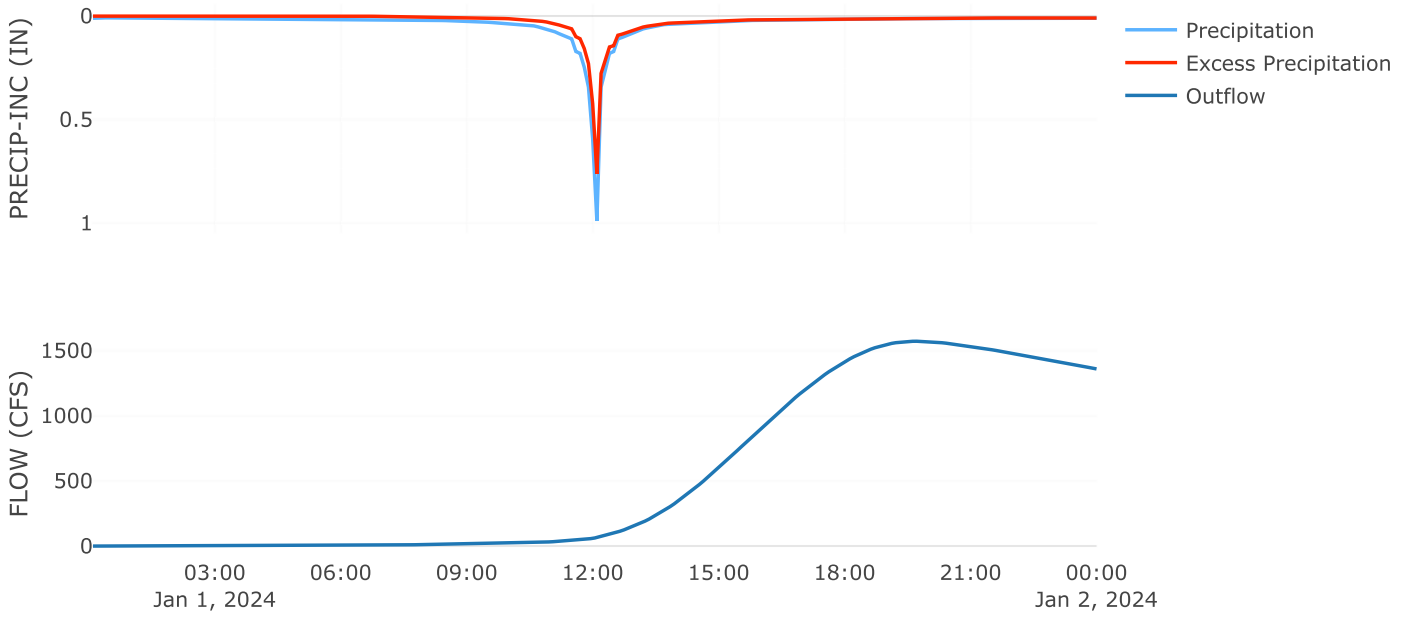
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

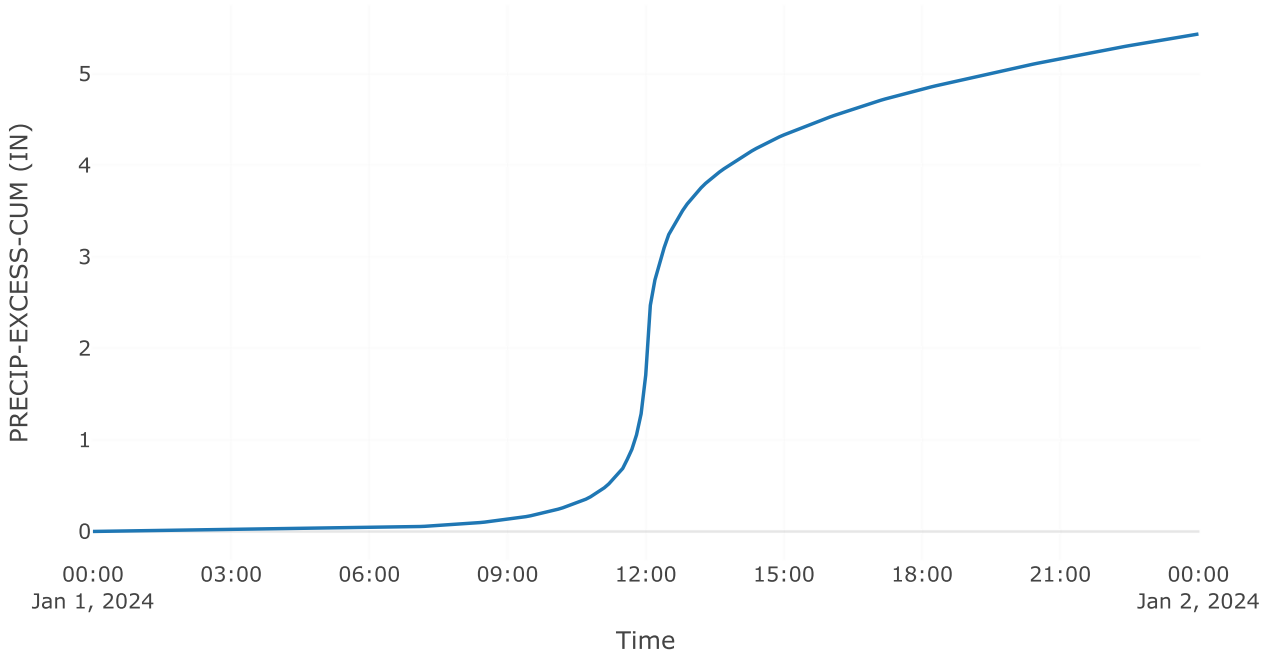
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	1571.84
Time of Peak Discharge	01Jan2024, 19:42
Volume (IN)	2.26
Precipitation Volume (AC - FT)	4052.31
Loss Volume (AC - FT)	1455.41
Excess Volume (AC - FT)	2596.9
Direct Runoff Volume (AC - FT)	1077.92
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 100yr2050
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:15

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	1913.16	01Jan2024, 19:42	2.76

Subbasin: Subbasin-1

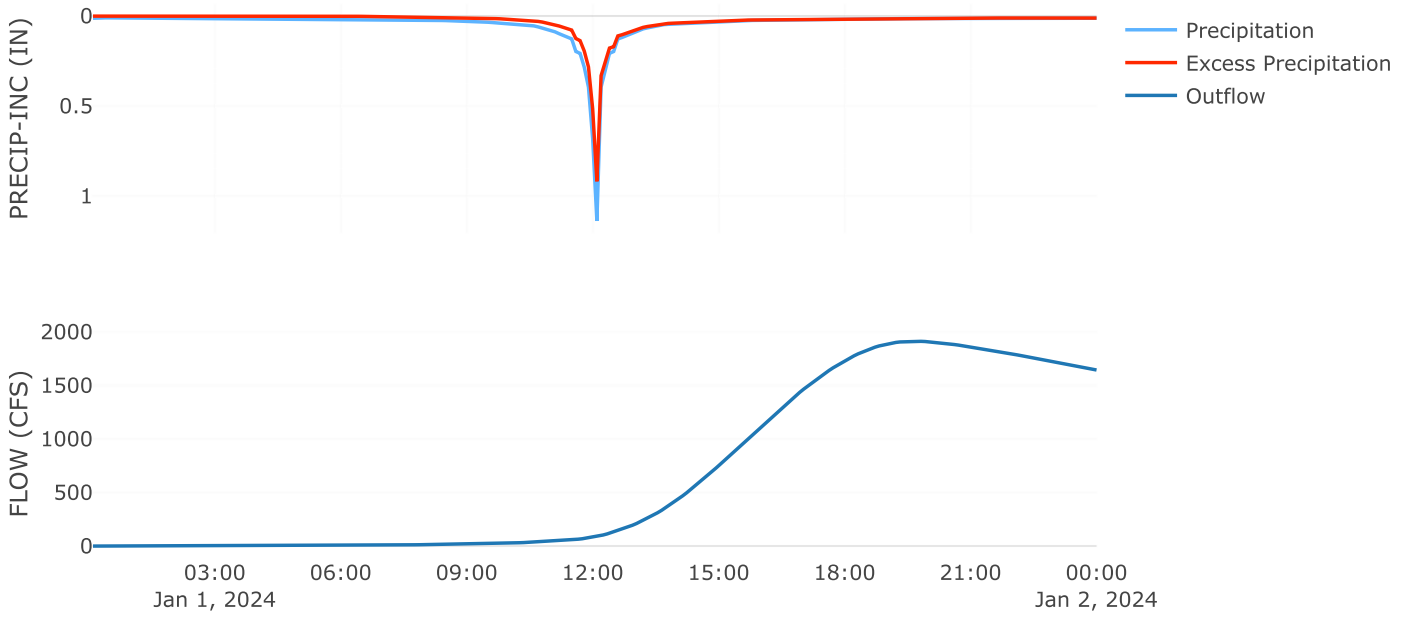
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

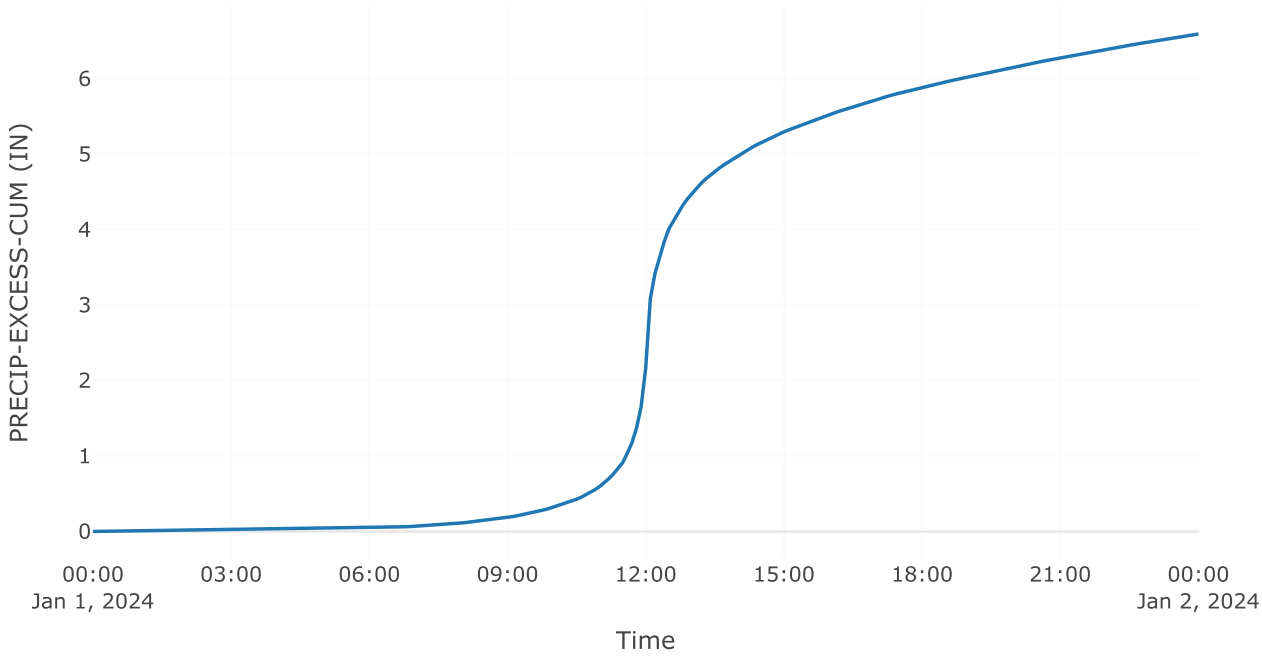
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	1913.16
Time of Peak Discharge	01Jan2024, 19:42
Volume (IN)	2.76
Precipitation Volume (AC - FT)	4659.2
Loss Volume (AC - FT)	1509.05
Excess Volume (AC - FT)	3150.15
Direct Runoff Volume (AC - FT)	1318.93
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Excess Precipitation



Project: Pomonkey_Creek_
Simulation Run: 100yr2080
Simulation Start: 31 December 2023, 24:00
Simulation End: 1 January 2024, 24:00

HMS Version: 4.11
Executed: 14 March 2024, 15:15

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	8.96

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Subbasin - 1	6.07	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	417	Delmarva

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	8.96	2052.11	01Jan2024, 19:36	2.97

Subbasin: Subbasin-1

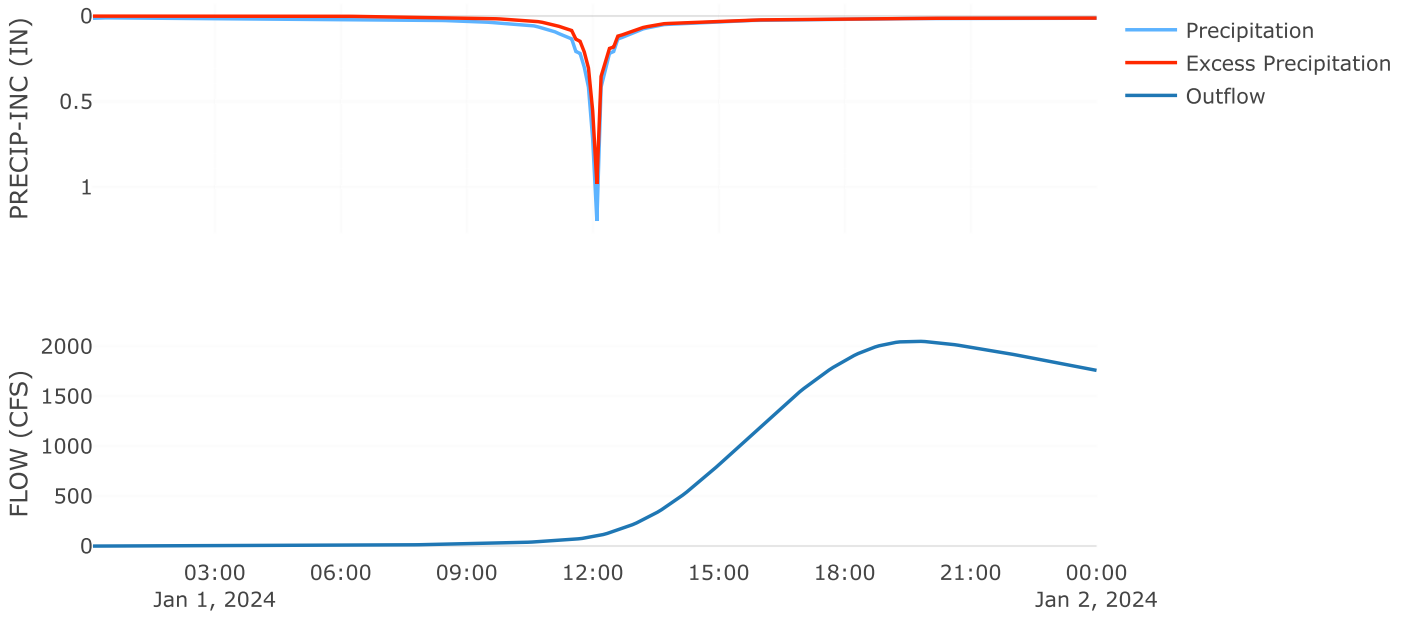
Area (MI2) : 8.96

Loss Rate: Scs	
Percent Impervious Area	6.07
Curve Number	73

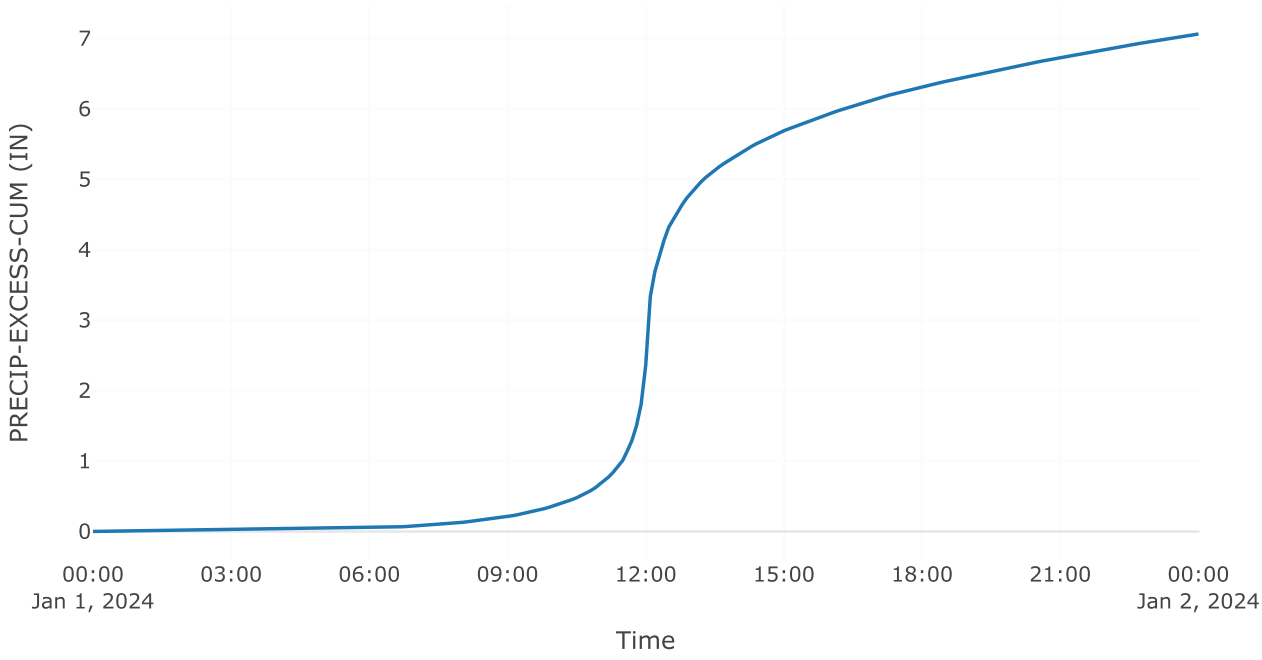
Transform: Scs	
Lag	417
Unitgraph Type	Delmarva

Results: Subbasin-1	
Peak Discharge (CFS)	2052.11
Time of Peak Discharge	01Jan2024, 19:36
Volume (IN)	2.97
Precipitation Volume (AC - FT)	4902.91
Loss Volume (AC - FT)	1527.69
Excess Volume (AC - FT)	3375.22
Direct Runoff Volume (AC - FT)	1417.51
Baseflow Volume (AC - FT)	0

Precipitation and Outflow

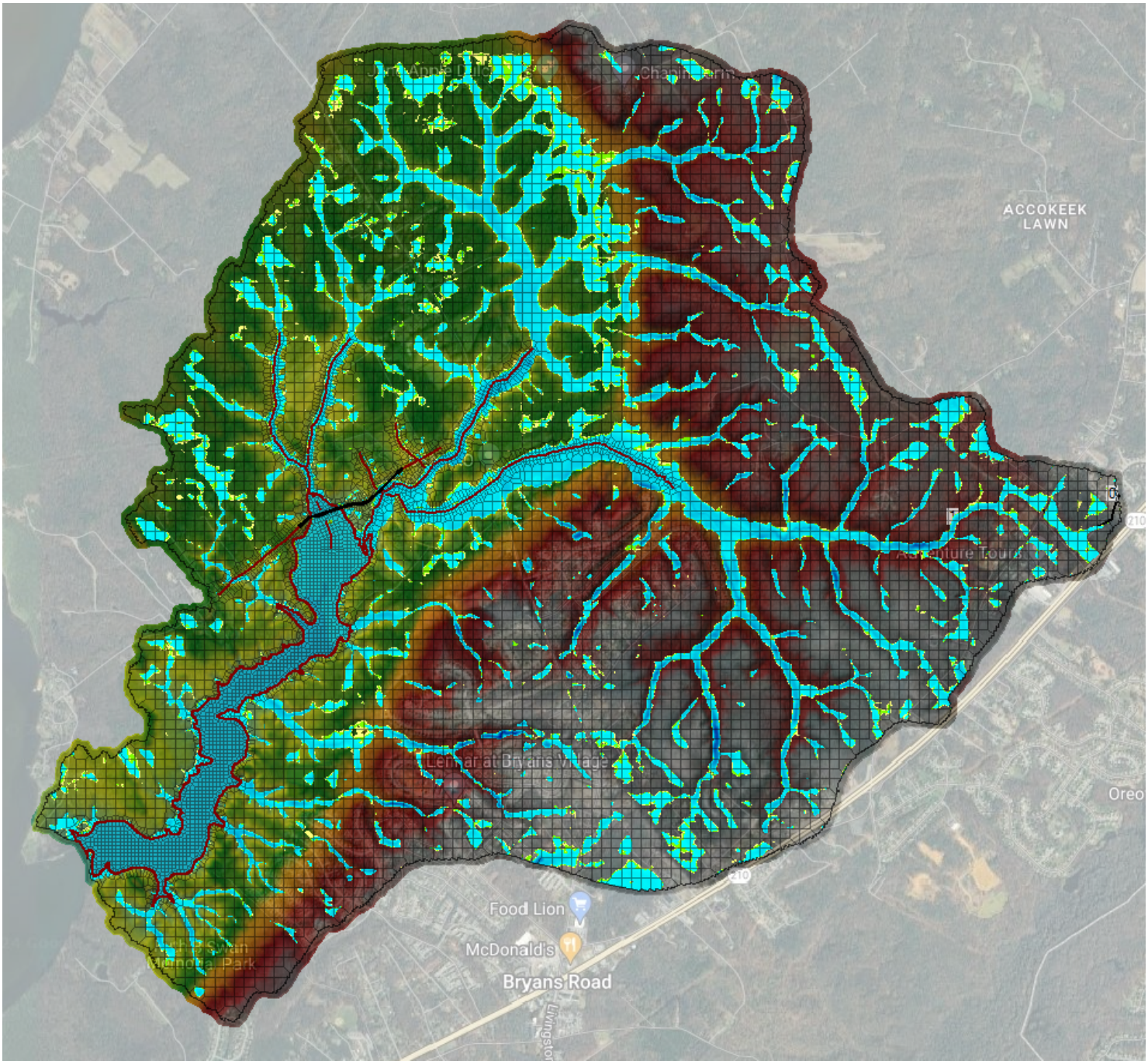


Cumulative Excess Precipitation

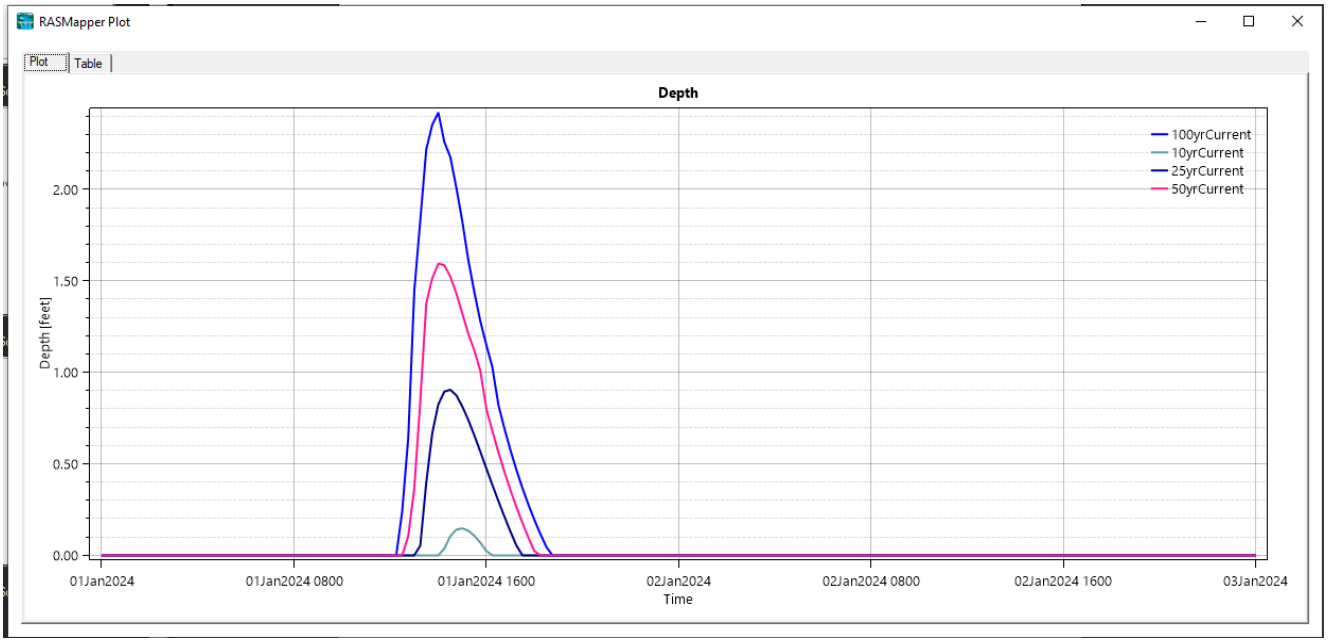


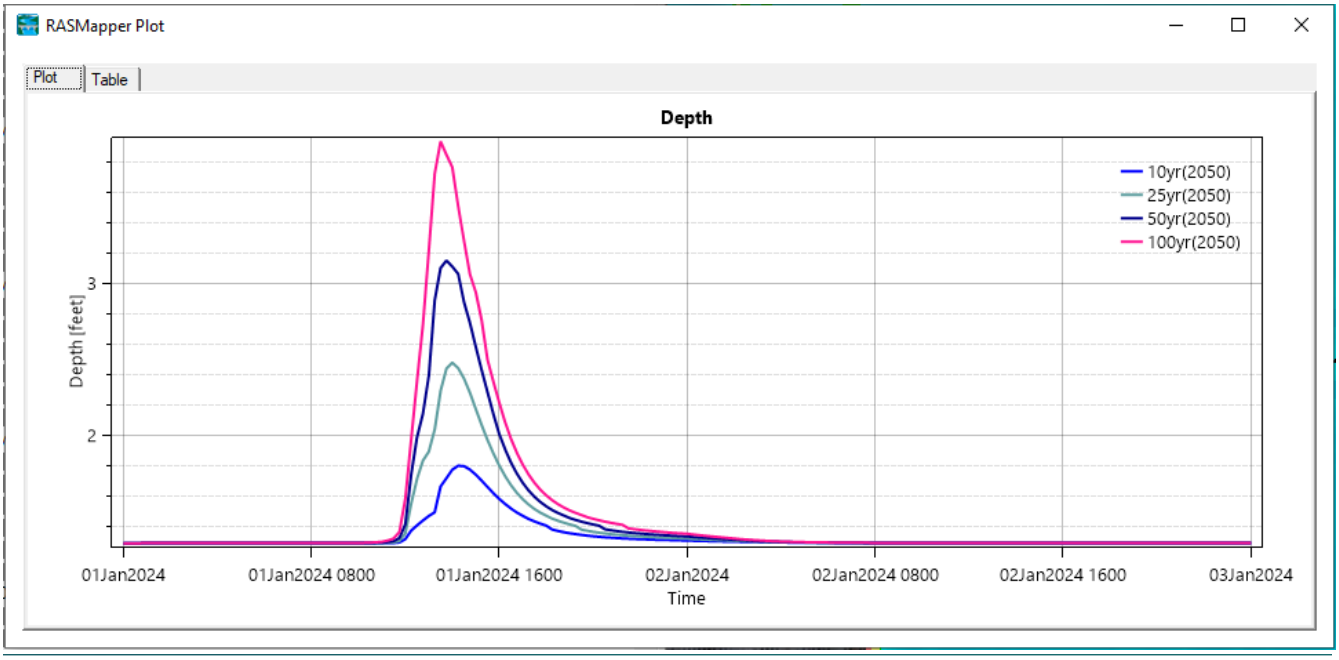
Attachment 4
Hydraulic Analysis

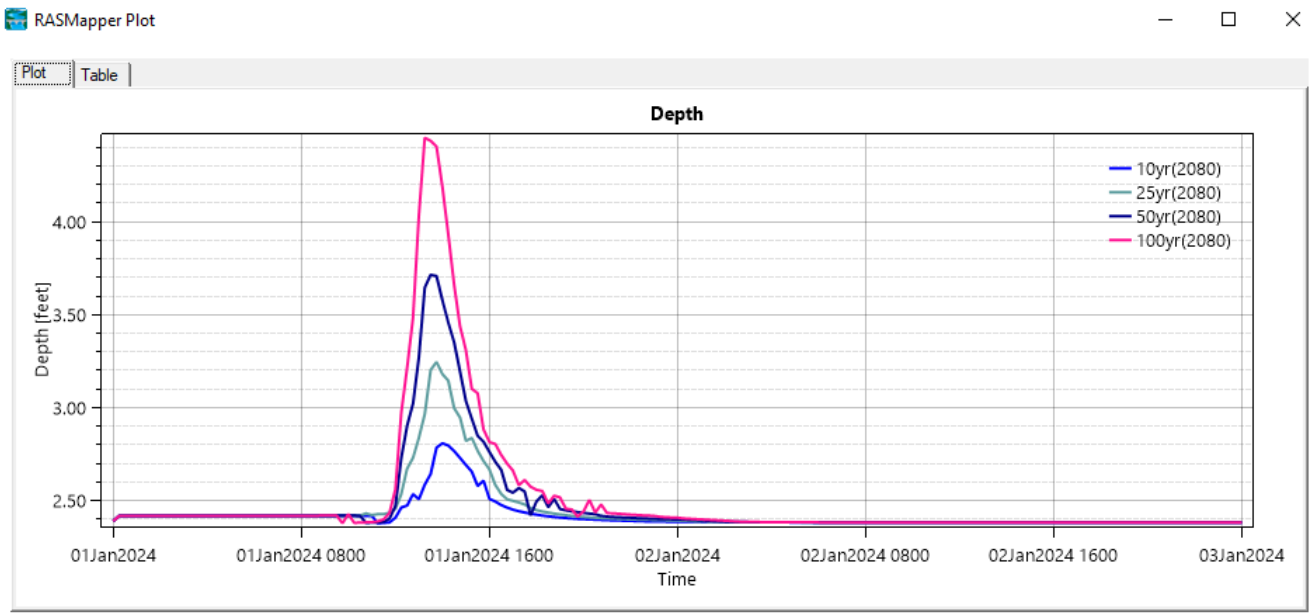
HEC-RAS 2D MODEL DOMAIN



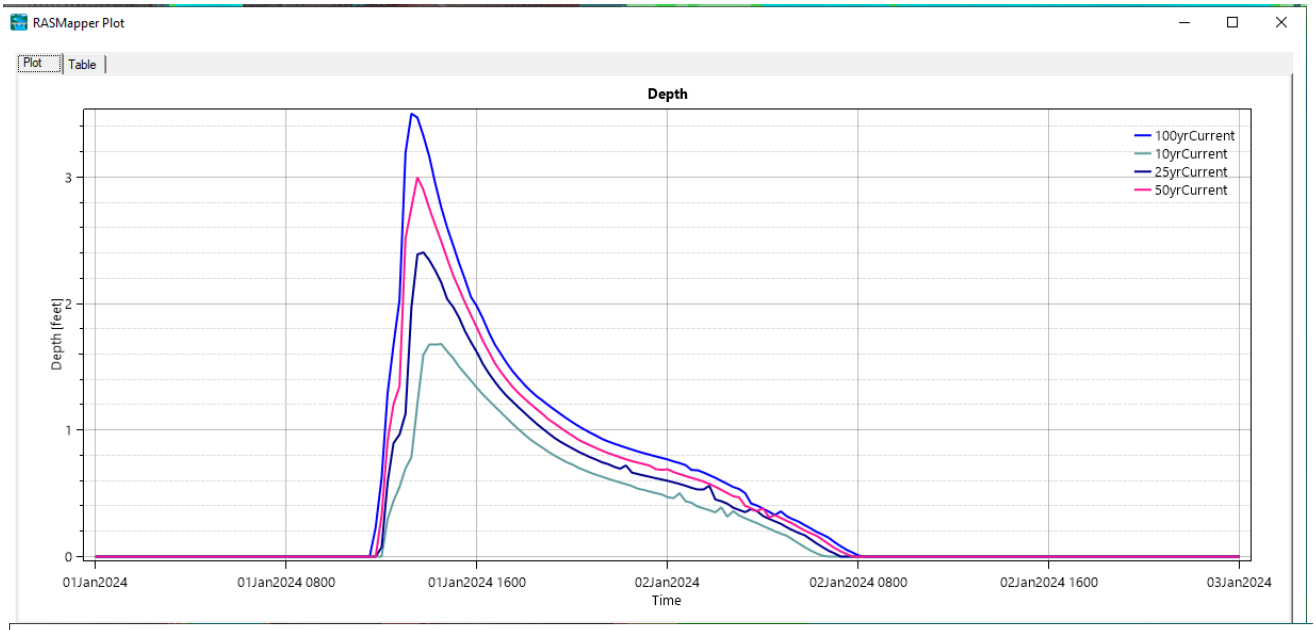
EXISTING CONDITIONS
FLOODING OVER FENWICK ROAD OVER POMONKEY

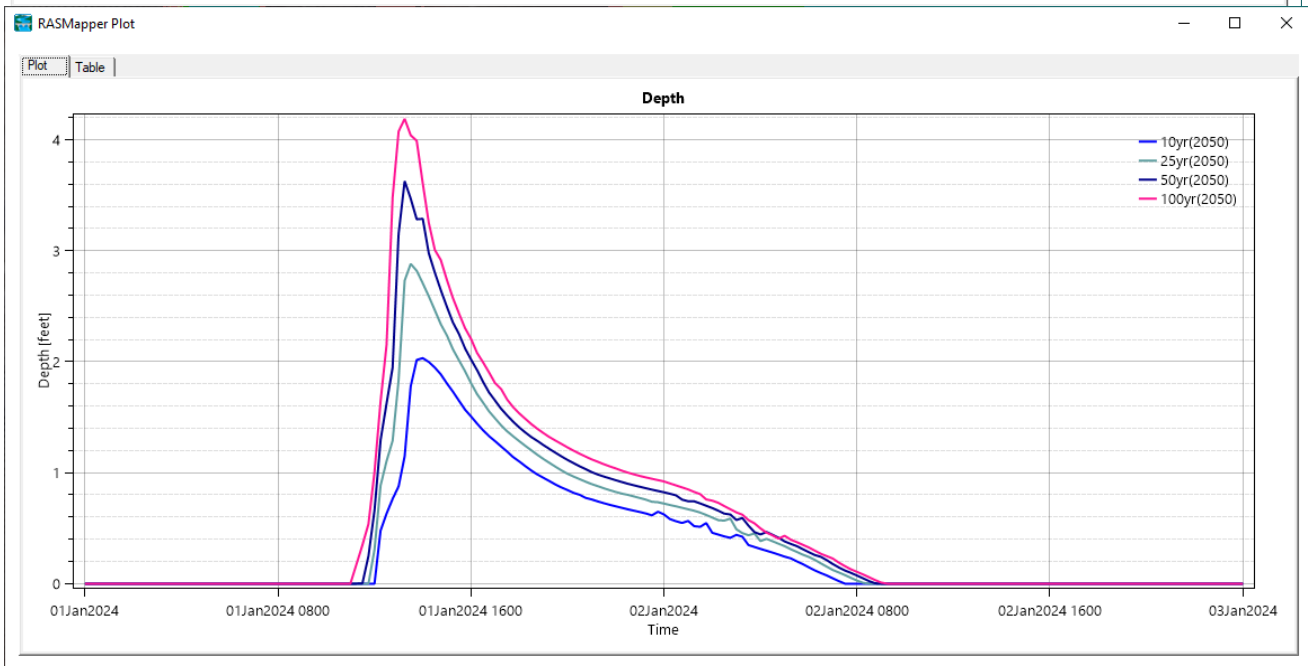


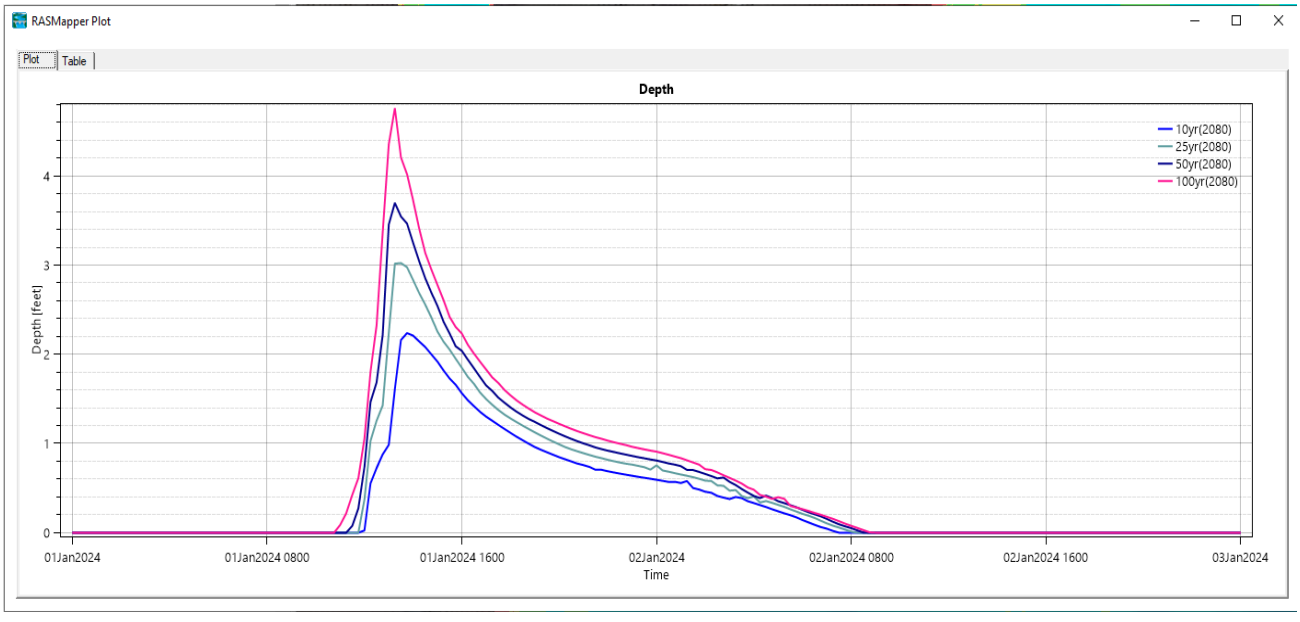




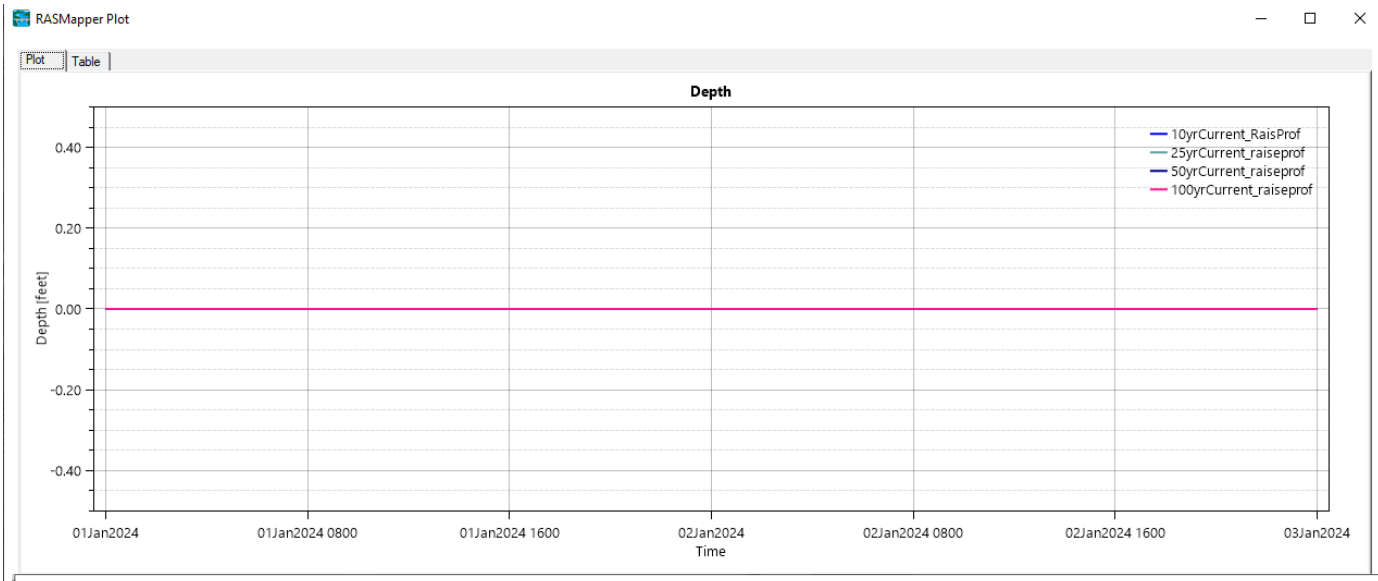
EXISTING CONDITIONS
FLOODING OVER FENWICK ROAD ALONG MILL SWAMP

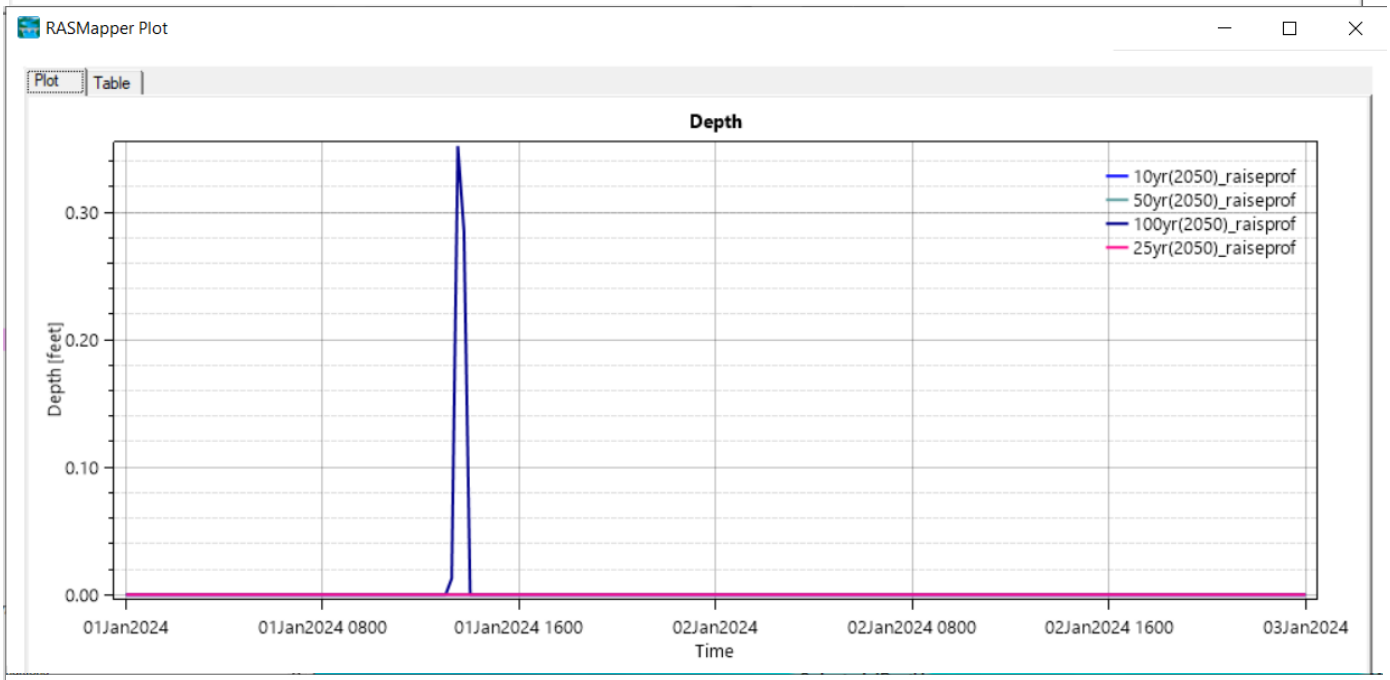


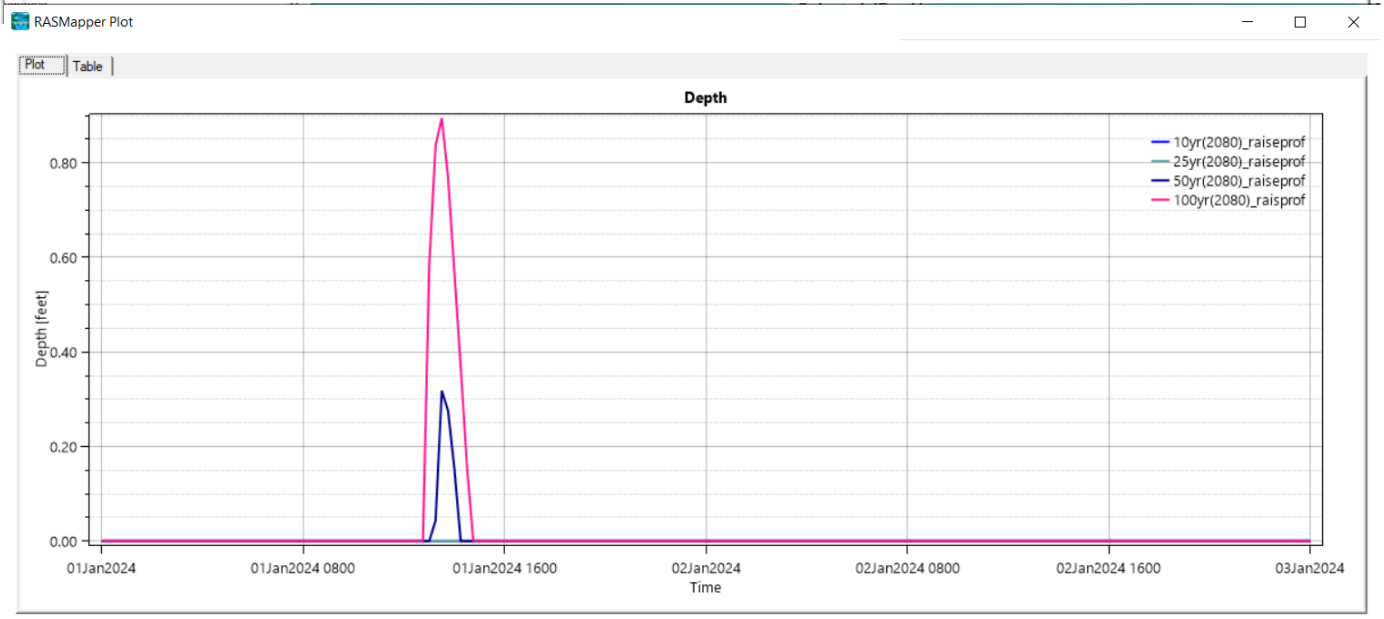




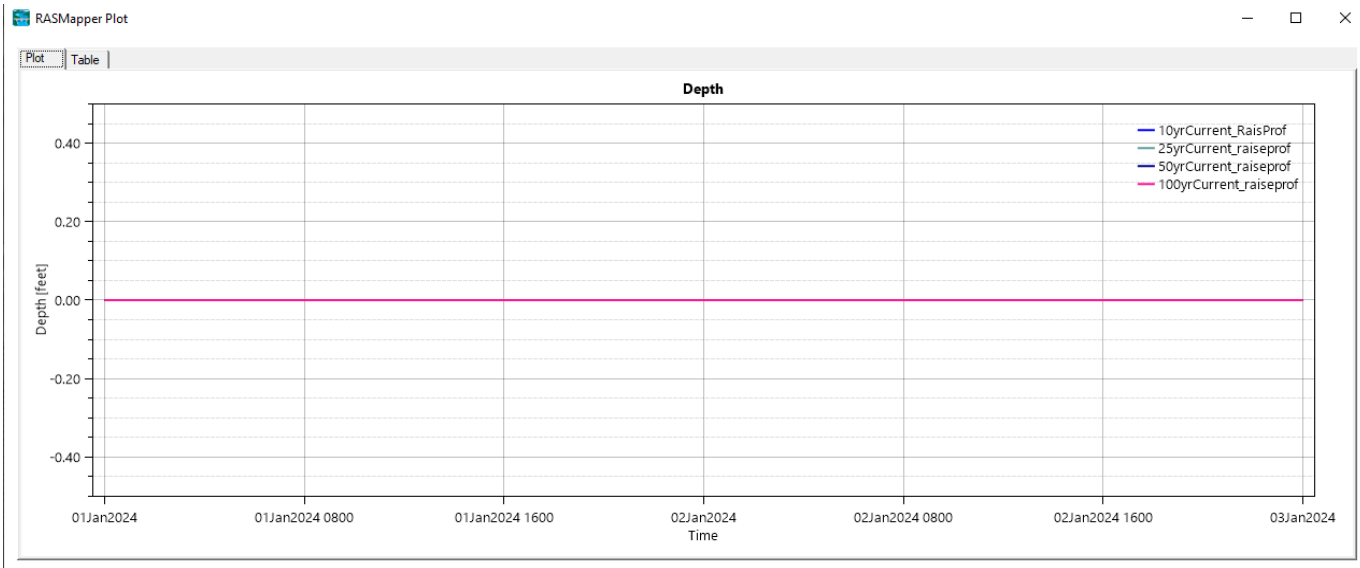
PROPOSED CONDITIONS
FLOODING OVER FENWICK ROAD OVER POMONKEY

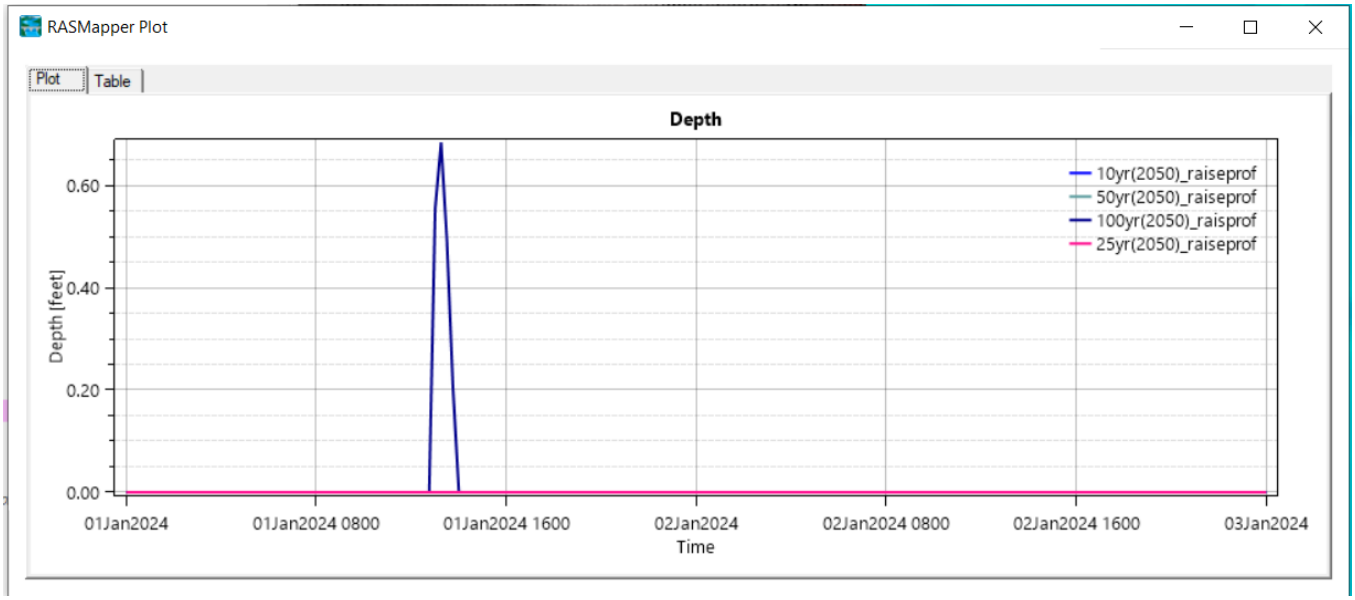


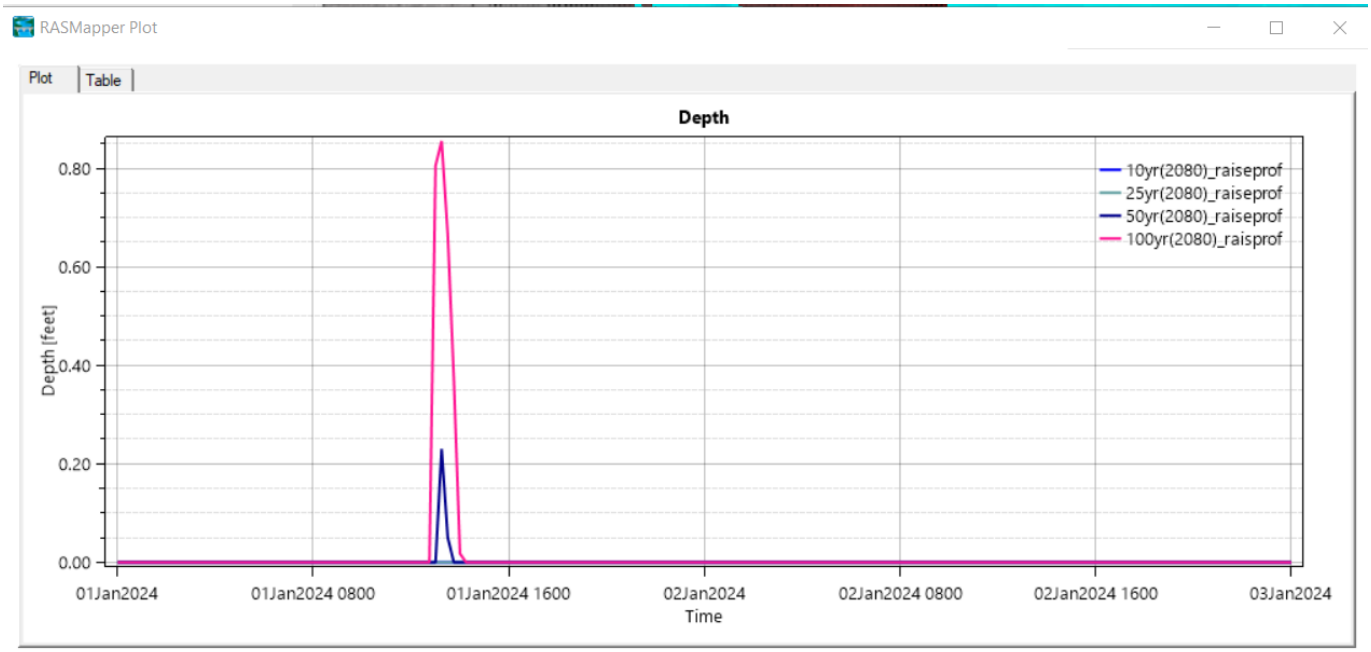


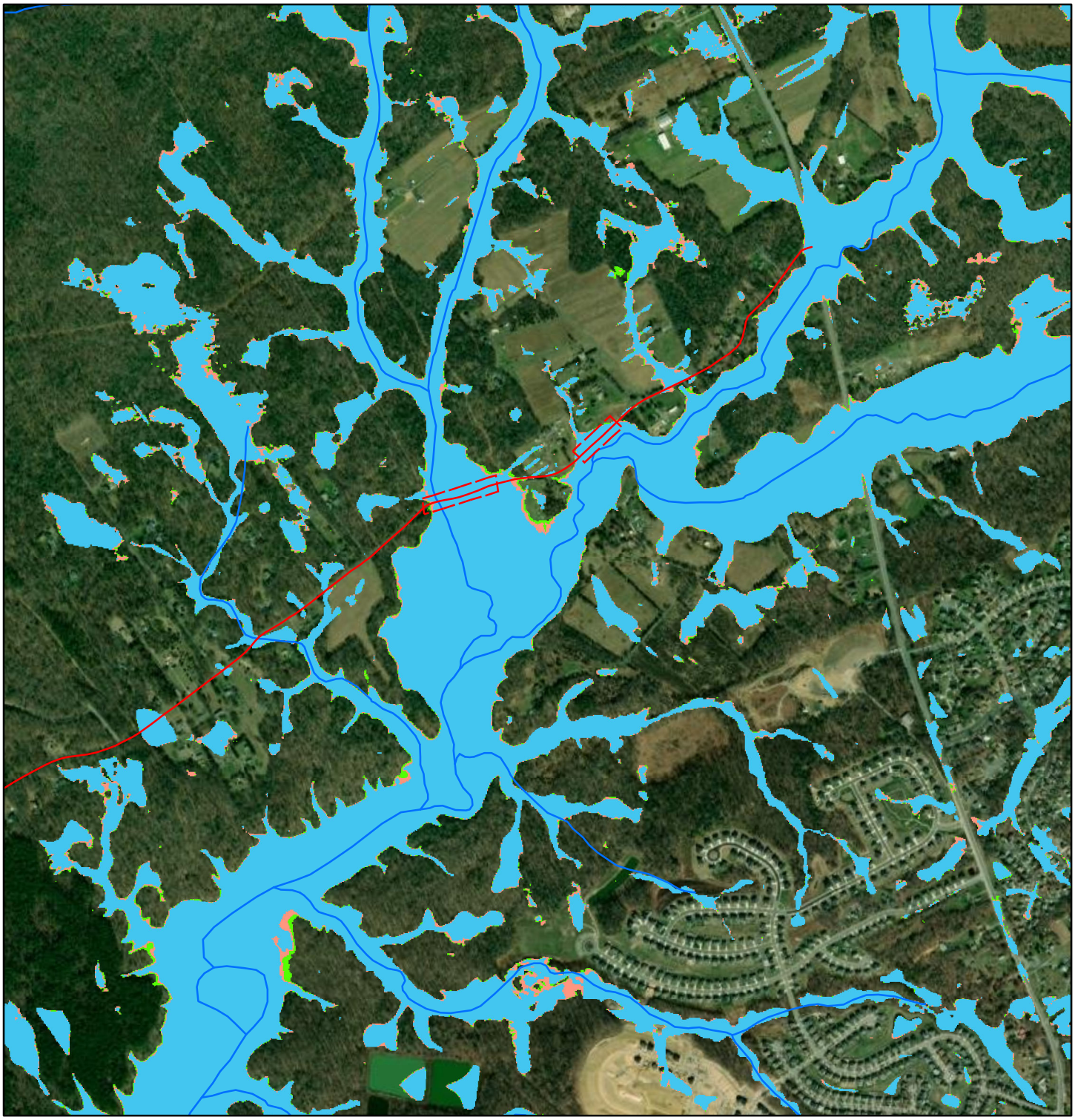


PROPOSED CONDITIONS
FLOODING OVER FENWICK ROAD ALONG MILL SWAMP









Legend

- Fenwick Road Low Points
- Fenwick Road
- Streams

100 yr Current

- 100 yr Current

100 yr (2050)

- 100 yr (2050)

100 yr (2080)

- 100 yr (2080)

N

0 0.1 0.2 0.4 Miles

Floodplain Map

Fenwick Road Over
Pomonkey Creek

Bryans Road, MD

Michael Baker
INTERNATIONAL

Attachment 5
Current & Future Flood Conditions
(2050 and 2080)

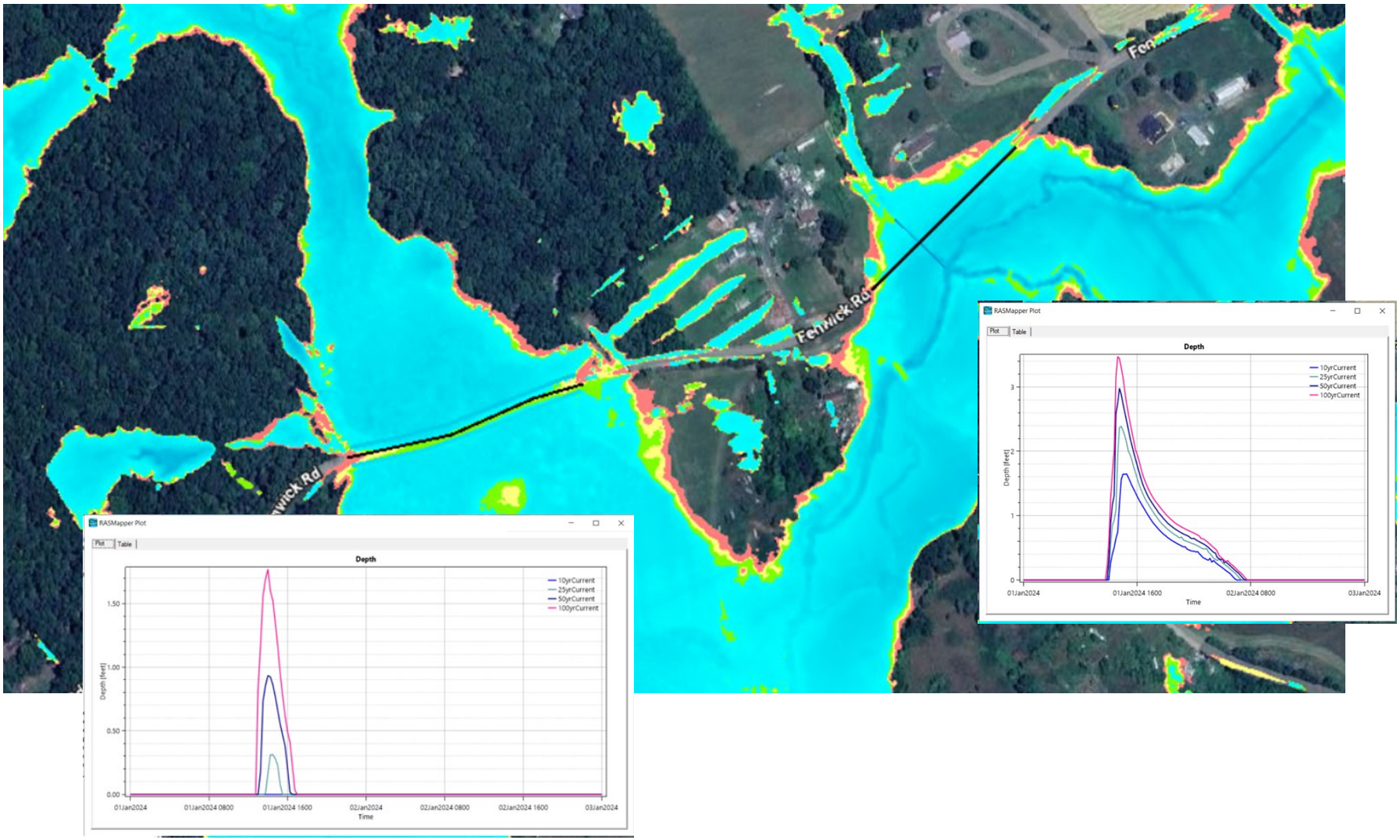
Current Conditions

10-yr

20-yr

50-yr

100yr



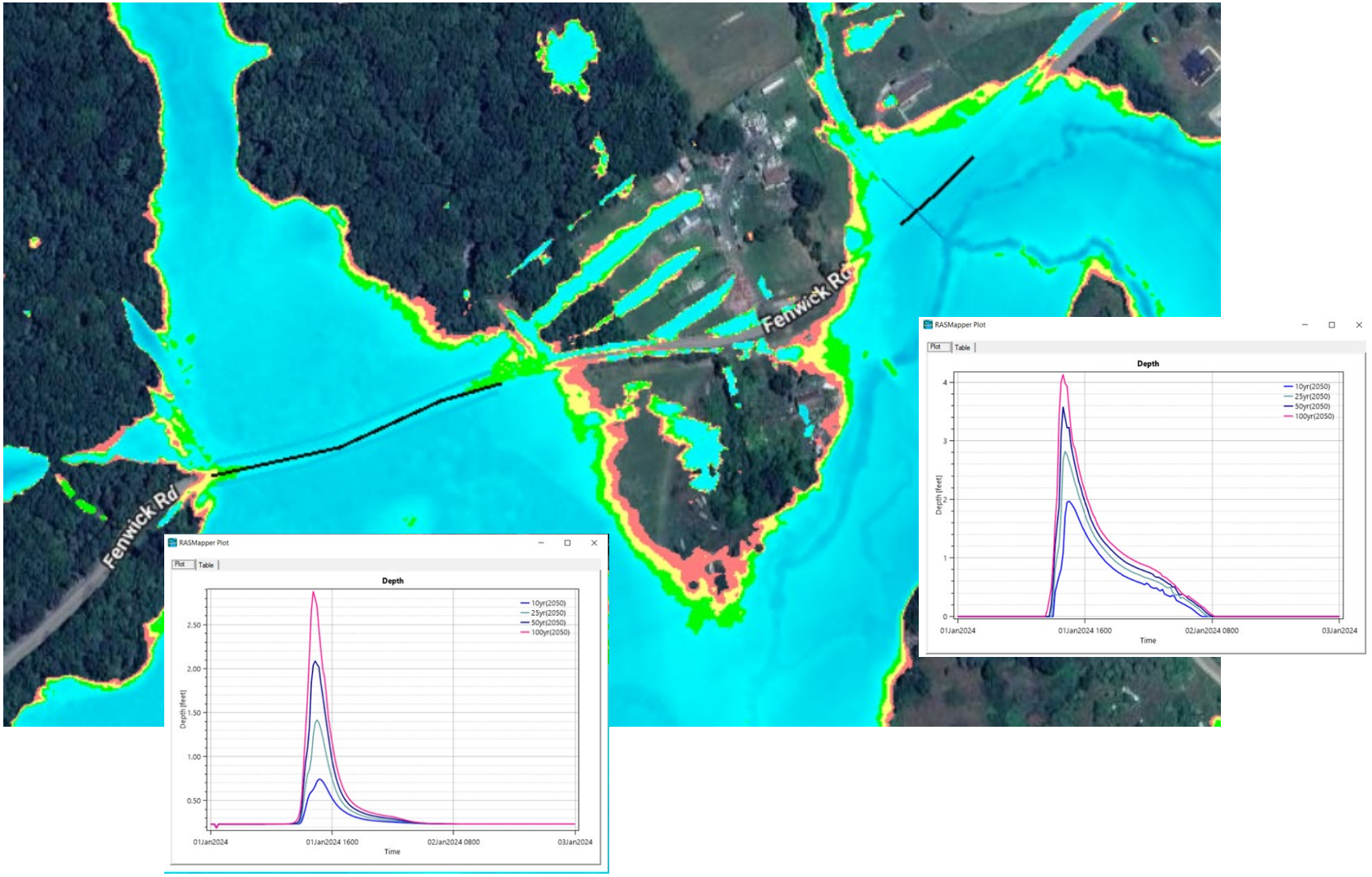
2050 Future Conditions

10-yr

20-yr

50-yr

100yr



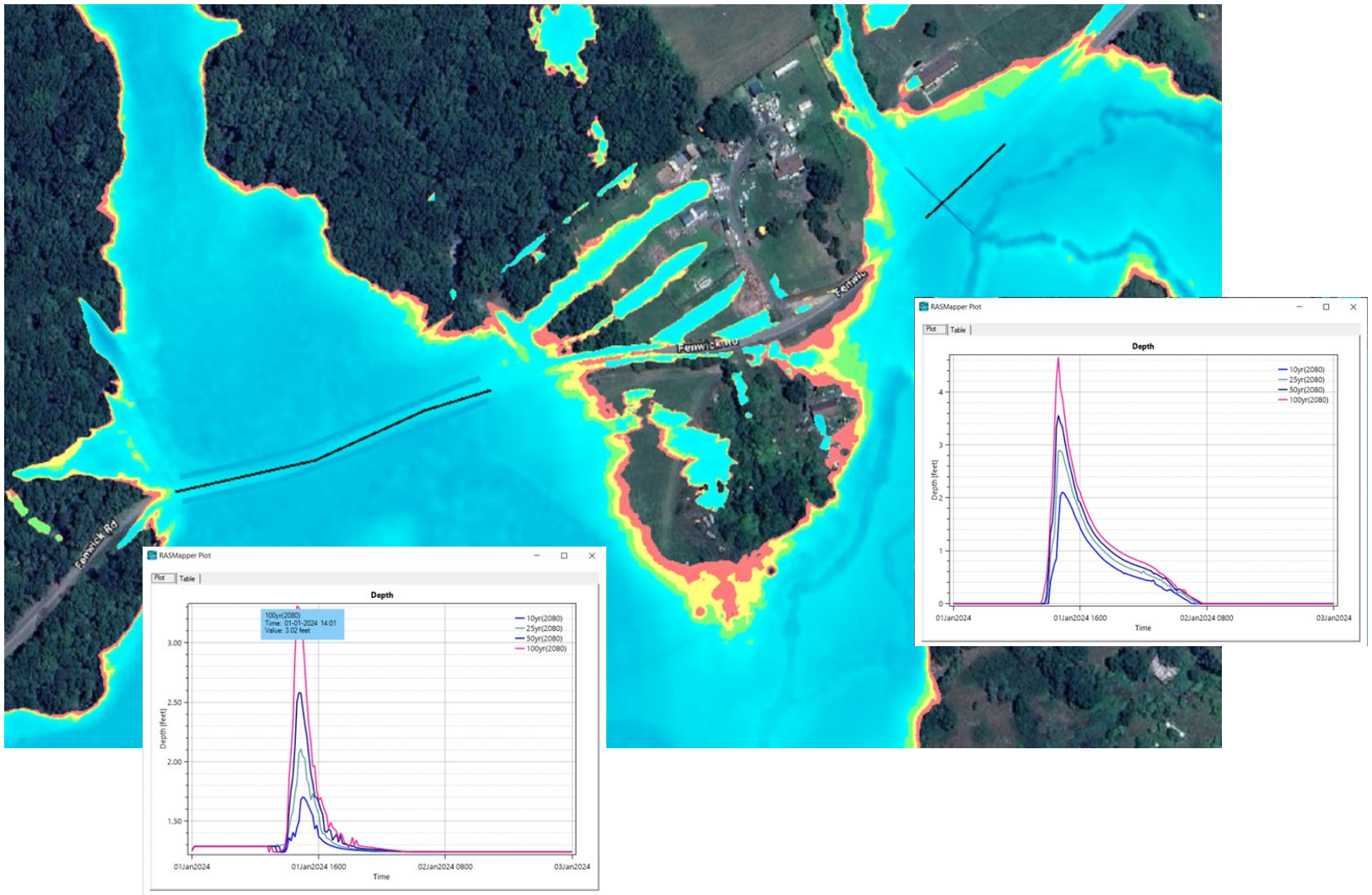
2080 Future Conditions

10-yr

20-yr

50-yr

100yr



Attachment 6
Road Elevation and Drainage Construction Details and Costs

Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

EARTHWORK (must be calculated)

	Unit	Quantity	x Unit Price	Amount
I-14 Soil Aggregate **See (A) for Unit Price**	C.Y.	5,159.0	$ 75.00	$ 386,925.00
Removal of Conc. Base & Conc. Surface Courses	S.Y.	0	$ 15.00	$ -
			EARTHWORK TOTAL =	$ 386,925.00

Suggested procedure for calculating earthwork:
A) See Construction Cost Estimate Work Sheet (Section 3.1) for the method to utilize the most recent price information.

PAVEMENT

12 FOOT WIDE LANE (from subgrade up)

Pav't. Type	Description of Pavement	Cost/Linear Foot
A	10 inch R.C. Pavement	$ 156.00
B	2 inch HMA Surf. Crs. & 8 inch HMA Base	$ 61.00
C	3 inch HMA Surf. Crs. & 4 inch HMA Base	$ 46.00
D	2 inch HMA Surf. Crs. & 2 inch HMA Base	$ 22.00
E	Bridge Approach & Transition Slabs	$ 156.00
	(Resurfacing Portion only F & G)	
F	2 inch HMA Surface Course	$ 8.25
G	3 inch HMA Surface Course	$ 12.00
H	Milling 2 inch	$ 5.50

Computation Table for Pavement. Cost

Type	Cost from table above	x Qty	x Pavement *W.F.	= Amount
HMA, Milling 3" or Less	$ 5.50			$ -
Pavement Removal	$ 22.00	4,251		$ 93,519.56
Full Depth Pavement	Based on Proposed Facilities			$ 412,105.62
				$ 412,105.62
				$ -
				$ -
				$ -
				$ -
				$ -
			PAVEMENT TOTAL =	$ 917,730.80

*Width Factors = Ratio of 12 foot wide lane to actual pavement width.

Example = actual pavement width = 25 foot = 25/12 = 2.08 W.F.

DRAINAGE (includes inlets and cross drains)

Item	Quanity	Cost	= Amount
Reset Casting (Unit)	Based on Proposed Facilities		
Reconstructed Inlets (Unit)			
Manoles (Unit)			
Inlet (Unit) *			
Pipe (L.F.) *			
		DRAINAGE TOTAL =	$ 1,400,000.00

* Any drainage problems to be corrected should be estimated and included.

Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

INCIDENTAL ITEMS

Item	Cost / L.F.	x Quantity	= Amount
HMA Driveway	$ 114.00	375	$ 42,750.00
			$ -
		INCIDENTAL ITEMS TOTAL =	$ 42,750.00

LANDSCAPE

The measurement is for each side of the roadway or ramp that requires landscaping. For example: If a road is widened on one side only the cost = 4.00 per foot. If the road is widened on both sides the cost = 8.00 per foot.

Pavement Edge Length in ft	Cost per pavement edge for Topsoil & Seeding	= Amount
1,739	$ 8.00	$ 13,912.00
	LANDSCAPE TOTAL =	$ 13,912.00

GENERAL ITEMS

Item	Project Length (miles)	x Cost/Mile	= Amount
Field Office	0.33	$ 44,260.00	$ 14,577.30
Materials Field Laboratory	0.33	$ 28,970.00	$ 9,541.45
		GENERAL ITEMS TOTAL =	$ 24,118.74

Work Type	Totals from other pages
Earthwork	$ 386,925.00
Pavement	$ 917,730.80
Drainage (Based on Proposed Facilities)	$ 1,400,000.00
Incidental Items	$ 42,750.00
Landscape	$ 13,912.00
General Items	$ 24,118.74
PROJECT SUBTOTAL =	**$ 2,785,436.54**

]

Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

Other Items	Proj. Subtotal Range	Choice	Amount
Lighting, Traffic Stripes, Signs and Delineators, and ITS	Based on Proposed Facilities (Electrical, Traffic, ITS, and Lighting)		$ 2,956.30
Maintenance of Traffic		7% of Proj. Subtotal	$ 194,980.56
Training		1% of Proj. Subtotal	$ 27,854.37
Mobilization			$ 222,834.92
	Project Cost < 5.0 (Mil.)	8% of Proj. Subtotal	
	Project Cost 5.0 & above	8% of Proj. Subtotal	
Progress Schedule	Project Cost (Mil.)	$	$ 6,000.00
	Less than 2.0	$ -	
	2.0 to 5.0	$ 6,000.00	
	5.0 & above	$ 8,000.00	
Clearing Site	Project Cost (Mil.)	$	$ 45,000.00
	Less than 1.0	$ 10,000.00	
	1.0 to 2.0	$ 30,000.00	
	2.0 to 5.0	$ 45,000.00	
	5.0 & above	$ 50,000.00	
Construction Layout	Project Cost (Mil.)	$	$ 26,500.00
	Less than 1.0	$ 6,000.00	
	1.0 to 2.0	$ 8,000.00	
	2.0 to 5.0	$ 26,500.00	
	5.0 & above	$ 31,000.00	
		PROJECT TOTAL =	**$ 3,311,562.69**

CONTINGENCIES & ESCALATION

		Y	
Y = Number of Years until midpoint of construction duration plus number of years until construction start. If midpoint is less than 2 years from the date of this estimate, no escalation is required. Maximum value = 10%		3.58	
$ 3,311,562.69	1.030	1.08	$ 3,683,782.34
Project Total	Contingencies (1+C)	1 + [0.01 (Y+1) (Y-2)]	Construction Estimate for PD

Project Cost(Mil.)	Contingencies (C) Percent	Average Construction Duration in Years
0-20	3%	1
Over 20	2.0%	2

CONSTRUCTION ENGINEERING (CE)

Project Cost (Mil.)		% of Construction Cost
Less than 1.0		20.30%
1.0 to 5.0		14.90%
5.0 to 10.0		10.80%
10.0 & above		9.50%
	CONSTRUCTION ENGINEERING AMOUNT =	$ 548,883.57

CONSTRUCTION CHANGE ORDER CONTINGENCIES

Total Federal Participating Items in Millions of $	Construction Change Order Contingency Amount
$0 to 0.1	$6,000.00
0.1 to 0.5	$25,000.00
0.5 to 5.0	$25,000 + 4% of amount in excess of $500,000
5.0 to 10.0	$205,000 + 3% of amount in excess of $5,000,000
10.0 to 15.0	$355,000 + 2% of amount in excess of $10,000,000
15.0 and above	$455,000 + 1.5% of amount in excess of $15,000,000 - max $500,000

For State Funded Projects, Contingencies for Change orders = 0

CHANGE ORDER CONTINGENCY AMOUNT = $ 152,400.00

]

Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

UTILITIES RELOCATIONS BY COMPANIES/OWNERS

$ 3,683,782.34	0.025	$ 92,094.56
Construction Cost for Initial Estimate	Use 2.5% or utilities detailed estimate	Utility Relocation Cost for Initial Estimate

If there are no utility relocations on the project indicate “No Utilities” in the box above.

RIGHT OF WAY COST

If there is no ROW cost on the project indicate “No ROW” the box

SUMMARY

Construction Estimate for Initial	$	3,683,782.34
Construction Engineering (CE)	$	548,883.57
Construction Contingencies	$	152,400.00
Right of Way Cost	$	292,450.00
Utilities Relocations	$	92,094.56
Total Construction Cost	$	4,769,610.46

Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

EARTHWORK (must be calculated)

	Unit	Quantity	x Unit Price	Amount
I-14 Soil Aggregate **See (A) for Unit Price**	C.Y.	3,930.0	$ 50.00	$ 196,500.00
Removal of Conc. Base & Conc. Surface Courses	S.Y.	0	$ 15.00	$ -
			EARTHWORK TOTAL =	$ 196,500.00

Suggested procedure for calculating earthwork:
A) See Construction Cost Estimate Work Sheet (Section 3.1) for the method to utilize the most recent price information.

PAVEMENT

12 FOOT WIDE LANE (from subgrade up)

Pav't. Type	Description of Pavement	Cost/Linear Foot
A	10 inch R.C. Pavement	$ 156.00
B	2 inch HMA Surf. Crs. & 8 inch HMA Base	$ 61.00
C	3 inch HMA Surf. Crs. & 4 inch HMA Base	$ 46.00
D	2 inch HMA Surf. Crs. & 2 inch HMA Base	$ 22.00
E	Bridge Approach & Transition Slabs	$ 156.00
	(Resurfacing Portion only F & G)	
F	2 inch HMA Surface Course	$ 8.25
G	3 inch HMA Surface Course	$ 12.00
H	Milling 2 inch	$ 5.50

Computation Table for Pavement. Cost

Type	Cost from table above	x Qty	x Pavement *W.F.	= Amount
HMA, Milling 3" or Less	$ 5.50	0		$ -
Pavement Removal	$ 22.00	2,191		$ 48,199.56
Full Depth Pavement	Based on Proposed Facilities			$ 412,105.62
				$ 412,105.62
				$ -
				$ -
				$ -
				$ -
				$ -
			PAVEMENT TOTAL =	$ 872,410.80

*Width Factors = Ratio of 12 foot wide lane to actual pavement width.

Example = actual pavement width = 25 foot = 25/12 = 2.08 W.F.

DRAINAGE (includes inlets and cross drains)

Item	Quanity	Cost	= Amount
Reset Casting (Unit)	Based on Proposed Facilities		
Reconstructed Inlets (Unit)			
Manoles (Unit)			
Inlet (Unit) *			
Pipe (L.F.) *			
		DRAINAGE TOTAL =	$ 1,400,000.00

* Any drainage problems to be corrected should be estimated and included.

]

Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

INCIDENTAL ITEMS

Item	Cost / L.F.	x Quantity	= Amount
HMA Driveway	$ 114.00	375	$ 42,750.00
Retaining Wall	Based on Proposed Facilities		$ 3,155,250.00
Crash Cushion	Based on Proposed Facilities		$ 330,000.00
Beam Guide Rail	Based on Proposed Facilities		$ 19,560.00
			$ -
		INCIDENTAL ITEMS TOTAL =	$ 3,547,560.00

LANDSCAPE

The measurement is for each side of the roadway or ramp that requires landscaping. For example: If a road is widened on one side only the cost = 4.00 per foot. If the road is widened on both sides the cost = 8.00 per foot.

Pavement Edge Length in ft	Cost per pavement edge for Topsoil & Seeding	= Amount
1,739	$ 8.00	$ 13,912.00
	LANDSCAPE TOTAL =	$ 13,912.00

GENERAL ITEMS

Item	Project Length (miles)	x Cost/Mile	= Amount
Field Office	0.33	$ 44,260.00	$ 14,577.30
Materials Field Laboratory	0.33	$ 28,970.00	$ 9,541.45
		GENERAL ITEMS TOTAL =	$ 24,118.74

Work Type	Totals from other pages
Earthwork	$ 196,500.00
Pavement	$ 872,410.80
Drainage (Based on Proposed Facilities)	$ 1,400,000.00
Incidental Items	$ 3,547,560.00
Landscape	$ 13,912.00
General Items	$ 24,118.74
PROJECT SUBTOTAL =	**$ 6,054,501.54**

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Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

Other Items	Proj. Subtotal Range	Choice	Amount
Lighting, Traffic Stripes, Signs and Delineators, and ITS	Based on Proposed Facilities (Electrical, Traffic, ITS, and Lighting)		$ 2,956.30
Maintenance of Traffic		7% of Proj. Subtotal	$ 423,815.11
Training		1% of Proj. Subtotal	$ 60,545.02
Mobilization			$ 484,360.12
	Project Cost < 5.0 (Mil.)	8% of Proj. Subtotal	
	Project Cost 5.0 & above	8% of Proj. Subtotal	
Progress Schedule	Project Cost (Mil.)	$	$ 8,000.00
	Less than 2.0	$ -	
	2.0 to 5.0	$ 6,000.00	
	5.0 & above	$ 8,000.00	
Clearing Site	Project Cost (Mil.)	$	$ 50,000.00
	Less than 1.0	$ 10,000.00	
	1.0 to 2.0	$ 30,000.00	
	2.0 to 5.0	$ 45,000.00	
	5.0 & above	$ 50,000.00	
Construction Layout	Project Cost (Mil.)	$	$ 31,000.00
	Less than 1.0	$ 6,000.00	
	1.0 to 2.0	$ 8,000.00	
	2.0 to 5.0	$ 26,500.00	
	5.0 & above	$ 31,000.00	
		PROJECT TOTAL =	**$ 7,115,178.09**

CONTINGENCIES & ESCALATION

		Y	
Y = Number of Years until midpoint of construction duration plus number of years until construction start. If midpoint is less than 2 years from the date of this estimate, no escalation is required. Maximum value = 10%		3.58	
$ 7,115,178.09	1.030	1.08	$ 7,914,924.11
Project Total	Contingencies (1+C)	1 + [0.01 (Y+1) (Y-2)]	Construction Estimate for PD

Project Cost(Mil.)	Contingencies (C) Percent	Average Construction Duration in Years
0-20	3%	1
Over 20	2.0%	2

CONSTRUCTION ENGINEERING (CE)

Project Cost (Mil.)		% of Construction Cost
Less than 1.0		20.30%
1.0 to 5.0		14.90%
5.0 to 10.0		10.80%
10.0 & above		9.50%
	CONSTRUCTION ENGINEERING AMOUNT =	$ 854,811.80

CONSTRUCTION CHANGE ORDER CONTINGENCIES

Total Federal Participating Items in Millions of $	Construction Change Order Contingency Amount
$0 to 0.1	$6,000.00
0.1 to 0.5	$25,000.00
0.5 to 5.0	$25,000 + 4% of amount in excess of $500,000
5.0 to 10.0	$205,000 + 3% of amount in excess of $5,000,000
10.0 to 15.0	$355,000 + 2% of amount in excess of $10,000,000
15.0 and above	$455,000 + 1.5% of amount in excess of $15,000,000 - max $500,000

For State Funded Projects, Contingencies for Change orders = 0

CHANGE ORDER CONTINGENCY AMOUNT =	$ 292,400.00

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Classification Number 4 - RESURFACING - English

Route		Section/Contract #	
PM		UPC No.	

UTILITIES RELOCATIONS BY COMPANIES/OWNERS

$ 7,914,924.11	0.025	$ 197,873.10
Construction Cost for Initial Estimate	Use 2.5% or utilities detailed estimate	Utility Relocation Cost for Initial Estimate

If there are no utility relocations on the project indicate “No Utilities” in the box above.

RIGHT OF WAY COST

If there is no ROW cost on the project indicate “No ROW” the box

SUMMARY

Construction Estimate for Initial	$	7,914,924.11
Construction Engineering (CE)	$	854,811.80
Construction Contingencies	$	292,400.00
Right of Way Cost	$	198,450.00
Utilities Relocations	$	197,873.10
Total Construction Cost	$	9,458,459.02