# STORM WATER MASTER PLAN FOR CHOWAN RIVER WATERSHED

## FINAL REPORT
## OCTOBER 2008

CLARK • NEXSEN
*Architecture & Engineering*

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# EXECUTIVE SUMMARY

To assist the City of Suffolk in making stormwater decisions to accommodate future development, Clark Nexsen will perform a study of the three watersheds in Suffolk. These watersheds include the James River Basin, the Chowan River/Blackwater River Basin and the Great Dismal Swamp Basin. The watershed studies will be performed in two phase. The James River Watershed with an approximate drainage area of 96 square miles was studied under Phase I and submitted to the City in November 2005. The Chowan River and the Great Dismal Swamp Watersheds with an approximate combined drainage area of 220 square miles, will be studied under Phase II. The Chowan River Watershed study is presented in this report.

The purpose of these studies is to develop a stormwater master planning model to assess existing conditions and the impacts future development will have on these stormwater systems based on the projected 2026 land use condition described in Suffolk's Comprehensive Plan.

The studies require the hydrologic and hydraulic analysis of the existing major drainage systems within the regional watersheds. To facilitate the analysis of a complex stormwater network, Expert System's XP-SWMM (version 10.50) software was used to construct the model. XP-SWMM is a proprietary software based on the USEPA Stormwater and Wastewaster Management Model (SWMM) computer program. The model represents the primary stormwater conveyances within the watershed to describe and integrate the relationship of the various land uses and hydraulic controls throughout the watershed. The model will be used to create the stormwater master plan from which the existing conditions and proposed future impacts will be evaluated to assist the City of Suffolk in day-to-day development decisions related to stormwater management concerns. The model was developed using the City's comprehensive GIS mapping and field data to define existing conditions and the 2026 Comprehensive Plan to consider future impacts.

The stormwater network was analyzed for the 2-yr, 10-yr, 25-yr and 100-yr 24-hour, Type II rainfall events. The various storm events were evaluated for the following:

- Identify areas prone to flooding for 10-year storm.
- Evaluate culverts for the 10- and 25-year storms.
- Evaluate bridges and spillways for the 100-year storm.
- Compare existing channel velocities with proposed development channel velocities based on the 2026 Comprehensive Plan for the 2-year storm.

From the analysis, deficiencies in the stormwater network for the existing condition and future land use condition were determined and recommendations with conceptual construction cost estimates provided to mitigate the problems.

The model also identified areas that should receive detailed analysis to determine if flood control improvements are warranted. Due to the lack of detailed survey data and the master plan assumptions used, the model should not be used for design applications. Additional data and survey, particularly for roadway culverts, is needed before this model can be used for making specific design decisions and should only be used as a tool preparing the groundwork for more detailed studies and design.

The model indicates that most of the roads within the watershed flood for the 10-yr design storm at culvert crossings. The model results confirm field observations where it appeared that many of the roadway elevations dip at culvert crossings allowing flood waters to overtop the road at these localized areas. At this time, only flooded culverts along the Primary Arterial and Minor Arterial roads are recommended for improvements. Table No. ES-1 below summarizes the recommended improvements for the deficiencies discussed under Section 3.0 (Existing Condition Model Results) and Section 4.0 (Proposed Condition (2026) Model Results) and associated costs for the respective conditions. Most of the improvements recommended were from inadequate culverts that had the potential to overtop the roadway for the respective 24-hour, Type II rainfall

event. The costs listed show the estimated value of improvements based on the existing condition and the proposed condition (2026) land uses. For those improvements where only one cost is listed, there were no additional improvements required to address the proposed condition (2026) land uses, with the exception of Node NQS21 where the improvements are for the proposed condition only. All of the costs shown are based on 2007 dollars and would be greater in the future due to construction cost escalation.

**Table No. ES-1 Summary of Erosion and Flood Control Recommendations**

| Location | Recommendation | Cost |
|---|---|---|
| NCS44 (DUTCH RD) | EXISTING AND 2026- REPLACE 24" RCP WITH (2) 36" RCP. | $125,353 |
| NJS11 (HOLLAND CORNER RD) | EXISTING AND 2026 - ADD A 60"x 46" CMP ARCH. | $147,373 |
| NKS21 (RT 58) | EXISTING – ADD (2) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL (2) 5'X3' BOX CULVERTS.* | $568,187<br>$809,269 (2026) |
| NKS4 (RT 58) | EXISTING AND 2026 - ADD A 6'X6' BOX CULVERT | $590,315 |
| NKS43 (GLEN HAVEN DR) | EXISTING AND 2026 – REPLACE 12" RCP WITH (3) 24" RCP, GRADE 850 LF OF CHANNEL. | $436,914 |
| NKS48 (RT 58) | EXISTING - REPLACE 36" RCP WITH (2) 5'X4' BOX CULVERTS. *2026 - ADD AN ADDITIONAL 5'X4' BOX CULVERT.* | $1,370,661<br>$1,746,658 (2026) |
| NKS57 (RT 58) | EXISTING – ADD A PARALLEL 36" RCP. *2026 - ADD AN ADDITIONAL 36" RCP CULVERT.* | $502,031<br>$712,058 (2026) |
| NQS13 (LUMMIS RD) | EXISTING AND 2026 - RAISE RD 1FT TO ELEV. 69 (360 LF), REPLACE 24" RCP WITH (4) 36" RCP. | $570,836 |
| NQS21 (RT 58) | 2026 - ADD AN ADDITIONAL 4'X4' BOX CULVERT. | $701,744 (2026) |

| Table No. ES-1 Summary of Erosion and Flood Control Recommendations | | |
|---|---|---|
| **Location** | **Recommendation** | **Cost** |
| NQS33 (DUTCH RD) | EXISTING AND 2026 - REPLACE 24" RCP WITH (4) 30" RCP. | $321,694 |
| NQS38 (RT 58) | EXISTING - ADD A 6'X4' BOX CULVERT TO THE EXISTING TWIN 4'X4' BOX. *2026 - ADD AN ADDITIONAL 6'X4' BOX.* | $767,768<br>$1,060,263 (2026) |
| NQS41 (DUTCH RD) | EXISTING ADD (1) 36" RCP TO THE EXISTING 36" RCP. *2026 – ADD AN ADDITIONAL 36" RCP.* | $148,649<br>$182,851 (2026) |
| NSMC10 (WHALEYVILLE BLVD) | EXISTING - REPLACE THE EXISTING 24" RCP WITH (2) 5'X3' BOX CULVERT. *2026 - ADD AN ADDITIONAL 5'X3' BOX.* | $365,935<br>$530,981 (2026) |
| NSMC9 (WHALEYVILLE BLVD) | EXISTING - REPLACE TWIN 24" RCP WITH (3) 5'X3 BOX CULVERT. *2026 - ADD AN ADDITIONAL 5'X3' BOX CULVERT.* | $372,275<br>$494,621 (2026) |
| NSS1 (WHALEYVILLE BLVD) | EXISTING - ADD (2) 4'X4' BOX CULVERTS TO THE EXISTING 4'X4' BOX CULVERT. *2026 – ADD AN ADDITIONAL 4'X4' BOX CULVERT.* | $317,943<br>$439,723 (2026) |
| NSS16 (MINERAL SPRING RD) | EXISTING - REPLACE THE EXISTING 18" AND 24" PIPES WITH (4) 36" RCP. *2026 - ADD AN ADDITIONAL 36" PIPE.* | $275,613<br>$351,623 (2026) |
| NSS24 (MINERAL SPRING RD) | EXISTING AND 2026 - ADD AN ADDITIONAL 30" RCP PARALLEL TO THE EXISTING 18" RCP. | $86,264 |
| NSS25 (MINERAL SPRING RD) | EXISTING AND 2026 - REPLACE 18" RCP WITH (2) 36" RCP. | $143,786 |
| NSS3 (MINERAL SPRING RD) | EXISTING - RAISE THE ROAD 1 FT TO 48 (600LF) AND REPLACE THE EXISTING 18" RCP WITH (4) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL (2) 5'X3' BOX CULVERTS.* | $903,845<br>$1,140,453 (2026) |
| NSS5 (MINERAL SPRING RD) | EXISTING AND 2026 - RAISE THE ROAD 1 FT TO 50 (156LF) AND REPLACE 24" RCP WITH (4) 42" RCP. | $499,696 |

| Table No. ES-1 Summary of Erosion and Flood Control Recommendations | | |
|---|---|---|
| **Location** | **Recommendation** | **Cost** |
| NSS8 (MINERAL SPRING RD) | EXISTING - - RAISE THE ROAD 1 FT TO 36 (570LF) AND REPLACE THE EXISTING 18" RCP WITH (6) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL 5'X3' BOX CULVERT.* | $1,226,254<br>$1,379,042 (2026) |
| NTBR1 (RT 58) | EXISTING AND 2026 - REPLACE 30" RCP WITH (2) 5'X4' BOX CULVERTS. | $1,148,176 |
| NTBR20 (SOUTH QUAY RD) | EXISTING AND 2026 - ADD A 48" RCP TO THE EXISTING 48" RCP. | $248,976 |
| NTBR24 (RT 58) | EXISTING AND 2026 - REPLACE 30" CMP WITH (2) 30" RCP. | $482,370 |
| NTBR9 (RT 58) | EXISTING AND 2026 - REPLACE 30" CMP WITH (2) 30" RCP. | $513,898 |

Large scale maps of the XP-SWMM model (GIS-01), flooding deficiencies (GIS-02), and recommended improvements (GIS-03) are located after the appendices.

In addition to the recommendations provided in Table No. ES-1, the following recommendations for supplemental analysis and study are provided:

- Detailed channel stability analysis. Because the stormwater master plan model does not focus on variations in channel geometry, roughness, and unique site conditions throughout the channel reach, specific improvement priorities cannot be immediately obtained from the model. At a minimum, outfall channels associated with deficient pipes should be studied in detail.

- Impacts of regional best management practices (BMPs). Due to the limitations associated with making decisions on channel stability, the use of regional BMPs was not addressed in detail. A detailed evaluation in concert with the channel stability analysis should be performed for the outfalls associated with the deficient pipes identified in the study recommendations.

- Discussions with the City Public Works Operations revealed that there are several areas throughout the City where localized flooding is caused by beaver activity which can block culverts and back up stream flow. The dams can be located directly at the culvert or several hundred feet downstream in marshes. The City currently sends crews to remove the dams once they are detected visually or due to an unusual increase in water level. The model does not account for beaver dams in the analysis of the culverts. Mitigation of beaver related flooding is considered a maintenance item.

# 1.0 INTRODUCTION

## 1.1 CITY OF SUFFOLK OVERVIEW

The City of Suffolk is located in southeastern Virginia and is bordered by Isle of Wight County and Southampton County to the west, the State of North Carolina to the south, the cities of Chesapeake and Portsmouth to the east, and the Lower James and Nansemond Rivers to the north. The city has a land area of approximately 430 square miles, which includes a portion of the Great Dismal Swamp.

The annual precipitation in Suffolk is approximately 50 inches per year. There are variations in the monthly rainfall averages; however, rainfall is generally distributed throughout the year. Snowfall is infrequent and typically melts in a short period of time. Elevations in the city range from sea level to approximately 85 feet. The greater relief promotes natural drainage for most areas of the city.

The City of Suffolk is currently undergoing a period of growth and development. To manage the City's future growth the 2026 Comprehensive Plan was adopted by the City in March 2006. The 2026 Comprehensive Plan established long term (20-yr) development strategies, goals, and policies. A map of the proposed landuse for the 2026 Comprehensive Plan is provided in Figure 1-1.

Central Suburban/Urban Growth Area

Northern Suburban/Urban Growth Area

See Northern Suburban/Urban Growth Area Inset

See Central Suburban/Urban Growth Area Insert

## Legend

- Mixed Use Core
- Core Support
- Inner-Ring Suburban
- Suburban
- Rural Conservation/ Low Intensity Residential
- Rural Agricultural Conservation
- Village Communities

# City of Suffolk, Virginia

2026 Comprehensive Plan

# Focused Growth Areas

0 3 Miles

Figure 1-1
Source: Comprehensive Plan for 2026 City of Suffolk, Virginia

JAMES RIVER WATERSHED

CHOWAN/ BLACKWATER RIVER WATERSHED

GREAT DISMAL SWAMP WATERSHED

N

0 7,500 15,000 30,000 45,000 Feet

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# CITY OF SUFFOLK

STORM WATER MASTER PLAN
MAJOR WATERSHED MAP

STUDY AREA
WATERSHEDS OVERVIEW

FIGURE 1-2

022687 - KRH - MP.01.005.VSD, DwMDI-area_River

The objectives of the 2026 Comprehensive Plan include, but are not limited to, the following:

- To define and delineate two areas of compact, high-quality urban and suburban development: one around the central city and one in the northeast.
- To allow and promote some low-density, high-quality, large-lot residential development between these two compact areas and in the northwest.
- To preserve the southern half of Suffolk as a rural, agricultural area.
- To make special efforts to protect the watersheds which provide drinking water for Suffolk, Portsmouth, Norfolk, Chesapeake, and Virginia Beach.
- To identify roadway classifications and indicate where major roadway improvements are to be implemented.

To comply with national, state, and local environmental regulations governing water quality, the proposed development in the 2026 Comprehensive Plan must be implemented in accordance with a variety of existing environmental regulations related to the management of stormwater runoff.

## 1.2 PROJECT OBJECTIVES

Clark Nexsen will perform a study of the three regional watersheds in Suffolk. The watersheds to be studied include the James River Watershed, Chowan River Watershed and the Great Dismal Swamp Watershed. The James River Watershed, with an approximate drainage area of 96 sq. mi., was studied under Phase I and submitted to the City in November 2005. The Chowan River and the Great Dismal Swamp Watersheds with an approximate combined drainage area of 220 sq. mi., will be studied under Phase II. The watershed study will involve the hydrologic and hydraulic analysis of the existing major drainage systems. A map of the major watersheds within the city is presented in Figure 1-2.

The analysis of the Phase II Study Area for the Chowan River Watershed, consisting of approximately 148 sq.mi., is presented in this report. The study area is located in the south western portion of the City. The primary outfalls for this watershed are the Blackwater River to the west and the Chowan River which flows southward into Gates and Hertford Counties North Carolina.

The hydraulic grade line within the major conveyances were computed for the existing and future land uses based on current GIS mapping, field observation and the 2026 Comprehensive Land Use Plan to determine the following:

- Identify areas prone to flooding for 10-year storm.
- Evaluate culverts for the 10- and 25-year storms.
- Evaluate bridges for the 100-year storm.
- Compare existing channel velocities with proposed development channel velocities based on the 2026 Comprehensive Plan for the 2-year storm.

Once the flood prone areas were determined, stormwater strategies and associated cost estimates were developed to address the deficiencies.

## 1.3 REPORT ORGANIZATION

The report is organized as follows:

- Section 1 "Introduction," provides a brief overview of the project objectives and of the report contents.
- Section 2 "Stormwater Modeling Approach" describes methods and assumptions used to develop the XP-SWMM model analysis of the primary drainage system.
- Section 3 "Existing Conditions" summarizes the results of the existing condition XP-SWMM model and the field reconnaissance. Evaluations of areas indicated by the model to be prone to repetitive flooding are provided along with recommendations and cost estimates for potential flood control improvements.
- Section 4 "Proposed Conditions" summarizes the results of the proposed condition XP-SWMM model based on the 2026 Comprehensive Plan land use. Evaluations of areas indicated by the model to be prone to repetitive flooding are provided along with recommendations and cost estimates for potential flood control improvements.
- Section 5 "Conclusions and Recommendations" summarizes the report conclusions, recommendations and cost estimates.

# 2.0 STORMWATER MODELING APPROACH

## 2.1 HYDROLOGIC/HYDRAULIC MODELING ANALYSIS

A computer model using XP-SWMM was developed to represent the primary stormwater conveyances within the project study area. The model will assist in accomplishing the following objectives:

- Identify areas prone to flooding for 10-year storm.
- Evaluate culverts for the 10- and 25-year storms.
- Evaluate bridges for the 100-year storm.
- Compare existing channel velocities with proposed development channel velocities based on the 2026 Comprehensive Plan for the 2-year storm.
- Evaluate the impact of proposed development and future projected development.
- Evaluate other stormwater-related issues as determined by the City.

## 2.2 SOFTWARE

The computer model utilized as the primary tool for modeling the existing and future (2026) land use condition watershed was XP-SWMM version 10.50. The XP-SWMM model was used for both the hydrologic and hydraulic analyses. XP-SWMM generates runoff hydrographs at specific locations within the system based on specified storm events. The model simulates surface runoff within each sub-area and the subsequent routing through the various drainage system components including pipes, channels and reservoirs. Runoff and routing are simulated based on specific input parameters for each component process. Technical information on model formulation and capabilities is available on-line at www.xpsoftware.com.

XP-SWMM is a "link-node" model that mathematically represents a drainage system as a series of links and nodes. A "link" represents a hydraulic element for flow transport, such as a pipe, channel, weir, orifice or flow control device. A "node" represents the junction of hydraulic elements (links), as well as a location for input of flow into the drainage

system. A node can also represent a storage device such as a lake or pond, or a point junction where link properties change (such as a change in channel slope).

## 2.3 WATERSHED BOUNDARY DELINEATION

The Chowan River Watershed Study Area encompasses approximately 148 square miles consisting of the south western portion of Suffolk and extending into Isle of Wight as well as Gates and Hertford Counties North Carolina. The majority of the watershed drains southwest through Suffolk toward the Chowan River in Gates County North Carolina. The western most section of the watershed drains to the Blackwater River which flows southward to the Chowan River. Agriculture is the predominant land use within the watershed. Other land use activities include residential homes and developments, light commercial and industrial properties (including the villages of Whaleyville and Holland), and conservation areas. The drainage (or sub-catchment) area boundaries within the city for the study area were delineated for primary channels and main receptors as shown in Figure GIS-01 at the back of the report.

To construct the model and the associated GIS (ARCInfo 9.1) coverages, various information including current USGS quadrangle maps and City of Suffolk GIS mapping were obtained.

Using the topographic map data, the likely locations (road and rail crossings) of drainage structures (pipe culverts, box culverts, and bridges) serving the primary stormwater conveyances in the delineated watershed boundaries were identified. Clark Nexsen performed field reconnaissance to evaluate and inventory drainage structures to be modeled. Additionally, structure data including material type, shape and dimensions, and photographs were obtained to document existing structures and channel conditions.

Several ponding locations (mostly private "farm ponds") were identified on the topographic mapping. Many of these ponds are located on private property or were inaccessible and were not included in the field reconnaissance. Where pond outlet structure data was unavailable, a 4' x 4' box riser was assumed with a crest elevation set at the existing water surface elevation as depicted in the GIS mapping.

As-built survey data (structure inverts and associated roadway elevations) from the Virginia Department of Transportation (VDOT) was generally unavailable for the drainage structures identified for the model. Assumptions were made to describe pipe inverts based on field data and GIS mapping. Surveyed channel cross-sections were unavailable. To develop channel sections for the model, Civil 3D software was used to cut-sections from the existing GIS contour surface. Stream sections were evaluated using a two year flood elevation of 3.00 feet (NAVD-88) for storms up to a 25-yr design frequency (2-yr, 10-yr, and 25-yr) and a ten year flood elevation of 6.70 feet (NAVD-88) for storms above a 25-yr design frequency (50yr and 100-yr).

Due to the lack of detailed survey data for hydraulic structures, roadway elevations, and channel cross sections, hydraulic modeling was only performed to the level of usefulness possible based on available information.

## 2.4 NODE NAMING CONVENTION

The naming convention used in the model is consistent with the naming convention outlined in the *Stormwater Master Plan for James River Watershed, Draft Report November 2005*. The naming convention used for identifying catchments was based on link nodes and storage nodes in the hydraulic model. Sub-catchments that discharge to link nodes are designated with the prefix "N " followed by the sub-catchment identifier and the link node number (e.g. NSMC6 = inflow from subcatchments to catchment "6" discharging to the Somerton Creek subwatershed). Table 2-1 below summarizes the Watershed naming conventions used in the model.

**Table 2-1 Summary of Watershed Naming Conventions**

| **Watershed** | **Sub-Catchment Identifier** | **Watershed** | **Sub-Catchment Identifier** |
|---|---|---|---|
| Somerton Creek | SMC | Jones Swamp | JS |
| Chapel Swamp | CS | Quaker Swamp | QS |
| March Swamp | MS | Kingsdale Swamp | KS |
| Spivey Swamp | SS | Tributary to Blackwater River | TBR |

## 2.5 RAINFALL-RUNOFF MODELING

The RUNOFF module of XP-SWMM was used to generate the runoff from each subcatchment. A 30-minute time step was used for the runoff computations. The 30-minute time step was selected since the rainfall distribution is given in 30-minute segments. Runoff is computed from sub-catchments by describing the drainage areas as idealized rectangular areas with the slope of the subcatchment perpendicular to the width.

If overland flow is visualized as running down-slope off an idealized rectangular catchment, then the width of the subcatchment is the physical width of overland flow. Since real subcatchments will not be rectangular with properties of symmetry and uniformity other procedures are required to approximate the idealized rectangular catchment. The width parameters for catchments with drainage channels off-center, was determined by computing a skew factor:

$$Sk = (A2 - A1) / A$$

$$W = (2 - Sk) * L$$

where

| | | |
|---|---|---|
| Sk | = | skew factor |
| A1 | = | area to one side of the channel |
| A2 | = | area to other side of the channel |
| A | = | total area |
| W | = | subcatchment width |
| L | = | length of main drainage channel |

The width parameter dictates the runoff response time of a sub-catchment and has a significant impact on the size and shape of the hydrograph. A narrower width produces a longer response time, and a wider width produces a shorter runoff response time.

To determine the slope parameter within each sub-area, three measurements were taken at representative locations within each catchment. These measurements were averaged to determine the overall slope for the sub-catchment.

Impervious surface area estimates for existing land use conditions were developed based on field observation and GIS mapping. Each identified land use category was assigned an impervious surface percentage based on information provided in Suffolk's Unified Development Ordinance (UDO). The normal water surface areas of permanent water bodies were modeled as impervious surfaces. From this information, area-weighted averages of impervious surface area were determined for each subcatchment and were used as the approximate baseline percent imperviousness.

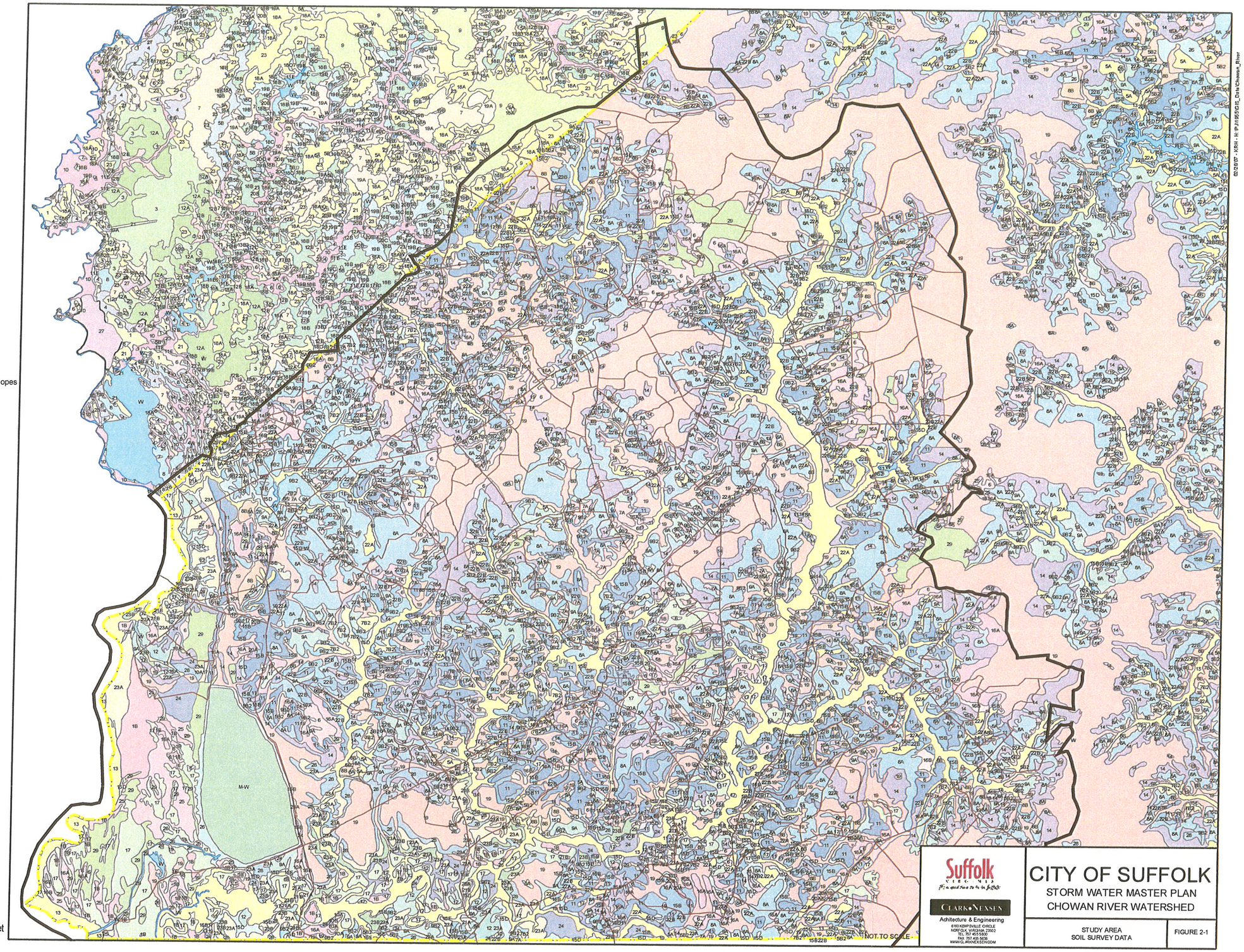
For the projected (2026) land use conditions, proposed zoning mapping for the 2026 Comprehensive Plan was obtained from the Suffolk Department of Planning. The proposed sub-catchment zoning coverages were assigned impervious surface ratios based on the Suffolk UDO to create area-weighted estimates of projected impervious surface area. The majority of the Study Area is located in the A (Agricultural District) Zone. In order to model the projected 2026 land use conditions a minimum 16% impervious coverage, based on the Suffolk UDO, was used.

## 2.6 SOILS INFORMATION

The Soil Survey for the City of Suffolk, published by the United States Department of Agriculture Soil Conservation Service in cooperation with Virginia Polytechnic Institute and State University, provided soil parameters such as hydraulic conductivity, permeability, and initial moisture deficit required for analysis using the Green-Ampt infiltration methodology in XP-SWMM. Additionally, digital soil coverage depicting soil types were obtained from the National Soil Survey Geographic (SSURGO) Database located on-line at **http://www.ftw.nrcs.usda.gov/ssur_data.html**. The SSURGO data, shown in Figure 2-2, was used to develop area-weighted soil parameters for the model. Green-Ampt infiltration parameters were assigned to each soil type. Those soil types were grouped into more generalized parameters to provide a master plan consideration of soil impacts and reduce the time spent developing soil parameters for use in the watershed model.

**Legend**

- "1" Alaga fine sand
- "10" Nawney loam
- "10A" Kalmia fine sandy loam, wet substratum, 0 - 2 % slopes
- "10B" Kalmia fine sandy loam, wet substratum, 2 - 6 % slopes
- "11" Kenansville loamy sand, 0 - 4 % slopes
- "11E" Nevarc and Remlik soils, 15 - 35 % slopes
- "12" Kenansville loamy sand, wet substratum, 0 - 4 % slopes
- "12A" Peawick silt loam, 0 - 2 % slopes
- "12B" Peawick silt loam, 2 - 6 % slopes
- "12C" Peawick silt loam, 6 - 10 % slopes
- "13" Levy silty clay loam
- "13B3" Peawick clay loam, 2 - 6 % slopes, severely eroded
- "14" Lynchburg fine sandy loam
- "14B" Peawick-Slagle complex, 2 - 6 % slopes
- "15" Rappahannock muck
- "15B" Nansemond loamy fine sand, 0 - 6 % slopes
- "15D" Nansemond loamy fine sand, 6 - 15 % slopes
- "15E" Nansemond loamy fine sand, 15 - 30 % slopes
- "16" Rumford loamy sand
- "16A" Nansemond fine sandy loam, 0 - 2 % slopes
- "16B" Nansemond fine sandy loam, 2 - 6 % slopes
- "17" Pactolus loamy fine sand
- "17B3" Slagle sandy loam, 2 - 6 % slopes, severely eroded
- "18" Pungo muck
- "18A" Slagle fine sandy loam, 0 - 2 % slopes
- "18B" Slagle fine sandy loam, 2 - 6 % slopes
- "18C" Slagle fine sandy loam, 6 - 10 % slopes
- "19" Rains fine sandy loam
- "19A" Uchee loamy sand, 0 - 2 % slopes
- "19B" Uchee loamy sand, 2 - 6 % slopes
- "19C" Uchee loamy sand, 6 - 10 % slopes
- "1B" Alaga loamy sand, wet substratum, 2 - 8 % slopes
- "2" Belhaven muck in Suffolk or Bohicket silty clay loam otherwise
- "20A" Rumford loamy fine sand, 0 - 2 % slopes
- "20B" Rumford loamy fine sand in Suffolk, or Uchee-Peawick complex, 2 - 6 % slopes
- "20C" Uchee-Peawick complex, 6 - 10 % slopes"
- "21" Udorthents, loamy
- "21A" State fine sandy loam, 0 - 2 % slopes
- "21B" State fine sandy loam, 2 - 6 % slopes
- "22A" Suffolk loamy sand, 0 - 2 % slopes
- "22B" Suffolk loamy sand, 2 - 6 % slopes
- "23" Yemassee fine sandy loam
- "23A" Tetotum fine sandy loam, 0 - 2 % slopes
- "23B" Tetotum fine sandy loam, 2 - 6 % slopes
- "24" Tomotley loam
- "25" Torhunta loam
- "26" Udorthents, loamy
- "27" Urban land
- "28" Wahee silt loam
- "29" Weston fine sandy loam
- "3" Bohicket silty clay loam in suffolk, or Chickahominy silt loam
- "4" Deloss mucky loam in Suffolk, or Chipley sand elsewhere
- "5A" Dogue fine sandy loamin Suffolk, or Emporia fine sandy loam, 0 - 2 % slopes
- "5B" Emporia fine sandy loam, 2 - 6 % slopes
- "5B2" Dogue fine sandy loam, 2 - 6 % slopes, eroded
- "6" Dragston fine sandy loam in Suffolk or Kenansville loamy sand elsewhere
- "7" Kinston loam
- "7A" Emporia fine sandy loam, 0 - 2 % slopes
- "7B2" Emporia fine sandy loam, 2 - 6 % slopes, eroded
- "8" Leon-Chipley sands
- "8A" Eunola loamy fine sand, 0 - 2 % slopes
- "8B" Eunola loamy fine sand, 2 - 6 % slopes
- "9" Myatt fine sandy loam
- "9A" Goldsboro fine sandy loam, 0 - 2 % slopes
- "9B2" Goldsboro fine sandy loam, 2 - 5 % slopes, eroded
- "DM" Dam
- "M-W" Industrial waste pond
- "W" Water
- Chowan River Sub-Basins




N

0 3,500 7,000 14,000 21,000 Feet

NOT TO SCALE

02/26/07 - KRH - H:\PJ\0505\GIS_Data\Chowan_River

Suffolk
CLERK'S OFFICE

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# CITY OF SUFFOLK
## STORM WATER MASTER PLAN
## CHOWAN RIVER WATERSHED

STUDY AREA
SOIL SURVEY DATA

FIGURE 2-1

## 2.7 STARTING WATER SURFACE CONDITIONS

Starting water surface conditions were developed to model the initial flooding influence on stream sections within the watershed. The 2-yr starting water surface elevation was used for storms up to a 25-yr design frequency (2-yr, 10-yr, and 25-yr) and a 10-yr starting water surface elevation was used for storms above a 25-yr design frequency (100-yr). The selection of these tailwaters is based on joint probability as described in the VDOT Drainage Manual. The 2-yr elevation of 3.00 feet (NAVD-88) and the 10-yr tidal boundary elevation of 6.70 feet (NAVD-88) was derived form the *Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for the City of Suffolk* dated September 4, 2002.

## 2.8 DESCRIPTION OF MODEL ACCURACY

Due to the lack of detailed survey data and the master plan assumptions used, the model should not be used for design applications. Additional data and survey needs exist before this model can be used for purposes other than approximate analysis and stormwater generalizations. These additional requirements include:

- Detailed survey of hydraulic structure inverts, channel cross sections, elevations of undersides of bridge decking, crown elevations of bridge decking, and adjacent roadway elevations.

- Identification and inventory of existing small impoundments (ponds and stormwater management facilities), volumetric measurements of each impoundment, and control structure information such as pipe sizes, inverts of pipes, and invert or crest information of any other control structure at each impoundment.

# 3.0 EXISTING CONDITION MODEL RESULTS

The existing condition model was analyzed to identify flood prone areas throughout the watershed. The different channel reaches and structures (spillways, culvert crossings and bridges) were analyzed based on the following criteria:

- Existing channel velocities for the 2-yr design storm.
- Roadway culverts for the 10-yr design storm (Minor Arterial, Collector, and Local roadways) and the 25-yr design storm (Principal Arterial roadways).
- Bridges for the 100-year storm.

Improvements and associated costs for the identified flooding and erosion problem areas are recommended based on the model results. Detailed cost estimates for each recommendation are located in Appendix A. Mapping of the flood prone areas and proposed improvements, GIS-03 and GIS-04 respectively, are located in the back of the report.

## 3.1 DISCUSSION OF FIELD OBSERVATIONS

Clark Nexsen performed a field investigation to identify and document the relevant drainage features within the Study Area. The field study included documenting evidence of erosion at the structures and within the stream channels. Several of the culvert crossings exhibited signs of undermining which caused sumps and sink holes within the roadway and shoulder. Evidence of repaired sumps within the road was also observed in the form of recent pavement patches. Table 3-1 below summarizes locations in the field where erosion, sink holes or sumps were observed.

| Table No. 3-1 Field Observations | | |
|---|---|---|
| **Node Name** | **Location** | **Field Observations** |
| NCS15 | 30" RCP Quaker Drive | Sump in Road |
| NCS18 | 24" RCP Quaker Dr | 24" RCP filled with sediment |
| NCS23 | 24" RCP at O'Kelly Dr | Sump in road |
| NCS32 | (5) 42" CMP at Cornith Chapel Rd | Sink hole at shoulder |
| NJS3 | 24" CMP at Porterfield Rd | 24" CMP rusted and bent |
| NKS21* | Box culvert Rutitan Blvd | Erosion at downstream outlet |
| NKS5 | Arch culvert at Glen Haven Rd | Pavement failure |
| NKS9 | 24" RCP at Kingsdale Rd | 24" RCP filled with sediment, eroded shoulder |
| NMS2 | (3) 30" RCP at New Rd | Sink hole at shoulder |
| NQS1 | 24" RCP at Buckhorn Rd | Upstream end of 24" RCP broken, sump in road |
| NQS16 | 24" CMP at Lummis Rd | 24" CMP rusted and bent |
| NQS18 | 24" Clay Pipe at Lummis Rd | Broken clay pipe |
| NQS2 | 24" RCP at Patchin Rd | Sediment in pipe and sinkhole in shoulder, erosion at downstream outlet |
| NQS25 | 24" RCP at Kingsdale Rd | 24" RCP filled with sediment, inadequate downstream slope |
| NQS28 | 15" RCP at Hare Rd | Sump in road |
| NQS41* | 36" RCP at Dutch Rd | Sump in road |
| NSS24* | 18" RCP Freeman Hill Rd | Sink hole at shoulder |
| NTBR20* | 48" RCP South Quay Rd | Downstream scour and broken pipe |

Most of the deficiencies listed in Table 3-1 above can be considered maintenance items which can be addresses by the City Public Works. Locations marked with an * are discussed in more detail in section 3-3 below.

## 3.2 EVALUATION OF EXISTING CONDITION CHANNEL REACHES

Analysis of the channel velocities from the model does not indicate a severe erosion condition exists within the watershed channel sections (velocity greater than 2.3 feet-second for the 2 yr design storm). The selection of a velocity of 2.3 feet per second or more is based on the general soil characteristics obtained from SSURGO and comparison with Recommended Maximum Water Velocities and Manning's n as a Function of Soil Depth and Flow Type chart contained in the VDOT Drainage Manual. The majority of the soils are classified as A-2 or A-4, which are gravel and sand with mixtures of silt and

clay and silts with mixtures of sand and clay, respectively. This is consistent with what was viewed in the field.

The model shows the velocity within several of the conduits contributes to scour at some pipe outfalls. Due to the limitations of a general stormwater model typical for master planning purposes, channel velocities could vary just as actual conditions along the channel vary but are not explicitly modeled. Therefore, caution is required to determine if a channel is not adequate based on the results.

No specific recommendations for channel stability are provided at this time.

## 3.3 EVALUATION OF EXISTING CONDITION ROADWAY CULVERTS

The roadway culverts analysis was based on the design criteria in the *VDOT Drainage Manual, Chapter 6, Design Criteria*. The roadway designations were taken from the City Master Thoroughfare Plan for the 2026 Comprehensive Plan. Principal Arterial roadways were evaluated for flooding using the 25-yr design storm and Minor Arterial, Collector and Local roadways were evaluated using the 10-yr design storm.

The model indicates that most of the roads within the watershed flood for the 10-yr design storm at culvert crossings. The model results confirm field observations where it appeared that many of the roadway elevations dip at culvert crossings allowing flood waters to overtop the road at these localized areas. At this time, only flooded culverts along the Primary Arterial and Minor Arterial roads are recommended for improvements.

Table No. 3-2 below summarizes the peak design storm flood elevation at each culvert for the Principal and Minor Arterial roads.

| Table No. 3-2 Culvert Peak Design Storm Flood Elevations | | | | | |
|---|---|---|---|---|---|
| **Node Name** | **Conduit Type** | **Road Name** | **Roadway Designation** | **Approximate Top of Road Elevation (ft)** | **Design Flood Elevation (ft)** |
| NCS44 | 24" RCP | Dutch Rd (Rt 653) | Minor Arterial | 65.00 | 65.52 |
| NJS11 | Bridge #8038 | Holland Corner Rd (Rt 653) | Minor Arterial | 35.00 | 34.99 |
| NJS12 | Bridge #8017 | Mineral Spring Rd (Rt 616) | Minor Arterial | 33.00 | 33.34 |
| NKS16 | Bridge #1828 | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 42.00 | 41.07 |
| NKS18 | 6'x6' Box Culvert | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 53.00 | 51.50 |
| NKS2 | Twin 4'x4' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 73.00 | 68.23 |
| NKS21 | 3'x3' Box Culvert | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 55.00 | 55.87 |
| NKS26 | 6'x6' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 61.50 | 58.80 |
| NKS4 | Twin 6'x6' Box Culvert | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 47.00 | 46.12 |
| NKS43 | 12" RCP | Glen Haven Dr (Rt 653) | Minor Arterial | 77.00 | 77.31 |
| NKS48 | 36" RCP | Franklin BP (Rt 58/189) | Principal Arterial | 69.00 | 69.84 |
| NKS5 | 15'x5' Arch CMP | Glen Haven Dr (Rt 653) | Minor Arterial | 50.00 | 45.62 |
| NKS57 | 36" RCP | Franklin BP (Rt 58/189) | Principal Arterial | 74.00 | 74.02 |
| NMS5 | Bridge #8046 | Gates Rd (Rt 666) | Minor Arterial | 33.00 | 33.60 |
| NQS10 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 75.00 | 70.50 |
| NQS13 | 24" RCP | Lummis Rd (Rt 649) | Minor Arterial | 68.00 | 68.36 |
| NQS21 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 70.00 | 69.18 |
| NQS33 | 36" RCP | Dutch Rd (Rt 653) | Minor Arterial | 58.00 | 58.35 |
| NQS37 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 66.00 | 63.39 |
| NQS38 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 70.00 | 70.01 |
| NQS41 | 36" RCP | Dutch Rd (Rt 653) | Minor Arterial | 73.00 | 73.31 |
| NQS8 | Triple 7'x6' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 57.00 | 53.79 |
| NQS9 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 77.00 | 74.73 |

**Table No. 3-2 Culvert Peak Design Storm Flood Elevations**

| Node Name | Conduit Type | Road Name | Roadway Designation | Approximate Top of Road Elevation (ft) | Design Flood Elevation (ft) |
|---|---|---|---|---|---|
| NSMC10 | 24" RCP | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.57 |
| NSMC12 | Twin 6'x6' Box Culvert | Whaleyville Blvd (Rt 13) | Principal Arterial | 37.00 | 33.90 |
| NSMC9 | Twin 24" RCP | Whaleyville Blvd (Rt 13) | Principal Arterial | 49.00 | 50.13 |
| NSS1 | 4'x4'xBox Culvert | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.54 |
| NSS16 | 18" & 24" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 49.00 | 49.35 |
| NSS2 | Bridge #1806 | Whaleyville Blvd (Rt 13) | Minor Arterial | 47.00 | 43.12 |
| NSS24 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 47.00 | 47.40 |
| NSS25 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 57.00 | 57.44 |
| NSS3 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 47.00 | 47.80 |
| NSS5 | 24" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 49.00 | 49.85 |
| NSS8 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 35.00 | 36.03 |
| NTBR1 | 36" RCP | Franklin BP (Rt 58/189) | Principal Arterial | 56.00 | 56.69 |
| NTBR10 | Triple 9'x12' Box Culvert | South Quay Rd (Rt 189) | Minor Arterial | 31.00 | 20.08 |
| NTBR11 | 5'x4' Box Culvert | South Quay Rd (Rt 189) | Minor Arterial | 44.00 | 42.85 |
| NTBR12 | (4) 10'x10' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 33.00 | 14.14 |
| NTBR14 | 36" RCP | Great Mill Hwy (Rt 160) | Minor Arterial | 60.00 | 45.50 |
| NTBR20 | 48" RCP | South Quay Rd (Rt 189) | Minor Arterial | 21.80 | 22.45 |
| NTBR24 | 30" CMP | Franklin BP (Rt 58/189) | Principal Arterial | 52.00 | 52.59 |
| NTBR25 | 30" CMP | Franklin BP (Rt 58/189) | Principal Arterial | 44.00 | 43.07 |
| NTBR3 | 10'x6' Box Culvert | South Quay Rd (Rt 272) | Minor Arterial | 37.00 | 35.44 |
| NTBR30 | 36" RCP | Great Mill Hwy (Rt 160) | Minor Arterial | 60.00 | 41.43 |
| NTBR8 | Twin 6'x6' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 37.00 | 36.31 |
| NTBR9 | 30" CMP | Franklin BP (Rt 58/189) | Principal Arterial | 39.00 | 39.02 |

The table above indicates that the design flood elevation for several culvert crossing overtop their respective roadways.

### 3.3.1 Recommendations

In order to reduce the design flood elevation for the culverts, the City may wish to consider the following recommendations.

- NCS44: The existing 24" RCP culvert does not have the required capacity to pass the 10-yr design storm without overtopping Dutch Road (Rt. 653). Though the road is overtopped; the level of ponding at the culvert is not expected to impact nearby residential structures. To convey the runoff beneath the road, two 36" RCP should be installed in place of the existing culvert. The cost of the culvert improvements would be approximately $125,353.

- NJS11: The roadway near Bridge # 8083 on Holland Corner Road (Rt. 653) is flooded for the 10-yr design storm; the level of ponding at the bridge is not expected to impact nearby residential structures. To convey the runoff beneath the road, an additional 60"x 46" CMP arch should be installed to provide additional flood relief for the bridge. The cost of the culvert improvements would be approximately $147,373.

- NKS21: The 3'x3' Box Culvert crosses beneath Ruritan Blvd (Rt. 58 BUS), the roadway is flooded at the culvert for the 10-yr design storm. Flooding at this elevation is not expected to impact nearby residential structures. Installing two parallel 5'x3' box culverts would lower the 10-yr design flood headwater elevation and prevent the road from being overtopped. The cost of the culvert improvements would be approximately $568,187.

- NKS4: The twin 6'x6' box culvert at this node crosses Ruritan Blvd (Rt. 58 BUS). The model indicates the roadway is flooded for the 10-yr design storm.

Adding an additional 6'x6' box culvert next to the existing culvert would lower the 10-yr peak design flood elevation and prevent the road from being flooded. The cost of the culvert improvements would be approximately $590,315.

- NKS43: The existing 12" RCP crossing Glen Haven Rd (Rt. 653) does not have adequate capacity to convey the 10-yr design storm. Flooding at this elevation is not expected to impact nearby residential structures. The existing pipe should be replaced with twin 24" RCP to prevent the road from being flooded and approximately 850 LF of downstream channel should be regarded to provide a more defined conveyance. The cost of the culvert improvements would be approximately $436,914.

- NKS48: The 36" RCP at this node crosses South Quay Rd (Rt. 58/189). The model indicates the roadway is flooded for the 25-yr design storm however; the level of ponding at the culvert is not expected to impact nearby residential structures. Replacing the existing pipe with two 5'x4' box culverts would lower the 25-yr peak design flood elevation and prevent the road from being flooded. The cost of the culvert improvements would be approximately $1,370,661.

- NKS57: The 36" RCP crosses beneath South Quay Rd (Rt. 58/189), the roadway is flooded at the culvert for the 25-yr design storm. Installing a parallel 36" RCP would lower the 25-yr design flood headwater elevation and prevent the road from being overtopped. The cost of the culvert improvements would be approximately $502,031.

- NQS13: The 24" RCP" at this node crosses Lummis Rd (Rt. 649). The model indicates the roadway is flooded for the 10-yr design storm however; the level of ponding at the culvert is not expected to impact nearby residential structures. Raising the road in the vicinity of the culvert (360 LF) to elevation 69.00 (approximately 1 ft) and replacing the existing 24" RCP with four 36" RCP would

prevent the road from being flooded. The cost of the road raising and culvert improvements would be approximately $570,836.

- NQS33: The existing 24" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping Dutch Rd (Rt. 653). The level of ponding at the culvert headwaters does not impact nearby residential structures. To convey the runoff without overtopping, the existing culvert should be replaced with four 30" RCP. The cost of the culvert improvements would be approximately $321,694.

- NQS38: The 25-yr design storm elevation existing 4'x4' Box Culvert overtops Holland Rd (Rt. 58). Flooding at this level may impact nearby residential structures. To convey the runoff beneath the road without overtopping, a 6'x4' Box Culvert should be installed parallel to the existing culvert. The cost of the culvert improvements would be approximately $767,768.

- NQS41: The existing 36" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping Dutch Road (Rt. 653). The level of ponding at the culvert headwaters does not impact nearby residential structures. To convey the runoff without overtopping, an additional 36" RCP should be installed parallel to the existing pipe. The cost of the culvert improvements would be approximately $148,649.

- NSMC10: The 25-yr design storm elevation existing 24" RCP overtops Whaleyville Blvd (Rt. 13). Flooding at this level may impact nearby residential structures. To convey the runoff beneath the road without overtopping, the existing pipe should be replaced with two 5'x3' Box Culverts. The cost of the culvert improvements would be approximately $365,935.

- NSMC9: The 25-yr design storm elevation existing twin 24" RCP overtops Whaleyville Blvd (Rt. 13). Flooding at this level does not impact any residential structures. To convey the runoff beneath the road without overtopping, the existing twin 24" RCP should be replaced with (3) 5'x3' Box Culverts. The cost of the culvert improvements would be approximately $372,275.

- NSS1: The 25-yr design storm elevation existing twin 4'x4' Box Culvert overtops Whaleyville Blvd (Rt. 13). Flooding at this level may impact nearby residential structures. To convey the runoff beneath the road without overtopping, two additional 4'x4' Box Culverts should be installed parallel to the existing 4'x4' Box. The cost of the culvert improvements would be approximately $317,943.

- NSS16: The existing 18" RCP and 24" RCP culverts do not have the required capacity to convey the 10-yr design storm without overtopping Mineral Spring Rd (Rt. 616). The level of ponding at the culvert does not impact nearby residential structures. To convey the runoff without overtopping, the existing culvert should be replaced with four 36" RCP. The cost of the culvert improvements would be approximately $275,613.

- NSS24: The existing 18" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping Mineral Spring Rd (Rt. 616). The level of ponding at the culvert does not impact nearby residential structures. To convey the runoff without overtopping, a parallel 30" RCP culvert should be added to the existing culvert. The cost of the culvert improvements would be approximately $86,264.

- NSS25: The existing 18" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping Mineral Spring Rd (Rt. 616). The level of ponding at the culvert may impact nearby residential structures. To convey the runoff without overtopping, the existing culvert should be replaced

with two 36" RCP. The cost of the culvert improvements would be approximately $143,786.

- NSS3: The existing 18" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping Mineral Spring Rd (Rt. 616). The level of ponding at the culvert does not impact nearby residential structures. To convey the runoff without overtopping, the road should be raised approximately 1 foot (600 LF) to elevation 48 and the existing culvert should be replaced with (4) 5'x3' box culverts. The cost of the culvert improvements would be approximately $903,845.

- NSS5: The existing 24" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping Mineral Spring Rd (Rt. 616). The level of ponding at the culvert does not impact nearby residential structures. To convey the runoff without overtopping, the road should be raised approximately 1 foot (156 LF) to elevation 50 and the existing culvert should be replaced with (4) 42" RCP. The cost of the culvert improvements would be approximately $499,696.

- NSS8: The existing 18" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping Mineral Spring Rd (Rt. 616). The level of ponding at the culvert does not impact nearby residential structures. To convey the runoff without overtopping, the road should be raised approximately 1 foot (570 LF) to elevation 36 and the existing culvert should be replaced with (6) 5'x3' box culverts. The cost of the culvert improvements would be approximately $1,226,254.

- NTBR1: The existing 30" RCP culvert does not have the required capacity to convey the 25-yr design storm without overtopping South Quay Rd (Rt. 58/189). The level of ponding at the culvert headwaters does not impact any residential

structures. To convey the runoff without overtopping, the existing culvert should be replaced with two 5'x4' box culverts. The cost of the culvert improvements would be approximately $1,148,176.

- NTBR20: The existing 48" RCP culvert does not have the required capacity to convey the 10-yr design storm without overtopping South Quay Rd (Rt. 189). The level of ponding at the culvert headwaters does not impact any residential structures. To convey the runoff without overtopping, a second 48" RCP should be installed parallel to the existing pipe. Additionally the broken joint of the existing pipe will need to be repaired and rip rap provided to protect against scour. The cost of the culvert improvements would be approximately $248,976.

- NTBR24: The existing 30" CMP culvert does not have the required capacity to convey the 25-yr design storm without overtopping Franklin By-Pass (Rt. 58/189). The level of ponding at the culvert headwaters does not impact any residential structures. To convey the runoff without overtopping, the existing culvert should be replaced with two 30" RCP. The cost of the culvert improvements would be approximately $482,370.

- NTBR9: The existing 30" CMP culvert does not have the required capacity to convey the 25-yr design storm without overtopping Franklin By-Pass (Rt. 58/189). The level of ponding at the culvert headwaters does not impact any residential structures. To convey the runoff without overtopping, the existing culvert should be replaced with two 30" RCP. The cost of the culvert improvements would be approximately $513,898.

Table No. 3-3 summarizes the existing and proposed improvements peak headwater elevations for the recommendations provided above.

**Table No. 3-3 Comparison of Existing and Improved Culvert Peak Headwater Elevations – Existing Condition Model**

| Node Name | Road Name | Roadway Designation | Approximate Top of Road Elevation (ft) | Existing Culvert Peak Headwater Elevation (ft) | Improved Culvert Peak Headwater Elevation (ft) |
|---|---|---|---|---|---|
| NCS44 | Dutch Rd | Minor Arterial | 65.00 | 65.52 | 64.38 |
| NJS11 | Holland Corner Rd | Minor Arterial | 35.00 | 34.99 | 34.19 |
| NKS21 | Ruritan Blvd | Minor Arterial | 55.00 | 55.87 | 54.25 |
| NKS4 | Ruritan Blvd | Minor Arterial | 47.00 | 46.12 | 46.06 |
| NKS43 | Glen Haven Dr (Rt 653) | Minor Arterial | 77.00 | 77.31 | 75.87 |
| NKS48 | Franklin BP (Rt 58) | Principal Arterial | 69.00 | 69.84 | 67.69 |
| NKS57 | Franklin BP (Rt 58/189) | Principal Arterial | 74.00 | 74.02 | 71.85 |
| NQS13 | Lummis Rd | Minor Arterial | 68.00 (69.00) | 68.36 | 67.55 |
| NQS33 | Dutch Rd | Minor Arterial | 58.00 | 58.36 | 57.73 |
| NQS38 | Holland Rd (Rt 58) | Principal Arterial | 70.00 | 70.01 | 68.50 |
| NQS41 | Dutch Rd | Minor Arterial | 73.00 | 73.31 | 71.56 |
| NSMC10 | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.57 | 49.45 |
| NSMC9 | Whaleyville Blvd (Rt 13) | Principal Arterial | 49.00 | 50.13 | 48.06 |
| NSS1 | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.54 | 50.26 |
| NSS16 | Mineral Spring Rd | Minor Arterial | 49.00 | 49.35 | 47.97 |
| NSS24 | Mineral Spring Rd | Minor Arterial | 47.00 | 47.40 | 46.19 |
| NSS25 | Mineral Spring Rd | Minor Arterial | 57.00 | 57.44 | 56.50 |
| NSS3 | Mineral Spring Rd | Minor Arterial | 47.00 (48.00) | 47.80 | 47.13 |
| NSS5 | Mineral Spring Rd | Minor Arterial | 49.00 (50.00) | 49.85 | 49.17 |
| NSS8 | Mineral Spring Rd | Minor Arterial | 35.00 (36.00) | 36.03 | 34.69 |

**Table No. 3-3 Comparison of Existing and Improved Culvert Peak Headwater Elevations – Existing Condition Model**

| Node Name | Road Name | Roadway Designation | Approximate Top of Road Elevation (ft) | Existing Culvert Peak Headwater Elevation (ft) | Improved Culvert Peak Headwater Elevation (ft) |
|---|---|---|---|---|---|
| NTBR1 | Franklin BP (Rt 58) | Principal Arterial | 56.00 | 56.69 | 53.79 |
| NTBR20 | South Quay Rd (Rt 189) | Minor Arterial | 21.80 | 22.45 | 20.04 |
| NTBR24 | Franklin BP (Rt 58) | Principal Arterial | 52.00 | 52.59 | 51.04 |
| NTBR9 | Franklin BP (Rt 58) | Principal Arterial | 39.00 | 39.02 | 38.70 |

Note: Road elevations in ( ) represent the proposed road raising elevation.

## 3.4 EVALUATION OF EXISTING CONDITION BRIDGES

The flood elevations at the bridges were evaluated using the 100-yr design storm. Table No. 3-4 below summarizes the 100-yr design flood elevation at the various bridges within the watershed.

**Table No. 3-4 Bridge 100-yr Design Storm Flood Elevations**

| Node | Location | Bridge Number | Low Chord Elevation (ft) | Low Point of Road Elevation (ft) | Bridge Deck Elevation (ft) | 100-yr Design Storm Elevation (ft) |
|---|---|---|---|---|---|---|
| NCS33 | Pineview Rd | 8043 | 23.00 | 25.00 | 27.50 | 20.13 |
| NCS6 | Southwestern Blvd | 8040 | 48.00 | 49.50 | 49.50 | 49.57 |
| NJS11 | Holland Corner Rd | 8038 | 35.00 | 35.00 | 37.00 | 36.07 |
| NJS12 | Mineral Spring Rd | 8017 | 34.00 | 33.00 | 35.50 | 34.31 |
| NJS6 | Box Elder Rd | 8041 | 42.00 | 43.50 | 43.50 | 44.38 |
| NKS15 | Ruritan Blvd | 1828 | 40.00 | 41.00 | 42.00 | 42.61 |
| NKS24 | Elwood Rd | 8016 | 35.00 | 37.00 | 37.00 | 36.77 |
| NKS32 | Harvest Dr | 8025 | 31.50 | 33.00 | 33.00 | 33.85 |
| NMS5 | Gates Rd | 8046 | 31.50 | 33.00 | 33.00 | 34.04 |
| NSMC13 | Arthur Dr | 8034 | 24.50 | 26.00 | 26.20 | 27.15 |
| NSMC14 | Butler Dr | 8039 | 25.50 | 23.20 | 27.00 | 21.61 |
| NSMC19 | Gates Rd | 8042 | 17.00 | 19.00 | 19.00 | 18.01 |
| NSMC23 | Camp Pond Rd | 8062 | 7.50 | 7.00 | 8.70 | 12.25 |
| NSMC29 | Robbie Rd | 8052 | 27.50 | 29.00 | 29.00 | 30.53 |
| NSS15 | Arthur Dr | 8033 | 31.00 | 31.00 | 32.70 | 33.71 |
| NSS6 | Freeman Mill Rd | 8049 | 37.50 | 39.00 | 39.00 | 39.60 |

The existing condition model shows that the 100-yr design flood elevations overtop the roadway and/or bridge for most of the bridges within the watershed.

### 3.4.1 Recommendations

Many of the bridges within the watershed are flooded for the 100-yr design storm. The majority of those bridges that flood for storm events less than the 100-yr design storm are on local and secondary roads. These roads and the bridges associated with them are generally between 4 and 8 feet above the estimated bottom of the channel or floodplain.

Often the adjacent roadway is depressed to provide overflow relief to protect the bridge structure. The current analysis indicates that significant improvements would be required to raise the bridges above the 100-yr flood elevation or to provide pipe crossings to direct flow below the roadway elevation. Individual bridges should have a detailed hydrologic and hydraulic analysis performed to assess the performance of the bridge and to provide appropriate recommendations.

# 4.0 PROPOSED CONDITION (2026) MODEL RESULTS

The existing condition model was modified to reflect the future planned development in the watershed as outlined in the 2026 Comprehensive Plan. The proposed sub-catchment zoning coverages were assigned impervious surface ratios based on the Suffolk UDO to create area-weighted estimates of projected impervious surface area. The majority of the Study Area is located in the A (Agricultural District) Zone. In order to model the future (2026) land use conditions a minimum 16% impervious coverage, based on the Suffolk UDO, was used for the sub-catchments within the model. The proposed model was analyzed to identify flood prone areas. The channel reaches and structures (spillways, culvert crossings and bridges) were analyzed based on the following criteria, similar to the existing condition model:

- Proposed channel velocities for the 2-yr design storm.
- Roadway culverts for the 10-yr design storm (Minor Arterial roadways) and the 25-yr design storm (Principal Arterial roadways).
- Bridges for the 100-year storm.

The improvements for the identified flooding and erosion problem areas recommended in Section 3 of the report were analyzed for the 2026 land use condition. Some of the improvements cited in Section 3 will be adequate for the 2026 land use condition. Detailed cost estimates for each recommendation are located in Appendix A. Mapping of the flood prone areas and proposed improvements, GIS-03 and GIS-04 respectively, are located in the back of the report.

## 4.1 EVALUATION OF PROPOSED CONDITION CHANNEL REACHES

As with the existing condition model, analysis of the channel velocities does not indicate a severe erosion condition exists within most of the watershed channels incorporated into the model. No specific recommendations for channel stability are provided at this time.

## 4.2 EVALUATION OF PROPOSED CONDITION ROADWAY CULVERTS

The proposed condition roadway culverts were analyzed using the same design criteria as the existing condition model based on the data in the VDOT Drainage Manual. Principal Arterial roadways were evaluated for flooding using the 25-yr design storm and Minor Arterial, Collector, and Local roadways were evaluated using the 10-yr design storm. As with the existing condition model, only flooded culverts at along the Primary Arterial and Minor Arterial roads are recommended for improvements.

Table No. 4-1 below summarizes the peak design storm flood elevation at each culvert modeled.

**Table No. 4-1 Culvert Peak Design Storm Flood Elevations – 2026 Condition Model**

| Node Name | Conduit Type | Road Name | Roadway Designation | Approximate Top of Road Elevation (ft) | Design Flood Elevation (ft) |
|---|---|---|---|---|---|
| NCS44 | 24" RCP | Dutch Rd (Rt 653) | Minor Arterial | 65.00 | 65.60 |
| NJS11 | Bridge #8038 | Holland Corner Rd (Rt 653) | Minor Arterial | 35.00 | 35.31 |
| NJS12 | Bridge #8017 | Mineral Spring Rd (Rt 616) | Minor Arterial | 33.00 | 33.51 |
| NKS16 | Bridge #1828 | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 42.00 | 41.25 |
| NKS18 | 6'x6' Box Culvert | Ruritan Blvd (Rt 58 Bus) | Minor Arterial | 53.00 | 52.19 |
| NKS2 | Twin 4'x4' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 73.00 | 68.23 |
| NKS21 | 3'x3' Box Culvert | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 55.00 | 56.05 |
| NKS26 | 6'x6' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 61.50 | 58.80 |
| NKS4 | Twin 6'x6' Box Culvert | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 47.00 | 46.38 |
| NKS43 | 12" RCP | Glen Haven Dr (Rt 653) | Minor Arterial | 77.00 | 77.36 |
| NKS48 | 36" RCP | Franklin BP (Rt 58/189) | Principal Arterial | 69.00 | 69.84 |
| NKS5 | 15'x5' Arch CMP | Glen Haven Dr (653) | Minor Arterial | 50.00 | 45.83 |
| NKS57 | 36" RCP | Franklin BP (Rt 58/189) | Principal Arterial | 74.00 | 74.02 |

**Table No. 4-1 Culvert Peak Design Storm Flood Elevations – 2026 Condition Model**

| Node Name | Conduit Type | Road Name | Roadway Designation | Approximate Top of Road Elevation (ft) | Design Flood Elevation (ft) |
|---|---|---|---|---|---|
| NMS5 | Bridge #8046 | Gates Rd (666) | Minor Arterial | 33.00 | 33.66 |
| NQS10 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 75.00 | 70.84 |
| NQS13 | 24" RCP | Lummis Rd (649) | Minor Arterial | 68.00 | 68.48 |
| NQS21 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 70.00 | 69.92 |
| NQS33 | 36" RCP | Dutch Rd (Rt 653) | Minor Arterial | 58.00 | 58.37 |
| NQS37 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 66.00 | 63.89 |
| NQS38 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 70.00 | 70.23 |
| NQS41 | 36" RCP | Dutch Rd | Minor Arterial | 73.00 | 73.41 |
| NQS8 | Triple 7'x6' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 57.00 | 54.05 |
| NQS9 | Twin 4'x4' Box Culvert | Holland Rd (Rt 58) | Principal Arterial | 77.00 | 75.35 |
| NSMC10 | 24" RCP | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.65 |
| NSMC12 | Twin 6'x6' Box Culvert | Whaleyville Blvd (Rt 13) | Principal Arterial | 37.00 | 34.08 |
| NSMC9 | Twin 24" RCP | Whaleyville Blvd (Rt 13) | Principal Arterial | 49.00 | 50.23 |
| NSS1 | 4'x4'xBox Culvert | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.59 |
| NSS16 | 18" & 24" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 49.00 | 49.42 |
| NSS2 | Bridge #1806 | Whaleyville Blvd (Rt 13) | Minor Arterial | 47.00 | 43.25 |
| NSS24 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 47.00 | 47.45 |
| NSS25 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 57.00 | 57.49 |
| NSS3 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 47.00 | 47.93 |
| NSS5 | 24" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 49.00 | 49.99 |
| NSS8 | 18" RCP | Mineral Spring Rd (Rt 616) | Minor Arterial | 35.00 | 36.08 |
| NTBR1 | 36" RCP | Franklin BP (Rt 58/189) | Principal Arterial | 56.00 | 56.69 |
| NTBR10 | Triple 9'x12' Box Culvert | South Quay Rd (Rt 189) | Minor Arterial | 31.00 | 20.14 |
| NTBR11 | 5'x4' Box Culvert | South Quay Rd (Rt 189) | Minor Arterial | 44.00 | 43.06 |

| Table No. 4-1 Culvert Peak Design Storm Flood Elevations – 2026 Condition Model | | | | | |
|---|---|---|---|---|---|
| **Node Name** | **Conduit Type** | **Road Name** | **Roadway Designation** | **Approximate Top of Road Elevation (ft)** | **Design Flood Elevation (ft)** |
| NTBR12 | (4) 10'x10' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 33.00 | 14.14 |
| NTBR14 | 36" RCP | Great Mill Hwy (Rt 160) | Minor Arterial | 60.00 | 45.65 |
| NTBR20 | 48" RCP | South Quay Rd (Rt 189) | Minor Arterial | 21.80 | 22.45 |
| NTBR24 | 30" CMP | Franklin BP (Rt 58/189) | Principal Arterial | 52.00 | 52.59 |
| NTBR25 | Twin 4'x4' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 44.00 | 43.07 |
| NTBR3 | 10'x6' Box Culvert | South Quay Rd (Rt 272) | Minor Arterial | 37.00 | 35.64 |
| NTBR30 | 36" RCP | Great Mill Hwy (Rt 160) | Minor Arterial | 60.00 | 41.56 |
| NTBR8 | Twin 6'x6' Box Culvert | Franklin BP (Rt 58/189) | Principal Arterial | 37.00 | 36.31 |
| NTBR9 | 30" CMP | Franklin BP (Rt 58/189) | Principal Arterial | 39.00 | 39.03 |

The table above indicates that the design flood elevation for several culvert crossing overtop their respective roadways. These results are similar to the existing condition model.

### 4.2.1 Recommendations

The existing condition recommendations for the culverts were analyzed for the 2026 land use condition. ***Improvements recommended under the existing condition were adequate for several of the culverts in the proposed condition (2026).*** The following summarizes the proposed improvements for the 2026 model.

- NCS44: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NJS11: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NKS21: In addition to the improvements recommended under Section 3, two additional 5'x3' box culverts should be installed to convey the 10-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $809,269.

- NKS4: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NKS43: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NKS48: In addition to the improvements recommended under Section 3, an additional 5'x 4' box culvert should be installed. The adjusted cost of the culvert improvements would be approximately $1,746,658.

- NKS57: In addition to the improvements recommended under Section 3, an additional 36" RCP should be installed. The adjusted cost of the culvert improvements would be approximately $712,058.

- NQS13: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NQS21: Route 58 is flooded for the 25-yr design storm at the existing twin 4'x4' box culvert. To convey the runoff beneath the road, an additional 4'x 4' box culvert should be installed. The cost of the culvert improvements would be approximately $701,744.

- NQS33: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NQS38: In addition to the improvements recommended under Section 3, a second parallel 6'x4' box culvert should be installed to convey the 25-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $1,060,263.

- NQS41: In addition to the improvements recommended under Section 3, another parallel 36" RCP should be installed to convey the 10-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $182,851.

- NSMC10: In addition to the improvements recommended under Section 3, a third parallel 5'x3' box culvert should be installed to convey the 25-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $530,981.

- NSMC9: In addition to the improvements recommended under Section 3, a fourth parallel 5'x3' box culvert should be installed to convey the 25-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $494,621.

- NSS1: In addition to the improvements recommended under Section 3, a third parallel 4'x4' box culvert should be installed to convey the 25-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $439,723.

- NSS16: In addition to the improvements recommended under Section 3, a fourth parallel 36" RCP should be installed to convey the 10-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $351,623.

- NSS24: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NSS25: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NSS3: In addition to the improvements recommended under Section 3, two more parallel 5'x3' box culverts should be installed to convey the 10-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $1,140,453.

- NSS5: In addition to the improvements recommended under Section 3, two more parallel 48" RCP should be installed to convey the 10-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $680,799.

- NSS8: In addition to the improvements recommended under Section 3, a sixth parallel 5'x3' box culvert should be installed to convey the 10-yr peak discharge. The adjusted cost of the culvert improvements would be approximately $1,379,042.

- NTBR1: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NTBR20: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NTBR24: The improvements proposed under Section 3 are adequate to address the 2026 land use condition.

- NTBR9: The improvements proposed under Section 3 are adequate to address the 2026 land use condition

- Regional Best Management Practices (BMPs): The comparative analysis of constructing a BMP versus making roadway drainage improvements indicates that a significant storage volume is typically required to attenuate sufficient flow to

avoid making roadway drainage improvements. Because these costs would far exceed making roadway improvements, no recommendations are made to use storage ponds upstream of roadways. The cost of regional BMPs would be greater than the cost associated with upgrading the roadway culverts. Additionally, construction of regional BMPs reduces the amount of developable land and would require substantial right-of-way to construct and maintain.

Table No. 4-2 summarizes the existing and proposed peak headwater elevations for the recommendations provided above.

**Table No. 4-2 Comparison of Existing and Improved Culvert Peak Headwater Elevations – 2026 Condition Model**

| Node Name | Road Name | Roadway Designation | Approximate Top of Road Elevation (ft) | 2026 Culvert Peak Headwater Elevation (ft) | Improved Culvert Peak Headwater Elevation (ft) |
|---|---|---|---|---|---|
| NCS44 | Dutch Rd | Minor Arterial | 65.00 | 65.60 | 65.00 |
| NJS11 | Holland Corner Rd | Minor Arterial | 35.00 | 35.31 | 34.54 |
| NKS21 | Ruritan Blvd | Minor Arterial | 55.00 | 56.05 | 53.52 |
| NKS4 | Ruritan Blvd (Rt 58 BUS) | Minor Arterial | 47.00 | 46.36 | 46.17 |
| NKS43 | Glen Haven Dr (Rt 653) | Minor Arterial | 77.00 | 77.36 | 76.03 |
| NKS48 | Franklin BP (Rt 58) | Principal Arterial | 69.00 | 69.84 | 65.48 |
| NKS57 | Franklin BP (Rt 58/189) | Principal Arterial | 74.00 | 74.02 | 72.27 |
| NQS13 | Lummis Rd | Minor Arterial | 68.00 (69.00) | 68.38 | 68.45 |
| NQS21 | Holland Rd (Rt 58) | Principal Arterial | 70.00 | 69.92 | 67.99 |
| NQS33 | Dutch Rd | Minor Arterial | 58.00 | 58.42 | 58.00 |
| NQS38 | Holland Rd (Rt 58) | Principal Arterial | 70.00 | 70.23 | 68.76 |
| NQS41 | Dutch Rd | Minor Arterial | 73.00 | 73.41 | 71.59 |
| NSMC10 | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.65 | 48.80 |
| NSMC9 | Whaleyville Blvd (Rt 13) | Principal Arterial | 49.00 | 50.23 | 48.03 |
| NSS1 | Whaleyville Blvd (Rt 13) | Principal Arterial | 51.00 | 51.59 | 49.91 |
| NSS16 | Mineral Spring Rd | Minor Arterial | 49.00 | 49.42 | 48.24 |
| NSS24 | Mineral Spring Rd | Minor Arterial | 47.00 | 47.48 | 46.66 |
| NSS25 | Mineral Spring Rd | Minor Arterial | 57.00 | 57.49 | 56.69 |
| NSS3 | Mineral Spring Rd | Minor Arterial | 47.00 (48.00) | 47.93 | 46.97 |
| NSS5 | Mineral Spring Rd | Minor Arterial | 49.00 (50.00) | 49.99 | 49.90 |

**Table No. 4-2 Comparison of Existing and Improved Culvert Peak Headwater Elevations – 2026 Condition Model**

| Node Name | Road Name | Roadway Designation | Approximate Top of Road Elevation (ft) | 2026 Culvert Peak Headwater Elevation (ft) | Improved Culvert Peak Headwater Elevation (ft) |
|---|---|---|---|---|---|
| NSS8 | Mineral Spring Rd | Minor Arterial | 35.00 (36.00) | 36.08 | 34.85 |
| NTBR1 | Franklin BP (Rt 58) | Principal Arterial | 56.00 | 56.69 | 55.62 |
| NTBR20 | South Quay Rd (Rt 189) | Minor Arterial | 21.80 | 22.45 | 20.28 |
| NTBR24 | Franklin BP (Rt 58/189) | Principal Arterial | 52.00 | 52.59 | 51.53 |
| NTBR9 | Franklin BP (Rt 58/189) | Principal Arterial | 39.00 | 39.03 | 38.07 |

Note: Road elevations in ( ) represent the proposed road raising elevation.

## 4.3 EVALUATION OF PROPOSED CONDITION BRIDGES

The flood elevations at the bridges were evaluated using the 100-yr design storm for the 2026 condition. Table No. 4-3 below summarizes the 2026 condition 100-yr design flood elevation at the various bridges within the watershed.

**Table No. 4-3 Bridge 100-yr Design Storm Flood Elevations**

| Node | Location | Bridge Number | Low Chord Elevation (ft) | Low Point of Road Elevation (ft) | Bridge Deck Elevation (ft) | 100-yr Design Storm Elevation (ft) |
|---|---|---|---|---|---|---|
| NCS33 | Pineview Rd | 8043 | 23.00 | 25.00 | 27.50 | 20.36 |
| NCS6 | Southwestern Blvd | 8040 | 48.00 | 49.50 | 49.50 | 49.84 |
| NJS11 | Holland Corner Rd | 8038 | 35.00 | 35.00 | 37.00 | 36.20 |
| NJS12 | Mineral Spring Rd | 8017 | 34.00 | 33.00 | 35.50 | 34.37 |
| NJS6 | Box Elder Rd | 8041 | 42.00 | 43.50 | 43.50 | 44.49 |
| NKS15 | Ruritan Blvd | 1828 | 40.00 | 41.00 | 42.00 | 42.73 |
| NKS24 | Elwood Rd | 8016 | 35.00 | 37.00 | 37.00 | 36.98 |
| NKS32 | Harvest Dr | 8025 | 31.50 | 33.00 | 33.00 | 33.91 |
| NMS5 | Gates Rd | 8046 | 31.50 | 33.00 | 33.00 | 34.10 |
| NSMC13 | Arthur Dr | 8034 | 24.50 | 26.00 | 26.20 | 27.19 |
| NSMC14 | Butler Dr | 8039 | 25.50 | 23.20 | 27.00 | 21.73 |
| NSMC19 | Gates Rd | 8042 | 17.00 | 19.00 | 19.00 | 18.29 |
| NSMC23 | Camp Pond Rd | 8062 | 7.50 | 7.00 | 8.70 | 12.68 |
| NSMC29 | Robbie Rd | 8052 | 27.50 | 29.00 | 29.00 | 30.85 |
| NSS15 | Arthur Dr | 8033 | 31.00 | 31.00 | 32.70 | 33.99 |
| NSS6 | Freeman Mill Rd | 8049 | 37.50 | 39.00 | 39.00 | 39.68 |

As previously determined from the existing condition model, the 100-yr design flood elevations overtop the roadway and/or bridge for most of the bridges within the watershed.

### 4.3.1 Recommendations

As outlined in section 3 above, no recommendations for the bridges are being presented at this time.

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

The recommendations proposed in the report are summarized in Table No. 5-1 below with associated construction cost estimates. These recommendations are based on model computations and certain conditions discerned from the field investigation. Other conditions could exist that were not modeled due to the scope of the project and the intended usefulness of a stormwater master planning model. The improvements are not in a specific order. Most of the improvements recommended were from inadequate culverts that had the potential to overtop Principal Arterial and Minor Arterial roadways for their respective 24-hour rainfall event. The costs listed show the estimated value of improvements based on the existing condition and the proposed condition (2026) land uses. For those improvements where only one cost is listed, there were no additional improvements required to address the proposed condition (2026) land uses, with the exception of Nodes NJS11 and NQS21 where the improvements are for the proposed condition only. The costs shown are based on 2007 dollars and would be greater in the future due to construction cost escalation.

**Table No. 5-1 Summary of Erosion and Flood Control Recommendations**

| Location | Recommendation | Cost |
|---|---|---|
| NCS44 (DUTCH RD) | EXISTING AND 2026- REPLACE 24" RCP WITH (2) 36" RCP. | $125,353 |
| NJS11 (HOLLAND CORNER RD) | EXISTING AND 2026 - ADD A 60"x 46" CMP ARCH. | $147,373 |
| NKS21 (RT 58) | EXISTING – ADD (2) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL (2) 5'X3' BOX CULVERTS.* | $568,187<br>$809,269 (2026) |
| NKS4 (RT 58) | EXISTING AND 2026 - ADD A 6'X6' BOX CULVERT | $590,315 |

**Table No. 5-1 Summary of Erosion and Flood Control Recommendations**

| Location | Recommendation | Cost |
|---|---|---|
| NKS43 (GLEN HAVEN DR) | EXISTING AND 2026 – REPLACE 12" RCP WITH (3) 24" RCP, GRADE 850 LF OF CHANNEL. | $436,914 |
| NKS48 (RT 58) | EXISTING - REPLACE 36" RCP WITH (2) 5'X4' BOX CULVERTS. 2026 - ADD AN ADDITIONAL 5'X4' BOX CULVERT. | $1,370,661<br>$1,746,658 (2026) |
| NKS57 (RT 58) | EXISTING – ADD A PARALLEL 36" RCP. 2026 - ADD AN ADDITIONAL 36" RCP CULVERT. | $502,031<br>$712,058 (2026) |
| NQS13 (LUMMIS RD) | EXISTING AND 2026 - RAISE RD 1FT TO ELEV. 69 (360 LF), REPLACE 24" RCP WITH (4) 36" RCP. | $570,836 |
| NQS21 (RT 58) | 2026 - ADD AN ADDITIONAL 4'X4' BOX CULVERT. | $701,744 (2026) |
| NQS33 (DUTCH RD) | EXISTING AND 2026 - REPLACE 24" RCP WITH (4) 30" RCP. | $321,694 |
| NQS38 (RT 58) | EXISTING - ADD A 6'X4' BOX CULVERT TO THE EXISTING TWIN 4'X4' BOX. *2026 - ADD AN ADDITIONAL 6'X4' BOX.* | $767,768<br>$1,060,263 (2026) |
| NQS41 (DUTCH RD) | EXISTING ADD (1) 36" RCP TO THE EXISTING 36" RCP. *2026 – ADD AN ADDITIONAL 36" RCP.* | $148,649<br>$182,851 (2026) |
| NSMC10 (WHALEYVILLE BLVD) | EXISTING - REPLACE THE EXISTING 24" RCP WITH (2) 5'X3' BOX CULVERT. *2026 - ADD AN ADDITIONAL 5'X3' BOX.* | $365,935<br>$530,981 (2026) |
| NSMC9 (WHALEYVILLE BLVD) | EXISTING - REPLACE TWIN 24" RCP WITH (3) 5'X3 BOX CULVERT. *2026 - ADD AN ADDITIONAL 5'X3' BOX CULVERT.* | $372,275<br>$494,621 (2026) |
| NSS1 (WHALEYVILLE BLVD) | EXISTING - ADD (2) 4'X4' BOX CULVERTS TO THE EXISTING 4'X4' BOX CULVERT. *2026 - ADD AN ADDITIONAL 4'X4' BOX CULVERT.* | $317,943<br>$439,723 (2026) |
| NSS16 (MINERAL SPRING RD) | EXISTING - REPLACE THE EXISTING 18" AND 24" PIPES WITH (4) 36" RCP. *2026- ADD AN ADDITIONAL 36" PIPE.* | $275,613<br>$351,623 (2026) |

| Table No. 5-1 Summary of Erosion and Flood Control Recommendations | | |
|---|---|---|
| **Location** | **Recommendation** | **Cost** |
| NSS24 (MINERAL SPRING RD) | EXISTING AND 2026- ADD AN ADDITIONAL 30" RCP TO THE EXISTING 18" RCP. | $86,264 |
| NSS25 (MINERAL SPRING RD) | EXISTING AND 2026 - REPLACE 18" RCP WITH (2) 36" RCP. | $143,786 |
| NSS3 (MINERAL SPRING RD) | EXISTING - RAISE THE ROAD 1 FT TO 48 (600LF) AND REPLACE THE EXISTING 18" RCP WITH (4) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL (2) 5'X3' BOX CULVERTS.* | $903,845<br>$1,140,453 (2026) |
| NSS5 (MINERAL SPRING RD) | EXISTING - RAISE THE ROAD 1 FT TO 50 (156LF) AND REPLACE 24" RCP WITH (4) 48" RCP. *2026 – ADD AN ADDITIONAL (2) 48" RCP.* | $513,495<br>$680,799 (2026) |
| NSS8 (MINERAL SPRING RD) | EXISTING - RAISE THE ROAD 1 FT TO 36 (570LF) AND REPLACE THE EXISTING 18" RCP WITH (5) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL 5'X3' BOX CULVERT.* | $1,226,254<br>$1,379,042 (2026) |
| NTBR1 (RT 58) | EXISTING AND 2026 - REPLACE 30" RCP WITH (2) 5'X4' BOX CULVERTS. | $1,148,176 |
| NTBR20 (SOUTH QUAY RD) | EXISTING AND 2026 - ADD A 48" RCP TO THE EXISTING 48" RCP. | $248,976 |
| NTBR24 (RT 58) | EXISTING AND 2026 - REPLACE 30" CMP WITH (2) 30" RCP. | $482,370 |
| NTBR9 (RT 58) | EXISTING AND 2026 - REPLACE 30" CMP WITH (2) 30" RCP. | $513,898 |

The model identified areas within the watershed that require a more detailed analysis to determine what flood control improvements are warranted. Due to the lack of detailed survey data and the master plan assumptions used, the model should not be used for design applications. Additional data and survey, particularly for roadway culverts, is needed before this model can be used for making specific design decisions and should only be used as a tool preparing the groundwork for more detailed studies and design.

Analysis of erosive channel velocities is provided only as general conditions that exist within the model. Since the model does not focus on variations in channel geometry, roughness, and unique site conditions throughout the channel reach, specific improvement priorities cannot be immediately obtained from the model. However, where recommendations for improvements are appropriate from field observations and the analysis of the pipes that show increased velocities at the outfalls, the cost of the channel improvements are included in the cost of the culvert improvements.

Regional best management practices (BMPs) were not closely evaluated at this stage of the model. Due to the limit limitations associated with making decisions on channel stability, the use of regional BMPs was not addressed in detail. Additionally, the cost for constructing a regional BMP would be greater versus the costs of making the pipe improvements. This increased cost is associated with land acquisition and large excavation and disposal hauling costs. The cost of constructing a regional BMP was therefore deemed unwarranted at this time. However, if a more detailed study of channel stability indicates that severe erosive condition exists along a major channel, the use of a regional BMP may be warranted over the cost for making extensive channel improvements and the associated cost in easement acquisition, property impacts and permitting. At this stage, we recommend a more detailed study be performed for those channels downstream of culverts recommended for improvements. This consideration is based on the increased flow volume released with the upgraded pipe systems and may therefore require downstream improvements beyond the distance assumed for initial cost of making the pipe improvements. Two existing regional ponds were modeled in the Chowan River watershed. Node NSS7A.1 located off of Mineral Spring Road. The pond has a tributary drainage area of 966 acres, a maximum storage capacity of 690 acre-feet and a 10-yr design storm storage volume of 44 acre-feet. The outlet was assumed as a 100-ft emergency spillway. Node NTBR32 is located off of South Quay Road. The pond has a tributary drainage area of 3,141 acres, a maximum storage capacity of 1,059 acre-feet and a 10-yr design storm storage volume of 121 acre-feet. The outlet was assumed as a 25-ft spillway. All pond data is based on GIS information, the ponds are on private property and were inaccessible during the field investigation.

Discussions with the City Public Works Operations revealed that there are several areas throughout the City where localized flooding is caused by beaver activity which can block culverts and back up stream flow. The dams can be located directly at the culvert or several hundred feet downstream in marshes. The City currently sends crews to remove the dams once they are detected visually or due to an unusual increase in water level. The model does not account for beaver dams in the analysis of the culverts. Mitigation of beaver related flooding is considered a maintenance item.

The improvement recommendations were reviewed by City Staff. Table 5-3 below is a listing of the ten (10) most critical points within the Chowan River Watershed based on the City review, field conditions and model results.

**Table No. 5-3 10 Most Critical Points in the Chowan River Watershed**

| Location | Recommendation | Cost |
|---|---|---|
| Various | Maintenance concerns noted in Table No. 3-1 of this report. | N/A |
| NJS11 (HOLLAND CORNER RD) | EXISTING AND 2026 - ADD A 60"x 46" CMP ARCH. | $147,373 |
| NSMC10 (WHALEYVILLE BLVD) | EXISTING - REPLACE THE EXISTING 24" RCP WITH (2) 5'X3' BOX CULVERT. *2026 - ADD AN ADDITIONAL 5'X3' BOX.* | $365,935<br>$530,981 (2026) |
| NSS16 (MINERAL SPRING RD) | EXISTING - REPLACE THE EXISTING 18" AND 24" PIPES WITH (4) 36" RCP. *2026- ADD AN ADDITIONAL 36" PIPE.* | $275,613<br>$351,623 (2026) |
| NSS24 (MINERAL SPRING RD) | EXISTING AND 2026- ADD AN ADDITIONAL 30" RCP TO THE EXISTING 18" RCP. | $86,264 |
| NSS25 (MINERAL SPRING RD) | EXISTING AND 2026 - REPLACE 18" RCP WITH (2) 36" RCP. | $143,786 |

| Table No. 5-3 10 Most Critical Points in the Chowan River Watershed | | |
|---|---|---|
| **Location** | **Recommendation** | **Cost** |
| NSS3 (MINERAL SPRING RD) | EXISTING - RAISE THE ROAD 1 FT TO 48 (600LF) AND REPLACE THE EXISTING 18" RCP WITH (4) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL (2) 5'X3' BOX CULVERTS.* | $903,845<br>$1,140,453 (2026) |
| NSS5 (MINERAL SPRING RD) | EXISTING - RAISE THE ROAD 1 FT TO 50 (156LF) AND REPLACE 24" RCP WITH (4) 48" RCP. *2026 – ADD AN ADDITIONAL (2) 48" RCP.* | $513,495<br>$680,799 (2026) |
| NSS8 (MINERAL SPRING RD) | EXISTING - RAISE THE ROAD 1 FT TO 36 (570LF) AND REPLACE THE EXISTING 18" RCP WITH (5) 5'X3' BOX CULVERTS. *2026 - ADD AN ADDITIONAL 5'X3' BOX CULVERT.* | $1,226,254<br>$1,379,042 (2026) |
| NTBR20 (SOUTH QUAY RD) | EXISTING AND 2026 - ADD A 48" RCP TO THE EXISTING 48" RCP. | $248,976 |

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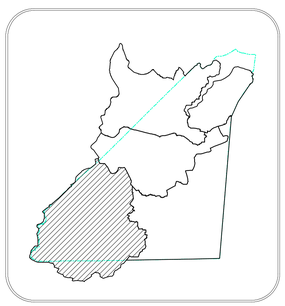
JAMES RIVER WATERSHED

JAMES RIVER WATERSHED

JAMES RIVER WATERSHED

CHOWAN / BLACKWATER RIVER WATERSHED

GREAT DISMAL SWAMP WATERSHED



**Legend**

- SUB BASIN BOUNDARY
- MAJOR WATERSHEDS BOUNDARY
- CITY OF SUFFOLK BOUNDARY

0 3,200 6,400 12,800 19,200 25,600 Feet

1"=6,000'

# CITY OF SUFFOLK, VIRGINIA

STORM WATER MASTER PLAN
CHOWAN RIVER WATERSHED
STUDY AREA XP-SWMM MODEL

CN NO: N1955.2 E
DATE: 12/12/08
DESIGN: JPP
DRAWN: KRH
REVIEW: RAS
REVISIONS:

| NO. | DATE | DESCRIPTION | BY |
|---|---|---|---|

GIS-01

SHEET 1 OF 4

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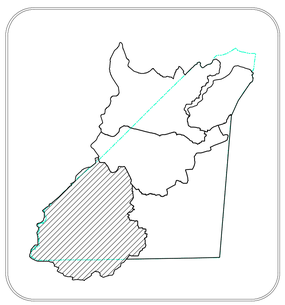
3

BLACKWATER RIVER

UNION CAMP HOLDING POND

CHOWAN RIVER



**Legend**

- SWMM MODEL NODES
- SWMM MODEL LINKS
- DRAINAGE_AREAS

0 1,250 2,500 5,000 7,500 10,000 Feet

1"=2500'

# CITY OF SUFFOLK, VIRGINIA
## STORM WATER MASTER PLAN
## CHOWAN RIVER WATERSHED
## STUDY AREA XP-SWMM MODEL

CN NO: N1955.2 E
DATE: 12/12/08
DESIGN: JPP
DRAWN: KRH
REVIEW: RAS
REVISIONS:

| NO. | DATE | DESCRIPTION | BY |
|---|---|---|---|

GIS-02

SHEET 2 OF 4

RURITAN BLVD 5'X3' BOX CULVERT ROAD FLOODED FOR THE 10YR DESIGN STORM

RURITAN BLVDTWIN 6'X6' BOX CULVERT ROAD FLOODED FOR THE 10YR DESIGN STORM

GLEN HAVEN RD FLOODED FOR THE 10YR DESIGN STORM

HOLLAND RD TWIN 4'X4' BOX CULVERT ROAD FLOODED FOR THE 25YR DESIGN STORM

LUMMIS RD 24" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

HOLLAND RD TWIN 4'X4' BOX CULVERT ROAD FLOODED FOR THE 25YR DESIGN STORM - 2026 CONDITION

SOUTH QUAY RD 36" RCP ROAD FLOODED FOR THE 25YR DESIGN STORM

DUTCH RD 36" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

SOUTH QUAY RD 36" RCP ROAD FLOODED FOR THE 25YR DESIGN STORM

FRANKLIN BY-PASS 30" CMP ROAD FLOODED FOR THE 25YR DESIGN STORM

FRANKLIN BY-PASS 30" CMP ROAD FLOODED FOR THE 25YR DESIGN STORM

SOUTH QUAY RD 30" RCP ROAD FLOODED FOR THE 25YR DESIGN STORM

DUTCH RD 24" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

DUTCH RD 24" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

SOUTH QUAY RD 48" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

HOLLAND CORNER RD ROAD FLOODED 2026 CONDITION NEAR BRIDGE #8038 FOR THE 10YR DESIGN STORM

MINERAL SPRING RD 18" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

MINERAL SPRING RD 18" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

MINERAL SPRING RD 18" & 24" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

MINERAL SPRING RD 24" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

MINERAL SPRING RD 18"RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

MINERAL SPRING RD 18" RCP ROAD FLOODED FOR THE 10YR DESIGN STORM

WHALEYVILLE BLVD 24" RCP ROAD FLOODED FOR THE 25YR DESIGN STORM

WHALEYVILLE BLVD 4'X4' BOX CULVERT RCP ROAD FLOODED FOR THE 25YR DESIGN STORM

WHALEYVILLE BLVD TWIN 24" RCP ROAD FLOODED FOR THE 25YR DESIGN STORM

BLACKWATER RIVER

UNION CAMP HOLDING POND

CHOWAN RIVER



**Legend**

- PRINCIPAL ARTERIAL
- MINOR ARTERIAL
- MAJOR WATERSHED
- CITY OF SUFFOLK BOUNDARY

0 1,250 2,500 5,000 7,500 10,000 Feet

1"=2500'

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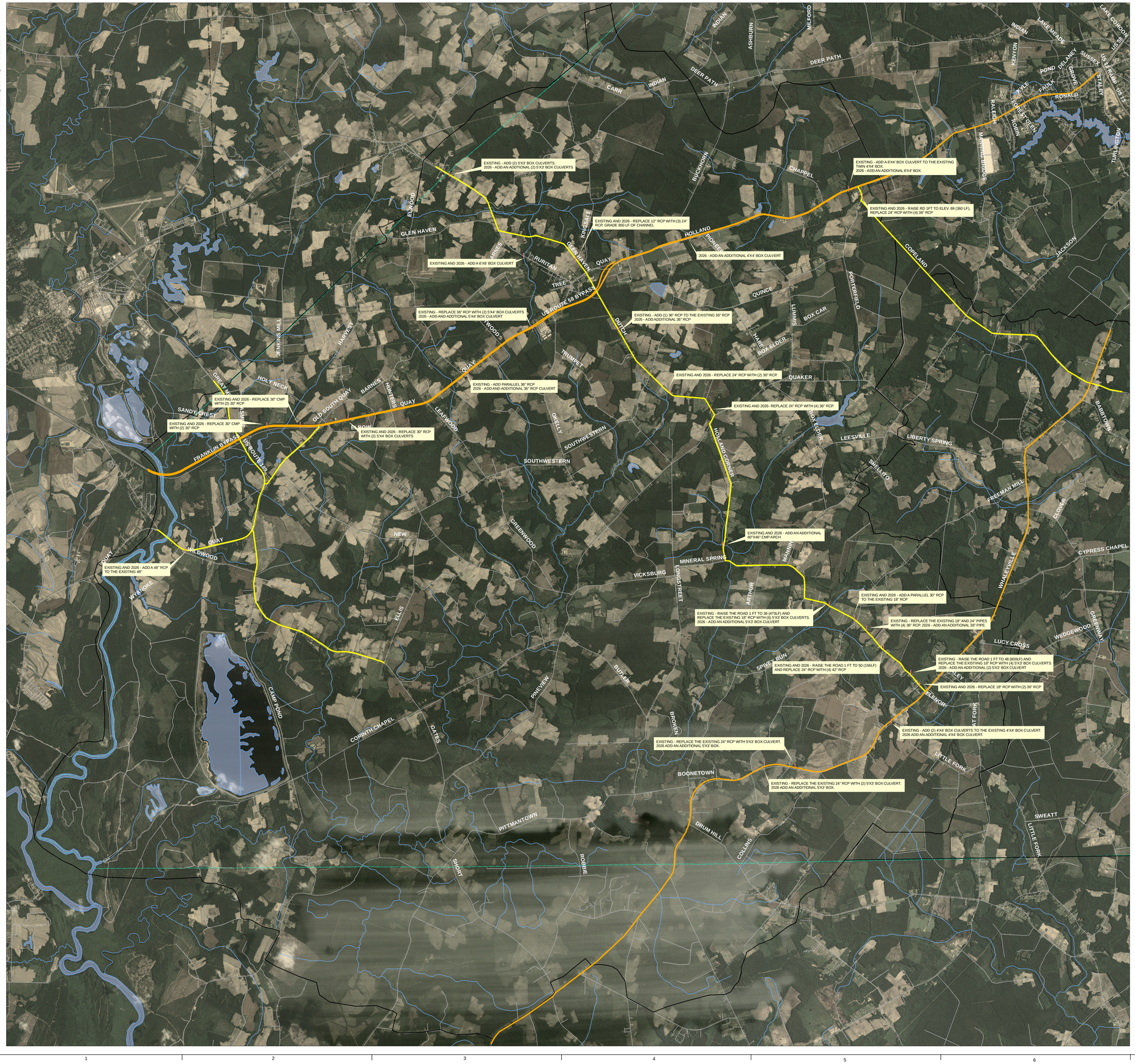
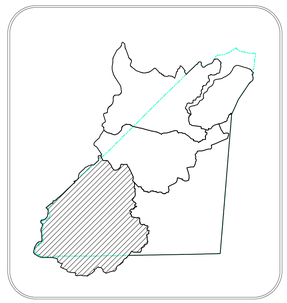
# CITY OF SUFFOLK, VIRGINIA
## STORM WATER MASTER PLAN
## CHOWAN RIVER WATERSHED
## STUDY AREA - DEFICIENCY AREAS

CN NO: N1955.2 E
DATE: 12/12/08
DESIGN: JPP
DRAWN: KRH
REVIEW: RAS
REVISIONS:

| NO. | DATE | DESCRIPTION | BY |
|---|---|---|---|

GIS-03



**Legend**

- PRINCIPA ARTERIAL
- MINOR ARTERIAL
- MAJOR WATERSHED
- Major Watersheds-original
- City of Suffolk Boundary

0 1,250 2,500 5,000 7,500 10,000 Feet

1"=2500'

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# CITY OF SUFFOLK, VIRGINIA
## STORM WATER MASTER PLAN
## CHOWAN RIVER WATERSHED
## STUDY AREA - IMPROVEMENT AREAS

CN NO: N1955.2 Q
DATE: 12/12/08
DESIGN: JPP
DRAWN: KRH
REVIEW: RAS
REVISIONS:

| NO. | DATE | DESCRIPTION | BY |
|---|---|---|---|

GIS-04

SHEET 4 OF 4