Stormwater Master Plan

DARE COUNTY

North Carolina

December 2023

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Executive Summary

The 2023 Dare County Stormwater Master Plan is an update to the 2001 plan and pertains only to the unincorporated portions of the County. This document provides recommendations for stormwater management through a review and evaluation of the governing regulations and stormwater infrastructure. The objective is to make regulatory recommendations and provide cost-effective engineered solutions to managing flooding risk within the county limits. Through public input and stakeholder engagement, specific project areas within the County were identified. WithersRavenel inventoried priority storm drain infrastructure in the project areas and developed comprehensive existing conditions 2D HEC-RAS models to simulate hydrology and hydraulics for the 2-, 10- and 100-year storm events. In addition to the current tidal conditions, scenarios for each return event were simulated to account for a 1-foot sea level rise and 2.6-foot (80 cm) sea level rise. Lastly, a storm surge condition was simulated for the 100-year event. These models, in addition to review of public and stakeholder input, were used to identify areas of concern for further investigation and for potential conceptual project areas to mitigate future flood risk. In total eight (8) areas of concern were identified and modeled. Conceptual stormwater improvement plan designs were developed for two (2) critical areas, including cost opinions.

Location	Problem Description	Project Description	Order of Magnitude Cost
North Roanoke Island	Ponding	Installation of Storm Drainage Network, Swales, and Culverts	$6M to $8M
Wanchese	Ponding	Swale Maintenance/ Enhancement	$500K to $1M
Colington Pond	Abandoned/blocked outlet	Installation of Pond Outfall	$250K to $500K
Rodanthe	Ponding/Altered Drainage Channel	Re-Establish North Drain Connectivity	$500K to 1M
Avon – Ocean View Drive	Ponding	Installation of Infiltration Trenches and Swales	$1.5M to $2M
Buxton – Old Lighthouse Rd	Ponding	Installation of Infiltration Trenches, Culverts and Storm Drainage Network	$500K to $1M
Frisco	Ponding	Culverts and Swale maintenance/enhancement	$500K to $1M
Hatteras Village	Ponding	Installation of Detention Swales	$250K to $500K
Countywide	Policy	Policy update: develop a comprehensive stormwater management policy with emphasis on implementing Low Impact Development	$50K to $250K
Countywide	Program Management	Stormwater Asset Inventory, Mapping, and Maintenance Program	$150K to $250K

Chapter 1 - Introduction

The Dare County *Stormwater Master Plan* (Plan) is a document that outlines an approach to stormwater management for the unincorporated portions of Dare County. This document provides direction for stormwater management for Dare County (County). The starting point for this Plan begins with the purpose, goals, and objectives described in this chapter.

Stormwater master plans that have the most success are the ones with clear purpose, goals, and action items. To develop a clear purpose and goals, it is necessary to identify the problems or potential problems in the watershed. Drainage/ponding and water quality within the County have been identified as problems and the purpose and goals described below provide direction for the future stormwater management effort to improve these problems. These problems have been magnified by the increasingly intense storm events and sea level rise the County is experiencing. These events and forces are causing challenges to existing infrastructures such as roads and stormwater network. Sand drifts may block drainageways with sediment deposits, reducing the capacity of the network. The 2022 Sea Level Rise Technical Report from the National Oceanic and Atmospheric Administration (NOAA) states that in the next 30 years, the sea level is expected to rise 10 to 14 inches on the East Coast.

1.1 Purpose and Goals

This updated Stormwater Master Plan serves as a tool to provide a comprehensive and unified framework for stormwater management and evaluate drainage issues and develop possible solutions to address stormwater issues. The scope of this study is restricted to unincorporated portions of Dare County and does not include any areas located with the municipal areas of Dare County. As part of this study, public input was solicited, and stakeholders engaged. This input along with field visits and hydrologic and hydraulic models were utilized to identify critical problem areas. The risk and hazards were assessed, and potential mitigation measures developed.

The goals of the plan are to provide recommendations to meet the purpose of improving hydrological functions and protecting and improving water quality. The specific goals are to:

1) Evaluate the water quantity and water quality problems in the County and recommend solutions to mitigate these problems.
2) Evaluate the current county policies regarding stormwater control and recommend potential improvements.
3) Provide capital improvement projects and outline maintenance actions that incorporate recommendations from the plan.

1.2 Master Plan Update

Dare County was awarded a Flood Mitigation Assistance Grant through the North Carolina, Department of Public Safety, Division of Emergency Management to provide updates to the 2001 master plan. The following are the primary tasks of the master plan update.

1) Solicit public input and engage local stakeholder groups.
2) Mapping and analysis of existing stormwater infrastructure.

3) Assess stormwater risks and hazards.
4) Identify critical project areas and potential mitigation measures with an emphasis on innovative and/or nature based-solutions where practicable.
5) Conduct site survey on identified critical project areas.
6) Develop at least two detailed engineering project proposals that can be used for future grant opportunities.

1.3 Structure of the Plan

- **Chapter One - Introduction**
  - The purpose and goals have been described and the contents of the plan are listed in this section. The methodology is provided to describe the basis for the recommendations.
- **Chapter Two - Regulation/Ordinance Review**
  - In this chapter all federal, state and local regulations and ordinances relating to stormwater will be reviewed.
- **Chapter Three - Policy**
  - In this chapter, the existing policy with regards to stormwater management is described. Changes to existing policy and new areas requiring a policy decision action are provided.
- **Chapter Four - County Overview**
  - This chapter provides a description of the physical setting and the interaction of land use, soil types, water features, and hydrology and their effect on water quantity and quality.
- **Chapter Five - Watershed Characteristics**
  - The characteristics of the County, along with the quantity and quality problems, are described and action items recommended.
- **Chapter Six - Stormwater Management Program**
  - The action items from the preceding chapters are summarized. The estimated costs for the recommended action items are provided in this chapter. Potential funding sources are identified.

1.4 Methodology

The methodology for this Plan included review and revision as needed of the Stormwater Master Plan produced in 2001, public input gathered to identify current flooding areas of concern, and hydrologic & hydraulic modeling of selected areas of concern. Recommendations for improvements to alleviate flooding issues are made based on identified sources of flooding. Concept plans with modeled improvements were further developed for two areas.

Chapter 2 - Regulation/Ordinance Review

Decisions the County currently makes regarding stormwater issues have an effect on future water quality, storm drain system performance, and system condition. This chapter outlines the existing Federal, State and County regulations and ordinances regarding stormwater management and evaluates policy changes necessary for effective management in the future.

2.1 Federal Regulations

This section provides a summary of federal regulations that presently define, or in the future may affect, stormwater management requirements for the County. The goal of this review is to identify and summarize the regulatory and technical issues that must be incorporated into the County's stormwater management and development policies. The requirements presented in this section will subsequently be compared to existing County stormwater management policies with recommended modifications provided as necessary.

2.1.1 The Clean Water Act

In 1972, Congress amended the Federal Water Pollution Control Act, referred to as the Clean Water Act (CWA), to prohibit the discharge of any pollutants to navigable waters from a point source, unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. As pollution control measures for industrial process wastewater and municipal sewage were implemented and refined, it became evident that diffuse sources of water pollution were adversely impacting water quality. In particular, stormwater runoff from agricultural and urban land was found to significantly impair water quality. Polluted stormwater runoff is commonly transported through municipal separate storm sewer systems (MS4s), and then often discharged, untreated, into local water bodies.

At the Federal level, Sections 401, 402 and 404 of the Clean Water Act require permits for those activities that might affect water quality either through direct discharge of dredged and fill materials or from runoff. The most recent federal regulations that will significantly impact existing storm water management practices are 40 CFR Parts 9, 122, 123, and 124 - National Pollutant Discharge Elimination System (NPDES) - Regulations for Revision of the Water Pollution Control Program Addressing Storm Water Discharges; Final Rule (commonly referred to as Phase II Storm Water Regulations). Phase II regulations expanded the existing NPDES stormwater program (Phase I) by addressing stormwater discharges from small MS4s and construction sites that disturb one acre or more.

2.1.2 Phase I NPDES Stormwater Regulations

In 1987, Congress amended the CWA to require implementation of a comprehensive national program for addressing storm water discharges. This implementation has occurred in two phases. The first phase, referred to as "Phase I," was promulgated in November 1990. Phase I requires NPDES permits for storm water discharge associated with the following sources:

- Municipal separate storm sewer systems serving populations of 100,000 or more.
- Several categories of industrial activity, including construction sites that disturb five or more acres of land.

Applicability to Dare County:

As of the year 2023, the County is not required to obtain an NPDES stormwater discharge permit under the Phase I regulations because of its small population and lack of industrial activity.

2.1.3 Phase II Stormwater Regulations

The second phase, referred to as "Phase II," was promulgated in August 1995. These regulations were adopted in December 1999. In June 2023, EPA signed a rule entitled NPDES Small MS4 Urbanized Area Clarification to clarify the term "urbanized areas" Phase II expands the existing stormwater program to include:

- Discharges of stormwater from urban areas with a population of at least 50,000
- Non-traditional MS4s such as public universities, department of transportation, hospitals, and prisons.
- Construction sites that disturb between one and five acres of land.

Certain sources are excluded from Phase II based on a demonstrable lack of impact on water quality. This regulation also allows other sources not automatically regulated on a national basis to be designated for inclusion based on their increased likelihood for local impairment of water quality. Phase II conditionally excludes stormwater discharges from industrial facilities that have "no exposure" of industrial activities or materials to storm water. States with NPDES permitting authority (North Carolina Division of Water Quality has permitting authority) can extend NPDES requirements to smaller Counties if there is reason to anticipate that stormwater runoff from those areas has been or may impact high quality waters. Phase II requires that industrial facilities owned by Small Municipal Separate Storm Sewers Systems (MS4s) obtain coverage under an NPDES permit by March 10, 2003.

Permitted MS4 entities are required to develop a Stormwater Management Plan (SWMP) to address pollutants. The SWMP is organized by the following six minimum measures which will be discussed in more detail in subsequent sections.

- Public Education and Outreach on Stormwater Impacts
- Public Involvement/Participation
- Illicit Discharge Detection and Elimination
- Construction Site Stormwater Runoff Control
- Post-Construction Stormwater Management in New Development and Redevelopment
- Pollution Prevention/Good Housekeeping for Municipal Operations

Public Education and Outreach on Stormwater Impacts

MS4 phase II entities must implement a public education program or conduct outreach activities to distribute educational materials to the community. The education programs and/or outreach activities should inform individuals and households about target pollutants, likely pollutant source, the impacts of pollutants on water bodies and identify the steps that must be taken to reduce storm water pollutants. Entities are required to maintain a website, provide a stormwater helpline, and have specific campaigns for target audiences. MS4s are encouraged to collaborate with other entities within their vicinity or with the State to amplify messaging and incorporate information into State implemented educational programs.

Public Involvement/Participation

Public Education is focused on information sharing while Public Involvement entails public participation in the planning and implementation of local stormwater management programs. The permitted entity is responsible for creating volunteer opportunities for citizens which could include volunteer monitoring, stream clean-ups, or serving on an advisory group.

Illicit Discharge Detection and Elimination

The intention of the illicit discharge minimum measure is to eliminate non-stormwater discharge into storm sewer systems. The program requirements include:

- Develop a storm sewer system map showing the location of all outfalls, and names and location of all waters of the United States that receive discharges from those outfalls.
- Effectively prohibit through ordinance, or other regulatory mechanism, illicit discharges into the separate storm sewer system and implement appropriate enforcement procedures and actions as needed, and to the extent allowable under State, Tribal, or local law.
- Develop and implement a plan to detect and address illicit discharges, including illegal dumping, to the system;
- Inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste.

The illicit discharge and elimination program addresses non-stormwater discharges if it falls under the categories listed below and if the operator of the small MS4 identifies them as significant contributors of pollutants. These categories include: water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration, uncontaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water.

Construction Site Stormwater Runoff Control

For the construction site stormwater runoff control measure, MS4 Phase II entities are required to develop, implement and enforce a pollutant control program to reduce pollutants in any stormwater runoff from construction activities that result in land disturbance of one or more acres. Construction activity on sites disturbing less than one acre must be included in the program if the

construction activity is part of a larger common plan of development or sale that would disturb one or more acres. The construction runoff control program must include an ordinance or other regulatory mechanism to require erosion and sediment controls to the extent practicable and allowable under State, Tribal or local law. The program must also include sanctions to ensure compliance. The program must also include, at a minimum:

- Requirements for construction site operators to implement appropriate erosion and sediment control.
- Procedures for site plan review by the small MS4, which incorporate consideration of potential water quality impacts.
- Requirements to control other waste such as discarded building materials, chemical and sanitary waste at the site that may adversely affect water quality.
- Procedures for receipt and consideration of information submitted by the public to the MS4.

Post-Construction Stormwater Management in New Development and Redevelopment

Studies and investigations indicate that prior planning and designing for the minimization of pollutants in stormwater discharges is the most cost-effective approach to stormwater quality management. MS4 Phase II entities are required to develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment projects that result in land disturbance of greater than or equal to one acre. This also includes projects less than one acre, which are part of a larger common plan of development or sale. The NPDES permit requires the operator of a regulated small MS4 to:

- Develop and implement strategies that include a combination of structural and/or non-structural Best Management Practices (BMP)s.
- Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State, Tribal or local law.
- Ensure adequate long-term operation and maintenance of BMPs.
- Ensure that controls are in place that would minimize adverse water quality impacts.

Pollution Prevention/Good Housekeeping for Municipal Operations

This minimum measure required MS4 Phase II entities to develop and implement an operation and maintenance program that includes a training component focused on preventing or reducing stormwater from municipal operations. The program must include government employee training that addresses prevention measures pertaining to municipal operations such as: parks, golf courses and open space maintenance; fleet maintenance; new construction or land disturbance; building oversight; planning; and stormwater system maintenance. The program may use existing stormwater pollution prevention training materials offered by the State, Tribe, EPA, or environmental, public interest, or trade organizations. The EPA encourages operators of MS4s to include the following in their programs:

- Implement maintenance activities, maintenance schedules, and long-term inspection procedures for structural and non-structural stormwater controls to reduce floatables and other pollutants discharged from the separate storm sewers.
- Implement controls for reducing or eliminating the discharge of pollutants from street,

roads, highways, municipal parking lots, maintenance and storage yards, waste transfer stations, fleet or maintenance shops with outdoor storage areas, and salt/sand storage locations and snow disposal areas operated by the MS4.

- Adopt procedures for the proper disposal of waste removed from the separate storm sewer systems and areas listed above, including dredge spoil, accumulated sediments, floatables, and other debris.

Applicability to Dare County

The final Phase II regulations, dated December 9, 1999 and updated July 2023 to clarify urbanized area, list areas in the United States that require or may require permitting under the Phase II program. These areas include:

- ***Urban areas with a population of at least 50,000***
- ***Governmental entities located fully or partially within an urbanized area***
- ***Governmental entities (located outside of an urbanized area) that must be examined by the NPDES permitting authority for potential designation***

As of October 2023, unincorporated Dare County was not included on any of these federal lists, and has not been designated to obtain a MS4 permit. Although a Phase II permit is not required at this time, WR recommends that the County implement applicable Phase II management measures as part of its long-term stormwater management policies. These management measures are good standard practice for water quality protection, and their implementation would ensure that Phase II requirements would be in place if a permit becomes necessary in the future.

2.2 State Regulations

Stormwater management requirements in North Carolina fall under the jurisdiction of the North Carolina Administrative Code (NCAC), the North Carolina Coastal Area Management Act (CAMA), and the North Carolina Sedimentation Pollution Control Act. The associated agencies responsible for the implementation of stormwater management requirements are the Department of Environmental Quality (DEQ); the Sedimentation Control Commission; and the Coastal Resources Commission (CRC). Summarized stormwater management requirements for the three agencies are provided as follows and will serve as the technical basis for recommended modifications to County ordinances. The Division of Energy, Mineral, and Land Resources (DEMLR) and the Division of Coastal Management (DCM), regulate development and land use activities to protect water quality. Additionally, the North Carolina Department of Transportation has published guidelines for drainage studies and hydraulic design.

2.2.1 Division of Coastal Management

In 1974, the NC General Assembly passed the Coastal Area Management Act (CAMA) to guide development in fragile and productive areas that border the state's sounds and oceanfront. The Division of Coastal Management (DCM) regulates development activities and stormwater controls that occur in the 20 coastal counties of North Carolina through the Coastal Area Management Act (CAMA) (15A NCAC 7H, 7J, & G.S. 133A, Article 7). Any land disturbing activity which occurs in an area of environmental concern (AEC) must receive a CAMA permit. There are four categories of AECs: Estuarine and Ocean System, the Ocean Hazard System, Public Water Supplies, and

Natural and Cultural Resource Areas. The following locations for a project would be considered occurring within an AEC:

- In, or on the shore of, navigable waters;
- On a marsh or wetland;
- Within 75 feet of the normal high water line along an estuarine shoreline;
- Near the ocean beach;
- Within an ocean high hazard flood area;
- Near an inlet;
- Within 30 feet of the normal high water level of areas designated as inland fishing waters by the N.C. Marine Fisheries Commission and the N.C. Wildlife Resources Commission;
- Near a public water supply;
- Within 575 feet of Outstanding Resource Waters defined by the Environmental Management Commission.

The DCM reviews proposed development plans with respect to agency and public comment, CRC rules, and local CAMA Land Use Plans. The CAMA permit system is divided into major and minor permits, based on the size and possible impacts of a project.

General permits are used for routine projects that usually pose little or no threat to the environment. General permits are issued on-site by DCM staff.

A **Major permit** is required for land disturbing activities which:

- Occur in an AEC
- Alter more than 20 acres of land
- Propose a structural footprint exceeding 60,000 square feet on a single parcel
- Require other State or Federal permits
- Excavates or drills for natural resources in an AEC or under water

Development activities requiring a CAMA Major Permit may also require one of the following permits that are issued by the State:

- Permit to excavate and/or fill
- Easement in lands covered by water
- Water quality certification

A **Minor permit** is required when a Major or General permit is not required but the project is located within or partially within an AEC. Minor permits are required if the project meets the following conditions:

- Occurs within an AEC (described above)
- Project requires no other state or federal permits
- It does not qualify for a CAMA permit expansion

- It is considered "development" under CAMA.

Development is defined as any activity in an AEC involving, requiring, or consisting of the construction or enlargement of a structure; excavation, dredging, filling, bulkheads, driving of pilings, alteration of land, sand dunes, shore, bank, or bottom of any waterway. The Coastal Area Management Act (CAMA) excludes certain activities, such as highway maintenance, agriculture and silviculture from permit requirements {GS 113A-103 (5)(b)}.

Minor permits are required for single-family homes unless it meets an exemption below. Local permit officers can provide assistance regarding CAMA requirements. It is advisable to inquire about a permit before starting any construction.

The following activities are exempt from a Minor permit:

- Additions and modifications to simple structures for private use such as existing bulkheads, piers, docks, boathouses, and boat ramps that already have permits.
- Maintenance and expansion of certain projects that have state easements and/or state Dredge-and-Fill permits. Projects qualify if the dimensions don't exceed 20 percent of the dimensions originally permitted, primary use does not change, work does not damage the natural environment and/or adjacent property owners.
- Emergency maintenance and repairs when life and property are in danger.
- Single-Family Residences built within the estuarine shoreline if the structure is built more than 40 feet landward of the normal water level. No land-disturbing activities may occur between the house and the water.
- Single-Family Residences in the High Hazard Flood AEC as long as development is consistent with other CAMA standard and the local land-use plan.
- Structural maintenance and repair (excluding replacement) of damaged structure provided the repair is less than 50 percent of the value of the structure and does not violate CAMA standards
- Accessory uses or structures related to the main use of the site that require no electricity, plumbing, or other service connections and do not exceed an area of 200 square feet of floor area.
- Installation and maintenance of sand fencing if CAMA requirements are met

2.2.2 Division of Energy, Mineral, and Land Resources

The NC Department of Environmental Quality - Division of Energy, Mineral, and Land Resources (DEMLR) requires a Sedimentation and Erosion Control Plan for land disturbing activities greater than one acre (15A NCAC 4B & G.S. 113A, Article 4). The purpose of the Sedimentation and Erosion Control Plan is to show practices that will be implemented, during and after construction, that will control erosion and prevent sediments from leaving the site.

Primary requirements for a Sedimentation and Erosion Control Plan are as follows:

- A sufficient buffer zone must be retained or established along any natural water course or lake to contain all visible sediment to the first 25 percent of the buffer strip nearest the disturbed area. An undisturbed 25-foot buffer must be maintained along trout waters.
- The angle of cut-and-fill slopes must be no greater than that sufficient for proper

stabilization. Graded slopes must be vegetated or otherwise stabilized within 21 working days of completion of a phase of grading.

Off-site sedimentation must be prevented, and a ground cover sufficient to prevent erosion must be provided within 7 to 14 days depending on the slope of the site. Temporary erosion control measures shall be converted to permanent ground stabilization as soon as possible but no later than 90 calendar after the last land disturbing activity.

- Erosion and sedimentation control measures must be designed to provide protection from a rainfall event equivalent in magnitude to the 10-year peak runoff. In areas where High Quality Waters (HQWs) are a concern the design requirement is the 25-year storm.
- Runoff velocities must be controlled so that the peak runoff from the 10-year frequency storm occurring during or after construction will not damage the receiving stream channel at the discharge point. The velocity must not exceed the greater of:
    - The maximum nonerosive velocity of the existing channel, based on soil texture.
    - Peak velocity in the channel prior to disturbance.
    - If neither condition can be met, then protective measures must be applied to the receiving channel.

The above referenced NC General Statute created the Sedimentation Control Commission to develop and administer North Carolina's sedimentation and erosion control program. This program is implemented by the DEQ DEMLR under the Commission's direction. Authorized local governments or agencies may adopt their own ordinances; however, local programs must be approved by the Commission and must meet or exceed the minimum standards set by the state. If their programs are approved, local governments administer and enforce them. Because these programs vary widely in content and scope, the administering agency should be consulted to avoid violations of local ordinances.

The state assists and encourages local governments and other state agencies to develop their own erosion and sedimentation control programs. DEMLR reviews local programs as needed to assure uniform enforcement of the Act.

As part of the educational requirements of the Sedimentation Pollution Control Act, the Sedimentation Control Commission sponsored the development of The Erosion and Sediment Control Planning and Design Manual dated May 2013 (ESC Design Manual). The ESC Design Manual is a basic reference for the preparation of a comprehensive erosion and sedimentation control plan and for the design, construction and maintenance of individual practices.

The ESC Design Manual contains information useful in the selection and design of Best Management Practices (BMPs) used in sedimentation and erosion control. The ESC Design Manual is intended to serve as a guide to help local governments and developers comply with the Sedimentation Pollution Control Act.

2.2.3 Division of Water Quality

The Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina (15A NCAC 2B & G.S. 143-214.1, 215.1, 215.3 Article 3) defines surface water classifications and provides development restrictions and buffer requirements. Surface waters in Dare County include the ocean, the Intracoastal Waterway, Croatan Sound, Currituck Sound, Pamlico Sound, Roanoke Sound, Alligator River, and various other small lakes, rivers, and canals.

The following letter system is used to define the "best usage classifications" for waters in Dare County area:

SA Tidal systems designated for shell fishing for market purposes, primary recreation, aquatic life propagation and survival, fishing, wildlife, and secondary recreation.

SB Indicates a designation of a tidal system for primary recreation, aquatic life propagation/protection and secondary recreation.

SC Tidal systems designated for aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, agriculture and any other usage except primary recreation or shell fishing.

C Fresh water systems designated for aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, agriculture, and any other usage except primary recreation or drinking water supplies.

HQW (High Quality Waters) Indicates a supplemental classification for waters protected by an Antidegradation Policy enforced through the DENR. These include waters with excellent ratings based on biological & physical/chemical characteristics, such as NC Marine Fisheries Commission designated primary nursery areas (PNA) and Wildlife Resource Commission designated trout waters.

ORW (Outstanding Resource Waters) Those waters that have exceptional state or national recreational or ecological significance and which have exceptional water quality.

SW Swamp waters, or waters which have low velocities and other natural characteristics which are different from adjacent streams.

The SA primary classification denotes surface waters, such as the Pamlico Sound, which are suitable for commercial shell fishing and all other tidal saltwater uses. Supplemental classifications such as HQW provide added protection for waterbodies.

The Department of Environmental Quality enforces the Stormwater Management regulation and general statute (15A NCAC 02H and G.S.143-215.1) and the Water Supply Watershed Protection Act (15A NCAC 02B & G.S. 143-214.5) for the protection of surface waters. These rules were developed to control pollutants in stormwater runoff, limit impervious surfaces or built upon area, and ensure that adequate stormwater management practices are implemented.

2.2.4 North Carolina Administrative Code Section 15A NCAC2H.1000

The North Carolina stormwater management regulations are located in Administrative Code Section 15A NCAC 2H.1019, which is included as Appendix A of this report. To ensure the protection of surface waters of the State, a stormwater management permit is required for any development activities in the 20 coastal counties which

- Require a CAMA major development permit (see Section 2.2.1 of this report)
- Requires an Erosion and Sedimentation Control Plan (see Section 2.2.2 of this report) a project that doesn't meet either previous requirements but meets one of the following criteria:
    - Nonresidential projects that propose to cumulatively add 10,000 square feet or more of built-upon area
    - Residential properties that are located within one-half mile and draining to SA waters and propose to add more than 10,000 square feet of built-upon area and result in a percentage built-upon area greater than 12 percent

Dare County is included in the 20 coastal counties and is subject to permitting requirements as specified in 15A NCAC 2H.1019. Permitting requirements as specified in 15A NCAC 2H.1019 are described in the following paragraph. North Carolina stormwater management permit application forms are provided in Appendix B.

2.2.5 Stormwater Permitting Requirements: Coastal Counties

Stormwater management permits for development activities within the 20 coastal counties fall into one of the three following categories:

- Category 1: Development activities located within one-half mile and draining to waters classified as SA-HQW or SA-ORW
- Category 2: Development activities that drain to freshwaters classified as B-ORW and C-ORW
- Category 3: Development activities in areas except those defined in items 1 and 2.

Dare County has a significant number of SA waters; therefore, permitting requirements are primarily as specified by Category 1.

Dare County Permitting Requirements (SA Waters)

Permitting requirements for the County's SA waters are classified according to low density and high-density options. Project density is calculated as the total built-upon area divided by the total project area as defined in 15A NCAC 2H.1003. Permitting requirements for the two options are summarized as follows:

- **Low Density Option – SA Waters**
    - Built-upon area of 12 percent or less;
    - A vegetative buffer of at least 50-feet wide from perennial waterbodies, perennial streams, and intermittent streams for new development and at least 30 feet in width for redevelopment.

- Maximize dispersed flow through vegetated areas and minimize channelization of flow
- Flows that can't be dispersed shall be transported by vegetated conveyance that is stable and won't erode during the peak flow from the 10-year storm event.
- Curb and gutter systems are allowed with outlets to convey stormwater to grassed swales or vegetated areas designed according to standards in 15A NCAC 2H.1003.

- **High Density Option – SA Waters**
  - Built-upon area of 25 percent or less within 575 feet of SA-ORW
  - A vegetative buffer of at least 50-feet wide from perennial waterbodies, perennial streams, and intermittent streams for new development and at least 30 feet in width for redevelopment.
  - Utilizing one of the following approaches for treating and discharging stormwater
    - Runoff volume match with any excess runoff volume released at a non-erosive velocity at the edge of the vegetated setback or to an existing stormwater drainage system
    - Runoff treatment without discharging in excess of the predevelopment conditions during the one-year, 24-hour storm event. Runoff treatment must meet the minimum design criteria set forth in 15A NCAC 2H.1050 -.1062. The runoff volume in excess of the one-year, 24-hour volume runoff shall be released at a non-erosive velocity at the edge of the vegetated setback or to an existing stormwater drainage system
    - Runoff treatment for the difference between the pre- and post-development runoff volumes for the one-year, 24-hour storm event and meet the following requirements:
      - Document infeasibility to design an infiltration system in accordance with 15A NCAC 2H.1051
      - Stormwater must be filtered through a minimum of 18 inches of sand prior to discharge
      - Discharge from the stormwater control shall be directed to a level spreader-filter strip or a swale that fans at natural grade, or a natural wetland that does not contain a conveyance to SA waters
      - Runoff volume in excess of the one-year, 24-hour volume runoff shall be released at a non-erosive velocity at the edge of the vegetated setback or to an existing stormwater drainage system

<u>Dare County Permitting Requirements (non-SA or freshwater)</u>

Permitting requirements for the County's other coastal water other than SA waters or freshwater ORW that are classified according to low density and high-density options. Project density is

calculated as the total built-upon area divided by the total project area as defined in 15A NCAC 2H.1003. Permitting requirements for the two options are summarized as follows:

- **Low Density Option - Non-SA or Freshwater**
  - Built-upon area of 24 percent or less;
  - A vegetative buffer of at least 50-feet wide from perennial waterbodies, perennial streams, and intermittent streams for new development and at least 30 feet in width for redevelopment.
    Maximize dispersed flow through vegetated areas and minimize channelization of flow
  - Flows that can't be dispersed shall be transported by vegetated conveyance that is stable and won't erode during the peak flow from the 10-year storm event.
  - Curb and gutter systems are allowed with outlets to convey stormwater to grassed swales or vegetated areas designed according to standards in 15A NCAC 2H.1003.
- **High Density Option - Non-SA or Freshwater**
  - Stormwater control systems must be designed to control runoff from all surfaces generated by 1.5 inch storm
  - A vegetative buffer of at least 50-feet wide from perennial waterbodies, perennial streams, and intermittent streams for new development and at least 30 feet in width for redevelopment.

Dare County Permitting Requirements (Freshwater ORW)

Water quality conditions shall clearly maintain and protect the outstanding resource values of waters classified as Outstanding Resource Waters (ORW). Stormwater management strategies to protect resource values of waters classified as ORW shall be developed on a site-specific basis during the proceedings to classify these waters as ORW. The requirements of this Rule serve as the minimum conditions that must be met by development activities. More stringent stormwater management measures may be required on a case-by-case basis where it is determined that additional measures are required to protect water quality and maintain existing and anticipated uses of these waters.

- **Low Density Option - Freshwater ORWs**
  - Built-upon area of 12 percent or less
  - A vegetative buffer of at least 50-feet wide from perennial waterbodies, perennial streams, and intermittent streams for new development and at least 30 feet in width for redevelopment.

    Maximize dispersed flow through vegetated areas and minimize channelization of flow
  - Flows that can't be dispersed shall be transported by vegetated conveyance that is stable and won't erode during the peak flow from the 10-year storm event.
  - Curb and gutter systems are allowed with outlets to convey stormwater to grassed swales or vegetated areas designed according to standards in 15A

NCAC 2H.1003.

- **High Density Option - Freshwater ORWs**
  - Stormwater control systems must be designed to control runoff from all surfaces generated by 1.5 inch storm
  - A vegetative buffer of at least 50-feet wide from perennial waterbodies, perennial streams, and intermittent streams for new development and at least 30 feet in width for redevelopment.

Stormwater Control Measure (SCM) Design Criteria

North Carolina's approach to stormwater quality management in the 20 coastal counties is based first on minimizing impervious surfaces and, secondly, on treating stormwater runoff from these surfaces. The state's Stormwater Design Manual is compatible with the Minimum Design Criteria (MDC)s that are codified in the stormwater rules 15A NCAC 02H .1050-.1062. This manual went into effect on January 1, 2017 and is periodically updated with new guidance to best meet the stormwater rules. The Stormwater Design Manual includes important information on the following:

- Common Site and SCM Elements
- Design Calculation Guidance
- MDCs and Recommendations for SCM Design
- MDCs and Recommendations for New Stormwater Technologies
- Guidance for Specific Types of Sites (Low Density, Single Family, Linear Transportation, etc.)

It is recommended that users refer to the Stormwater Design Manual to ensure all SCMs meet required sizing and minimum design criteria.

2.2.6 North Carolina Division of Highways

Guidance in methods, policies, procedures, and criteria that must be followed during highway drainage studies and hydraulic designs is provided in the North Carolina Department of Transportation, Guidelines for Drainage Studies and Hydraulic Design document dated August 8th, 2022. Information from this document is pertinent to the development of recommended County stormwater management policies as there are various state roads in unincorporated Dare County.

General Drainage Policies and Practices

North Carolina long adhered to the Civil Law Rule in regard to surface water drainage. This rule obligates owners of lower land to receive the natural flow of surface water from higher lands. It subjects a landowner to liability whenever he interferes with the natural flow of surface waters to the detriment of another in the use and enjoyment of his land. Since almost any use of land involves some change in the drainage and water flow, a strict application of the civil law principles was impracticable in a developing society. Thus, a more moderate application of this rule evolved to allow a landowner reasonable use of his property.

The North Carolina Supreme Court formally adopted the Rule of Reasonable Use with respect to surface water drainage and abandoned the Civil Law Rule (Pendergrast V. Aiken) in August 1977.

The adopted Reasonable Use Rule allows each landowner to make reasonable use of his/her land even though by doing so, alters in some way the flow of surface water thereby harming other landowners. Liability is incurred only when this harmful interference is found to be unreasonable and causes substantial damage.

There are still some unanswered questions in the application of the adopted Reasonable Use Rule to specific areas of State agency activities. However, the rule is in line with the realities of modern life and will provide just, fair and consistent treatment. Therefore, the policies and practices of the Department of Transportation in regard to surface drainage matters follow this rule.

Engineer's Responsibility

The Reasonable Use Rule places responsibility on the "landowner" to make reasonable use of their land. While "reasonable use" is open for interpretation on a case-by-case basis, it would certainly infer from an engineering standpoint that provisions for, and treatment of, surface waters on the property are made in accordance with sound, reasonable and acceptable engineering practices.

The rule also states that liability incurs only when harmful interference with the surface water is found to be unreasonable and causes substantial damage. Therefore, it is incumbent on the Engineer to evaluate the potential effects of surface water activities on both up and downstream properties and to include provision in the design to hold these effects to reasonable levels.

Augmentation, Acceleration

Development of property can cause an increase in the quantity and peak rate of flow by increasing impervious areas and providing more hydraulically efficient channels and overland flow. It is the policy of the Department of Transportation to develop and make reasonable use of its lands and rights-of-way through sound, reasonable and acceptable engineering practices and to deny responsibility for augmented accelerated flow caused by its improvements unless determined to cause unreasonable and substantial damage. It is likewise the policy of the Department of Transportation to expect this same practice and acceptance of responsibility by other property owners and those engaged in the development of these properties.

Diversions

Diversions are defined as the act of altering the path of surface waters from one drainage outlet to another. It is the policy of the Division of Highways to design and maintain its road systems, so that no diversions are created thereby, insofar as is practicable from good engineering practice.

Any person(s) desiring to create a diversion into any highway rights-of-way shall do so only after receiving written permission. This permission will be granted only after it has been determined that the additional flow can be properly handled without damage to the highway, that the cost for any required adjustments to the highway system will be borne by the requester, and that appropriate consideration and measures have been taken to indemnify and save harmless the Division of Highways from potential downstream damage claims. It is Department of Transportation policy not to become a party to diversions unless refusal would create a considerable and real hardship to the requesting party.

Improvements and Maintenance of Drainage Within the Right-Of-Way

Drainage structures and ditches shall be kept open and maintained at a functioning level such that they do not present an unreasonable level of damage potential for the highway or adjacent

properties.

Where the elevation of the flow-line of an existing culvert under a highway is not low enough to adequately provide for natural drainage, the Department of Transportation will assume full responsibility for lowering the culvert or otherwise provide needed improvement.

Where a requested culvert invert adjustment is a result of a property owner lowering the flow-line of the inlet and outlet ditch in order to improve drainage of his property, the following considerations shall be given to the action taken:

- The lowered drain must have a reasonable expectancy of being functional and maintainable.
- Department of Transportation participation (up to full cost) must be based on benefit gained by the roadway drainage system as a result of the lowering.
- Where the new installation is of doubtful benefit, or of no benefit to highway drainage, the requesting party must bear the entire cost of installation.

Where the size of an existing highway culvert is determined to be of unacceptable adequacy in regard to the roadway system functioning as a result of a general overall development of the watershed, it is the Department of Transportation responsibility to replace the structure or otherwise take appropriate action. Where this same culvert inadequacy is the result of a single action or development, it is felt to fall within the realm of "unreasonable and substantially damaging" under the State adopted drainage ruling. Therefore, the party responsible for the action or development should bear the cost of replacement.

Where a new culvert crossing is requested, if the culvert is required for proper highway drainage or sufficient benefits to the highway drainage system would occur, the full cost will be borne by the Department of Transportation providing there is no diversion of flow involved. Where the new installation is of doubtful or no benefit to highway drainage, the property owner will bear the entire cost. When both parties receive benefit, a joint effort may be negotiated.

Established culvert crossings will be maintained and requests to eliminate any culvert should have approval of the State Hydraulics Engineer.

When new private drives are constructed entering the highway, the property owner can furnish, delivered to the site, the amount, type and size pipe designated by the Department of Transportation, to be installed by maintenance forces.

No alteration, attachment, extension, nor addition of appurtenance to any culvert shall be allowed on highway rights-of-way without written permission.

Improvements and Maintenance of Drainage Outside the Right -Of -Way

While it is the responsibility of the Department of Transportation to provide for adequate drainage for constructing and maintaining the State Highway System, it is not its policy nor responsibility to provide improved drainage for the general area traversed by such roads, unless incidental to the drainage of the road or highway itself. Drainage involvement outside the highway rights-of-way is limited to two general areas of justification:

- Sufficient benefit would be gained by such action to warrant the cost. These benefits would be in such areas as reduction in roadway flood frequency or extent, facilitation of maintenance, or a reduction in potential damages.

- Work is required to correct a problem or condition created by some action of the Division of Highways.

It is not the responsibility of the Department of Transportation to eliminate flooding on private property that is not attributable to acts of the agency or its representative.

In general, outlet ditches will be maintained for a sufficient distance below the road to provide adequate drainage, therefore. On large outlets serving considerable areas outside the right-of-way, the maintenance should be done on a cooperative basis, with the benefited properties bearing their proportionate share. Shares will, in general, be based on proportioning of runoff from the areas served by the outlet.

It is not the policy of the Department of Transportation to pipe inlet or outlet drains, natural or artificial, outside the right-of-way, which existed as open drains prior to existence of the highway. Where the property owner wishes to enclose an inlet or outlet, the Division of Highways may install the pipe adjacent to the right-of-way if justified by reason of reduced maintenance, safety or aesthetics if the pipe is furnished at the site by the property owner. This does not apply to the development of commercial property.

Obstructions

It is the policy of the Department of Transportation that when a drain is blocked below the highway, which is detrimental to highway drainage, if from natural causes, the Department of Transportation will take necessary measures to remove the block or obstruction. Where the block is caused by wrongful acts of others, it is the policy of the Department of Transportation to take whatever recourse deemed advisable and necessary to cause the party responsible to remove the block. Where a block occurs downstream of a highway, whether natural or artificial, and is of no consequence to the Division of Highways, it is the policy to remain neutral in causing its removal.

Drainage Easements

Where runoff is discharged from the right of way at a point where there is no natural drain or existing ditch, a permanent drainage easement is required to allow construction of a ditch or channel to convey the discharge to an acceptable natural outlet. When the discharge is into a natural drain or existing ditch and the increase in flow would exceed the capacity or otherwise create a problem, a temporary drainage easement can be obtained to allow enlarging or otherwise improving the drain to a point where the increase in discharge will not cause damage. It is generally preferable that any structural feature such as a drop inlet, catch basin, or pipe-end be contained within a permanent easement.

Subdivision Streets

When road and streets built by others are accepted onto the system for maintenance, responsibility for the drainage system, discharge pattern and outlet locations is as it existed at the time of acceptance and is limited to the rights-of-way.

Hydrology

The hydrological analysis phase involves the determination of discharge rates and/or volumes of runoff that the drainage facilities will be required to convey or control. Many hydrological methods are available, and most can be appropriately and effectively used under proper control and application. When the site involves a FEMA flood study area, discharge methods and values

provided in the report will take precedent over these methods for determining compliance with the regulation. The results from any hydrologic procedure should be compared to historical site information and adjustments made in the values estimated or procedure used when deemed appropriate. The designer must also consider potential future land use changes within a watershed over the life of a roadway structure and include this effect when estimating design discharges.

Method for Calculating Peak Discharge

If a watershed less than 100 acres, is primarily composed of pavement, grassed shoulders and slopes, and/or other mixed surface type runoff, the rational formula should be used for discharge determination.

Highway Design Discharge Criteria

One specific criterion on which the design is evaluated and generally referred to as the "design discharge" is the flood level and frequency which results in inundation of the travel way. The minimum desirable levels of protection from travel way inundation by roadway classification are listed as follows:

Roadway Classification	Design Frequency
Interstate (I)	50 year
Primary (US & NC)	50 year
Secondary (Major, City Thoroughfare)	50 year
Secondary	25 year

Culvert Design Criteria

There are four discharge levels that must be evaluated for each culvert design. These are:

1. The "design discharge".
2. The Q100 base flood.
3. Q-overtopping. This discharge is computed after a trial size is selected.
4. Q10 for outlet protection and erosion control measures.

Other discharges may be required on a site-specific basis. Examples are:

1. Q-average. For permit determination.
2. Q-bank full. For fish passage, channel stability or floodplain analysis.

Storm Drainage System Design Criteria

The purpose of a storm drainage system is to collect and transport stormwater runoff from the highway to an outlet. The complete system consists of the curb and gutter, inlet structures, lateral and trunk line pipes, and junctions and manholes. The design process for storm drainage systems usually follows the basic steps of planning/data collection, hydrologic/hydraulic design, and outfall analysis.

Design Frequency

Roadway inlet location, capacities and gutter spread is to be analyzed using a standard rainfall intensity of 4.0 inches/hour. The storm drain pipe system is to be designed using a Q10 discharge with a minimum time of concentration of 10 minutes assuming 100% pick-up at each inlet.

In sag areas where relief by curb overflow is not provided, the system standard design level (Q25–Q50) is to be used for analysis to ensure traffic flow is not interrupted.

Pipe System

Storm drain pipes shall be concrete unless a site limitation such as grade or corrosive conditions dictate the use of an alternate material. The minimum pipe size to serve a single inlet is 12-inch diameter. For more than one inlet, or a length of more than 100 feet, a 15-inch diameter pipe is the minimum size. When differing size pipes enter and exit a junction, the desired practice is to match the crowns of the pipes.

Roadside Ditches

A roadside ditch is a man-made channel generally paralleling the roadway surface and distinguished by a regular geometric shape. Roadway ditches are to be designed to contain as a minimum the Q10 (10-year) flow. The typical roadway ditch section is established with sufficient depth to drain the pavement subbase and flat side slopes for safe vehicle traverse. This generally provides very generous capacity for the design flow requirements. Therefore, actual capacity determination can be done on a selective basis at sites on common project grades to verify adequacy and establish limitations on the length of the ditch run.

The size requirements of the project special side ditches along the toes-of-fill will be established based on an analysis of the design flood. This ditch capacity analysis will be performed using Mannings' equation. The roadway section including shoulders and slopes shall be considered an urban watershed.

2.2.7 NCDOT Subdivision Roads

A subdivision road is one that serves a parcel or tract of land that is subdivided into two or more lots, building sites or other divisions for sale or building development for residential purposes where such subdivisions include a new road or change in an existing road.

Subdivision roads may be designated public or private. Public designations will be built to minimum construction standards of the North Carolina Department of Transportation (NCDOT) as required under North Carolina General Statute 136-102.6. Private roads need not meet minimum construction requirements but must meet minimum construction requirements before ever becoming a part of the State-maintained system.

NCDOT Subdivision Roads Drainage Design and Construction Requirements

Design criteria for NCDOT subdivision roads are provided in Subdivision Roads – Minimum Design Standards dated January 2010 and revised July 2020, which is included as Appendix C of this report. Drainage design and construction requirements for state-maintained subdivision roads are summarized for review purposes in the following paragraphs.

Requirements for Addition of Subdivision Roads to the State System

- Erosion and Sedimentation – All subdivision roads shall have an acceptable permanent vegetative cover established and other acceptable permanent erosion control measures installed in accordance with Division of Highways' specifications, prior to addition to the State-maintained system.
- All pipe culverts, storm sewers and appurtenances shall be free of all debris and silt build-up and shall be structurally and hydraulically sound and functioning in a normal manner. All drainage ditches shall be of such a width and depth and with such a slope as to carry the anticipated discharges. Paved ditches or riprap shall be required where necessary.

Minimum Drainage Requirements for Subdivision Roads

The Department of Transportation shall review all drainage prior to acceptance of any facility to the State System. All storm drainage shall be adequate so that the road may be maintained without excessive cost, and not cause flooding on private property from storm runoff of the design frequency. Permanent drainage easements may be required. The minimum design frequency shall be as follows but may be increased at the recommendation of the State Hydrographic Unit Head.

1. Storm sewer collector - 10 years
2. Cross drainage – 25 years

In areas where ditch grades or quantities of flow deem it impracticable to establish and maintain vegetation, an erosive resistant lining such as paving or rock riprap may be required. Subsurface drainage shall be adequate to maintain a stable subgrade.

When road crossings are within areas designated as flood hazard areas under the Federal Flood insurance Program, the design must be approved by the responsible local governing agency for its consistency with local flood zoning ordinances.

Minimum Criteria for Curb and Gutter Design

Minimum design criteria for curb and gutter include the following:

- All curb and gutter sections must meet Department of Transportation standards
- The standard 2'-6" concrete curb and gutter is the preferred type to be used. Types of other curb may be used provided the 6" height is maintained.
- The concrete Valley Gutter is an allowable type.
- Any other types of gutters will be subject to the approval of the Division Engineer after review on an individual basis. Approval will be subject to the terrain factors in the area under study as they relate to potential maintenance problems.

2.2.8 NCDOT Policy on Street and Driveway Access to Highways

The North Carolina Department of Transportation has deemed it necessary to regulate the location, design, construction, and maintenance of street and driveway connections to the State Highway System for the purpose of protection for such highways, economy of maintenance, preservation of proper drainage, safe and efficient movement of traffic thereon, and full utilization of the taxpayer's investment. The objective of this Policy is to establish uniform criteria governing

such location, design, construction, and maintenance. A copy of the most recent NCDOT Policy on Street and Driveway Access to North Carolina Highways dated July 2003, is provided in Appendix D. Drainage requirements for street and driveway access to highways are summarized for review purposes in the following section.

Drainage Requirements for Street and Driveway Access to Highways

Driveways must be constructed so that they do not adversely affect the highway drainage or drainage of the adjacent properties. The drainage and the stability of the highway subgrade must not be impaired by driveway construction or roadside development. In no case may the construction of a driveway cause water to flow across the highway pavement, or to pond on the shoulders or in the ditch, or result in erosion within the right-of-way.

- Drainage collected by ditches, gutters, or pipes on private property shall not be discharged into the highway drainage system unless expressly approved by the Division of Highways. The applicant may be required to submit a drainage study to the Division of Highways justifying the drainage system proposed and the pipe or sewer sizes to be used. Natural drainage laws and practices must be observed.
- Where the construction of a driveway necessitates crossing a highway ditch, a culvert pipe shall be installed in the ditch. The low point of the driveway profile shall be at or close to the ditch line. Under no circumstances will existing ditches or gutters be filled without adequate alternate provisions for drainage being made.
- Culvert pipe shall be of a size adequate to carry the anticipated flow in the ditch as determined by the Division of Highways and shall not be smaller than 15 inches, inside diameter.
- The structural material and gauge of the driveway culvert pipe shall be adequate to withstand the loads from the anticipated vehicular traffic across the driveway. The culvert shall meet or exceed the requirements of the North Carolina Standard Specifications for Roads and Structures. The length of the culvert may be determined as the sum of the width of the driveway (surfaced width and shoulder) at the ditch line and the length needed to accommodate a sideslope of at least 1 vertical to 3 horizontal from the driveway grade to the ditch. A minimum 20 feet of pipe shall be used on all commercial and residential subdivision driveways. Plastic pipe is not acceptable for drainage purposes.
- Where headwalls or wingwalls are constructed with drainage facilities, a minimum roadway clearance of 30 feet, measured from the edge of pavement, should be observed unless protected by guardrail. The use of flared-end sections should be encouraged.
- All drainage structures deemed necessary by the Division of Highways, including incidentals, shall be furnished by the applicant. The Division of Highways will install the drainage pipe for the applicant at the current rate of installation. If, however, the applicant makes the installation, the Division of Highways is required to inspect the installation, and the applicant will be appropriately charged for the inspection. One inspection fee will be charged for each application, regardless of the number of installations involved, provided all installations are available for inspection.

2.3 Local Ordinances

Local ordinances are critical in regulating development through zoning and planning. Local

ordinances should control the density of development and establish building codes consistent with sound environmental practice. This section refers to the Dare County Code of Ordinances current through Ordinance passed 5-17-2023 and State legislation through 2023 Regular Section #1. The following provides a summary of some of the subdivision and zoning ordinances for Dare County.

Dare County has the following subdivision and zoning ordinances in place to control development:

- Minimum lot size, per the subdivision ordinance, is 20,000 square feet for lots with a private well (this includes unzoned areas within the County).
- Minimum lot size, per the subdivision ordinance, is 15,000 square feet for lots served by central water (this includes unzoned areas within the County).
- Minimum lot size of 20,000 square feet for single family homes with a private well and on-site septic system in zones N-H, BNH, ELNH, CP-R, RS-1, MP-1, RS-6, RS-8, RS-10, R-1, R-1A, R-2, R2-A, R-2B, R2-H, SP-2,R-3, , C-1, SP-C, S-1, and V-C. (Note: A single family home served by a private well and an on-site septic tank system in zone R-4 requires a minimum lot area of 15,000 square feet).
- Minimum lot size of 15,000 square feet for single family homes served by a central water supply and on-site septic system in zones N-H, BNH, CP-R, RS-1, MP-1, RS-6, RS-8, RS-10, R-1, R-1A, R-2, R2-A, R-2B, R2-H, SP-2,R-3, R-4, C-1, SP-C, S-1, V-C and VC-2.
- Minimum lot size of 15,000 square feet for single family homes served by a central water supply and a central wastewater disposal system in zones N-H, BNH, CP-R, RS-1, MP-1, RS-6, RS-8, RS-10, R-1, R-1A, R-2, R2-A, R-2B, R2-H, SP-2, SP-C, C-1, S-1, V-C and VC-2.
- Minimum lot size of 40,000 square feet for single family homes in zone SED-1.
- Minimum lot size requirement is 20,000 square feet for duplexes with a private well regardless of wastewater disposal method and 15,000 square feet for duplexes served by a central water supply regardless of wastewater disposal method in zone S-1, RS-6, RS-8.
- Minimum lot size requirement is 25,000 square feet for duplexes in zone RS-10, , unless served by an approved public or community sewage disposal system, in which case the lot size may be reduced to 12,500 square feet
- Minimum lot size requirement is 20,000 square feet for duplexes in zones R-2, R-2A, R-2B, and R-3 unless served by an approved public or community sewage disposal system, in which case the lot size may be reduced to 15,000 square feet.
- Minimum lot size of 80,000 square feet for duplexes in zone SED-1.
- Multi-family dwellings in RS-6: Must be served by an approved public or community sewage disposal system: Six (6) dwelling units per acre.
- Multi-family dwellings in RS-8: Must be served by an approved public or community sewage disposal system. Eight (8) dwelling units per acre.
- Minimum lot size of 7,500 square feet for first dwelling unit and 4,000 square feet for each additional dwelling unit in multi-family dwellings in zone RS-10.
- Multi-family dwellings in R-3: Must be served by an approved public or community sewage disposal system. Ten (10) dwelling units per acre except a dwelling density bonus of ten (10) additional units per acre may be applied in a commercial group development existing on October 20, 1992 that is served by an approved public or community sewage treatment

and disposal system.

- Minimum lot size of 160,000 square feet, developed at a density of one unit per 40,000 square feet of land area (or 4 single family structures per cluster lot) in zone SED-1.
- Minimum lot size of 30,000 square feet for residential businesses in zones R2-A and R-2B.
- Minimum lot size of 40,000 square feet for commercial services in zone CS.
- Minimum lot size of 20,000 square feet for commercial businesses in zone V-C.
- For commercial districts all minimum lot sizes must be sufficient to meet requirements of County Health Department.
- 35-foot building height restrictions for zones N-H, CP-R, RS-1, MP-1, RS-6, RS-8, RS-10, R-1, R-1A, R-2, R-2B, R-3, R-4, C-1, C-2, C-3, CS, V-C, and SED-1.
- A 52-foot building height restriction for zones S-1.
- The maximum allowable lot coverage by principal use and all accessory structures is 20% for zones N-H and SED-1 (lots used as cluster sites).
- The maximum allowable lot coverage by principal use and all accessory structures is 25% for zone SED-1 (lots 80,000 or more square feet).
- The maximum allowable lot coverage by principal use and all accessory structures is 30% for zones CP-R, RS-1, MP-1, RS-6, RS-8, RS-10, R-1, R-1A, R-2, R-2A, R-2B (for homes, bed and breakfasts, and resident businesses), R-3, R-4, V-C (single family homes), SED-1 (lots 60,000-79,999 square feet).
- The maximum allowable lot coverage by principal use and all accessory structures is 35% for zones I-1 and SED-1 (lots 40,000-59,000 square feet).
- The maximum allowable lot coverage by principal use and all accessory structures is 50% for zones R-2B (for all structures not listed above) and C-1.
- The maximum allowable lot coverage by principal use and all accessory structures is 60% for zones C-2, C-3, CS, S-1, and V-C (other than single family homes).

See the Dare County Zoning Ordinances for specific requirements. There are several zoning districts in which vegetation removal is restricted. Dare County has requirements for stormwater drainage included in their subdivision ordinances. These requirements dictate that surface water drainage in all subdivisions must comply with NCDOT standards.

CAMA Land Use Plan

Dare County is currently in the process of updating its CAMA Land Use Plan. The following Statements of local policy on land use issues which affect stormwater management in Dare County were taken from the current 2009 Land Use Plan. WithersRavenel understands that an updated 2019 Land Use Plan is under review and as of the date of this report has not been approved.

Floodplain Management

Dare County participates in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS). Dare County's Flood Damage Prevention is the governing regulation for implementation of floodplain rules and follows the model floodplain ordinance developed by the

North Carolina Floodplain Management Program.

Areas of Environmental Concern (AECs), Estuarine Waters, Public Trust Waters, Ocean Hazard Areas

According to the policy statement regarding AECs, Dare County shall seek to ensure that these areas are protected and only those uses which are compatible with the appropriate management of the Estuarine System will be allowed. Such development must be compatible so as to minimize the likelihood of significant loss of private property and public resources. Enforcement of the County's Zoning Ordinance, Subdivision Regulations, CAMA use standards, and the National Flood Insurance Program's base flood elevation standards will continue to protect these resources.

Stormwater Runoff

The County recognizes the value of water quality maintenance in regards to protecting commercial and recreational fishing resources and providing clean water for other recreational purposes. The stormwater management program will provide another tool for the County to reduce stormwater pollution to the waterways and enhance the water quality in the area. The stormwater management of the County Code of Ordinances (Chapter 153.34) does not include provisions for attenuating runoff for proposed development.

Surface Water Quality

The County is continuing to seek methods to protect and enhance the water quality of the estuarine system, and to develop new management measures and practices to improve water quality. The stormwater management program will provide another tool for the County to reduce stormwater pollution to the waterways and enhance the water quality in the area. The County relies on state and federal permitting authority to augment local management strategies. Tools such as the Division of Energy, Mineral, and Land Resources Sedimentation and Erosion Control Permit and the Division of Water Quality Stormwater Management Permit are integral to Dare County's ability to mitigate effects of stormwater runoff. The County encourages the use of low impact development (LID) practices for stormwater management and relies on practices developed by the Division of Water Quality. The Dare County Soil and Water Conservation Office provides technical, educational, and cost share programs for improving water quality through the installation of Best Management Practices (BMPs).

Protection of Trees and Vegetation

The County's policy is to provide the public with information on best management practices for tree removal and land clearing, but not to prevent vegetation removal on private property due to a conflict with property rights generally associated with private ownership.

Types of Urban Growth Patterns Desired

The implementation of the stormwater management program will not affect the desired growth patterns on the island. The program will help to improve visual aspects on the island (reducing or eliminating standing water during storms), which will help to encourage the desired growth patterns.

Redevelopment of Developed Areas, Including the Relocation of Threatened Structures

It is County policy that density allowances for redevelopment areas conform to existing County

building and zoning regulations, even if they are more restrictive than when the structure was originally built.

Continuing Public Participation

County policy is to assure that all residents have a full and adequate opportunity to be informed of and participate in the County's planning decision-making process. The stormwater management program also includes public education and public participation.

Chapter 3 - Policy

This chapter outlines the existing County policies regarding stormwater management and evaluates what policies need changes for effective management in the future. Current responsibilities of the County are explained in this chapter.

3.1 Responsibilities

Stormwater management in Dare County is currently the responsibility of the State of North Carolina. Dare County would be responsible for stormwater management if the County implements a stormwater management program and adopts a stormwater management ordinance.

Currently the County has the following responsibilities regarding stormwater management:

- Approval of site plans with respect to amount of built upon area, setbacks from the mean high water mark.
- Inspection of new subdivisions for compliance with subdivision ordinances, including stormwater drainage systems.

3.2 Stormwater Management

Chapter 153.34 of the Code of County Ordinance includes stormwater management requirements as it relates to development drainage. However, the County does not currently have a comprehensive Stormwater Management Ordinance. A stormwater ordinance would help to prevent illicit discharges and dumping into the storm drain. An ordinance can make it illegal to put gasoline, oil, antifreeze, and other pollutants into the storm drain system. It would also be illegal for any person to put anything in the ditch, storm drain, or other drainage way that impedes or interferes with the free flow of stormwater. Additionally, the stormwater ordinance would also assist in limiting the amount of impervious surface on lots, thus reducing the quantity of stormwater entering the storm drain system and help to reduce the risk of flooding during storms.

3.2.1 Public Education/Involvement

This *Stormwater Master Plan* provides a way for the County to improve stormwater management in the future and to reduce deficiencies of the storm drain system. An important part of the plan is educating citizens about stormwater runoff, the importance of protecting the environment by not polluting the stormwater runoff, and ways that they can reduce stormwater runoff to help decrease flooding.

The County has also provided for public involvement as part of the development of the stormwater master plan. Two public workshops, one in Manteo and one in Buxton were held to inform the public about the plan and to solicit input regarding areas of concern and potential solutions. The public provided input on additional areas of concern and other topics.

3.2.2 Pollution Prevention

Pollution prevention can play a large part in the amount of pollution that enters the waterways through stormwater runoff. Educating business owners and citizens about pollution prevention techniques is the best approach to reduce or prevent pollution. Dare County and the Dare Soil and

Water Conservation District implement the following measures for reducing pollutants.

- Dare County Public Works offers Hazardous Household Waste drop-off events each spring.
- Offers practical tips for conservation on the Soil and water Conservation website: https://www.darenc.gov/departments/planning/soil-and-water/conservation-practices
- Shares information about the Community Conservation Assistance Program, which is a voluntary, incentive-based program designed to improve water quality through the installation of various best management practices (BMPs) on urban, suburban and rural lands not directly involved with agriculture production.

The following programs are recommended for enhancing the stormwater pollution prevention program in Dare County:

- Develop specific lawn maintenance recommended practices for the area and make a pamphlet to be mailed in the beginning of every spring.
- Develop a recommended list of vegetation that are effective in filtering pollutants, promote voluntary planting of a vegetative buffer.
- Coordinate with commercial business owners to establish parking lot cleaning operations including recommended procedures and schedules. Develop a stormwater management manual with focus on low impact development and retrofits to existing structures. The Town of Nags Head's *Low Impact Development Manual and Stormwater Reference Manual* can be used as a template by the County: https://nagsheadnc.gov/AgendaCenter/ViewFile/Item/3408?fileID=5185

3.2.3 Illicit Discharge Detection and Elimination

Illicit discharge detection and elimination is a way for the County to ensure that only stormwater is entering the stormwater system. The infiltration of septic tank effluent into drainage channels and wetlands have been identified by the County as an ongoing concern. Currently, the County Health Department sites, permits, and inspects septic tank systems on a case-by-case basis. In the future, it is possible that the impact of septic tank discharges on the quality of County stormwater runoff will be scrutinized more closely by regulatory agencies.

Under the final NPDES Phase II rule, permit requirements for system operators, regarding illicit discharges, will include the following:

- Develop a storm sewer system map showing the location of all outfalls, and names and location of all waters of the United States that receive discharges from those outfalls.
- Effectively prohibit though ordinance, or other regulatory mechanism, illicit discharges into the separate storm sewer system and implement appropriate enforcement procedures and actions as needed, and to the extent allowable under State, Tribal, or local law.
- Develop and implement a plan to detect and address illicit discharges, including illegal dumping, to the system;
- Inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste.

At this point in time, the County is not regulated under the NPDES Phase II rule and has not

implemented these components. As part of the field investigation conducted with this update an approximate inventory of piped systems was created and can be found in Appendix F. This preliminary map could be utilized in the preparation of full drainage system mapping with drainage boundary delineation and outfall identification. Drainage system mapping would provide long-term benefit to the County, especially if the County plans to implement a long-term maintenance program. In addition to the illicit discharge issues, the mapping would be beneficial in the general administration of the County's stormwater management program. WR recommends that the County incorporate the preparation of drainage system mapping into its long-term stormwater management goals.

3.2.4 Increased Runoff Due to Development

As land is developed, the area of perviousness usually decreases which reduces the natural ability of soils to absorb rainfall. This decrease accelerates the quantity of runoff and increases peak rates of flow. If measures are not taken during design to incorporate low impact development of other runoff attenuating measures, this increased rate of flow can cause flooding and erosion and sedimentation problems. The use of structural and non-structural Stormwater Control Measures can provide a solution, as can the implementation of a stormwater ordinance.

3.3 Drainage System Design, Operation and Maintenance

A stormwater drainage system consists of manmade conduits and channels and natural ponds, streams, creeks, rivers, and floodplains. Flooding is the most noticeable problem that occurs with poorly designed or maintained drainage systems. North Carolina Department of Transportation design criteria has been reviewed for applicability in the service area and these criteria were summarized in Section 2.2.5 - 2.2.6. These design criteria, along with NC DEMLR stormwater design criteria are excellent references and should be followed by the County during design and construction of additional stormwater management measures. The County may also want to develop their own Stormwater Drainage Design Manual.

It is important that the County has an easement for its storm drain systems so maintenance and repairs can be performed when necessary. For County-owned storm drain systems carrying runoff from public right-of-way, the County may want to obtain an easement for any drainage channel. Storm drain systems which only carry runoff from private property are considered private systems and the County is not responsible for their maintenance.

If the County so decides, the operation and maintenance of the drainage system in the County will be the responsibility of the County. For the County to effectively maintain the stormwater drainage system, the County needs an inventory of the major components. This inventory includes type, location, size, material, slope, length, condition, and current ownership. Some of this has been collected from previous field investigations of the drainage system. All areas of the system would be put on a schedule that identifies what type of maintenance needs are to be performed and how often it should be done. A contingency plan would be developed that outlines what maintenance activities are needed after a major storm or hurricane.

A step-by-step procedure for responding to minor maintenance and repair requests would also be developed. The amount of major and minor maintenance work performed would be tracked as a way to evaluate stormwater management program success.

3.4 Stormwater Control Measures (SCMs)

SCMs are methods or practices that can effectively reduce stormwater pollution. Some SCMs prevent pollutants from reaching stormwater such as street sweeping and other SCMs reduce the amount of pollutants already in the runoff such as an infiltration trench. Structural control SCMs described in the NC Department of Environmental Quality – Division of Energy, Mineral, and Land Resources *Stormwater Design Manual* include:

- Infiltration System
- Bioretention Cell
- Wet Pond
- Stormwater Wetland
- Permeable Pavement
- Sand Filter
- Rainwater Harvesting
- Green Roof
- Level Spreader-Filter Strip
- Disconnected Impervious Surface
- Treatment Swale
- Dry Pond
- New Stormwater Technologies
    - StormFilter
    - Silva Cell Suspended Pavement with Bioretention
    - Filterra
    - Bayfilter

3.5 Low Impact Development (LID) for Homeowners

Although new development or redevelopment may not necessitate structural SCMs to meet the state's stormwater program requirements, homeowners are encouraged to proactively incorporate LID devices where feasible to mitigate the impact of impervious surfaces and reduce runoff. LID uses techniques to capture and store stormwater as close to the source as possible to promote infiltration and treatment, thereby reducing runoff and the amount of pollution that runoff can convey. Several factors should be determined when considering best LID practices, such as:

- Identify natural features
- Focus on prevention
- Work with the landscape by identifying direction of flow and locations of stormwater accumulation and infiltration.
- Keep it simple managing stormwater close to its source
- Practice multitasking such that the landscape treat pollutants and is aesthetically pleasing
- Maintenance requirements to ensure practice is right fit for the location
- Approximate level of seasonal high water table.

Devices and practices suitable for residential stormwater improvements may include:

- Rerouting downspouts to vegetation

- Vegetated swales
- Rain gardens
- Drip line infiltration trenches
- Infiltration trench/gravel bed
- Cistern/rain barrel

For more information on considerations, design recommendations, maintenance, and best practices, refer to the Town of Nags Head Low Impact Development Manual – Appendix E: https://nagsheadnc.gov/AgendaCenter/ViewFile/Item/3408?fileID=5185.

3.6 Floodplain Management

Dare County participates in the Federal Flood Insurance Program. As part of this program, if a building is located in a flood prone area, the ground floor elevation must be certified before a building permit can be issued.

No changes are recommended to the existing floodplain practices and policies regulated by the County. Any drainage system improvements proposed in the floodplain will have to comply with the existing requirements.

Chapter 4 - County Review

This overview describes the physical features of the unincorporated portions of Dare County and the effects these features have on stormwater quality and quantity.

Dare County is located in the northeastern corner of the Coastal Plains of North Carolina. Its land area encompasses a portion of mainland, Roanoke Island, and barrier islands. The County comprises a total land area of 383.23 square miles, 354.64 square miles is unincorporated. According to data from the U.S. Fish and Wildlife Service's National Wetlands Inventory, there are approximately 6,895 acre of wetlands in the unincorporated areas of Dare County. The primary village areas of interest in this study are shown on Figure 1 below. The incorporated areas of Dare County not addressed in this plan include the municipalities of Duck, Kill Devil Hills, Kitty Hawk, Manteo, Nags Head, and Southern Shores. Additionally, federal lands such as National Parks Service Property, National Seashore property, National Wildlife Refuges, and military facilities are not addressed in this Plan.

Figure 1 – Unincorporated Dare County Villages

4.1 Setting

Dare County is located along the eastern seaboard of North Carolina and borders 85 miles of the Atlantic Ocean. The county is part of the lower Coastal Plain physiographic region of North Carolina and has a mean elevation of 12 feet. Mainland Dare County is predominantly residential development with some commercial businesses. The barrier islands of Dare County, known as the Outer Banks, have a steady year-round population with a significant increase during the summer months due to seasonal tourism.

4.2 Hydrography

Approximately 89% of Dare County is located within the Pasquotank River Basin, which begins in the southeast corner of Virginia, and flows southeast into North Carolina continuing to the Atlantic Ocean. A portion of this river basin has been classified by the United State Geological Survey (USGS) as the Albemarle watershed and has been given a corresponding 8-digit hydrological unit code (HUC) (03010205). The Albemarle watershed contains most of the Dare County mainland, Roanoke Island, barrier islands north of Oregon Inlet, and Hatteras Island North of Gull Island Bay. Primary water features include Currituck Sound, Albemarle Sound, Roanoke Sound, Croatan Sound, and the Atlantic Ocean.

The remaining portion of Dare County is included in the USGS Pamlico Sound watershed (03020105). This watershed is located in the Tar-Pamlico River Basin. Within the Pamlico Sound watershed, the Hatteras Inlet watershed includes Hatteras Island south of Gull Island Bay and the peninsula formed at the southeast comer of the Dare County mainland, located between the Long Shoal River and Sandy Point. Primary water features of this watershed include the Pamlico Sound and the Atlantic Ocean.

4.3 Hydrologic and Hydraulic Characteristics

4.3.1 Water Bodies

The Albemarle Sound is a large estuarine waterbody containing fresh to brackish water. Salinity is low due to dilution from freshwater inflow from several rivers including the Chowan, Roanoke, Pasquotank, and Alligator rivers. The Alligator River is a large blackwater river that flows into the Albemarle Sound from the south. A major portion of this river (south of US 64) has been designated as outstanding resource waters (ORW) as determined by the NC Division of Water Quality (DWQ) Water Quality Standards Program. ORWs are considered to have exceptional state or national recreational or ecological significance. These waters are of excellent quality and require special protection to maintain existing uses. The Alligator River borders the Alligator River National Wildlife Refuge on the eastern shore and serves as a spawning area for anadromous fish.

Currituck Sound is in the northeast portion of the basin, where Martin's Point is located, and is characterized as a shallow waterbody containing fresh to brackish water. Wind movement largely influences water circulation in the sound. The Northwest River, which receives drainage from the Great Dismal Swamp, is a major tributary to Currituck Sound.

The Croatan-Albemarle, Croatan, Roanoke, and Pamlico Sounds border the western side of the barrier islands south of Currituck Sound. A majority of this estuarine area is classified as shellfish harvesting areas (SA). SA waters are tidal systems that have been designated for shellfish harvesting, primary recreation, fishing, aquatic life propagation, and wildlife use. Some of these

waters are classified as SB waters, which are waters that are used for primary recreation, including frequent or organized swimming. Currituck Sound and Kitty Hawk Bay are classified SC waters. The Best Usage classification of these waters is considered aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, and other uses besides primary recreation and shell fishing.

Salt marshes occur between the open water of the sounds and the upland areas of the barrier islands. These marshes are comprised of several various marsh grasses which filter shoreline runoff and river deposits.

The majority of Dare County is located within the 100-year flood plain. There is an area west of Stumpy Point on the Mainland that is located outside the 100- and 500- year floodplains. Much of northern Roanoke Island and much of the central area of Wanchese is located outside the 100- and 500-year floodplains. The majority of the unincorporated Outer Banks in Dare County are within the 100-year floodplain, with the exception of some pockets of high ground throughout.

4.3.2 Soils

Dare County is comprised of several general soil groups also called soil units. The 1977 Dare County Soil Survey categorizes these units based on similar soil types, patterns, relief, and drainage. Typically, these areas consist of one or more major soils and several minor soils. These general categories are used to compare the suitability of large areas for general land uses, but should not be used for individual site selection. For the purposes of this document, however, they offer a concise description of the general soil characteristics of the county.

Mainland

The Dare County mainland consists of very poorly drained organic and mineral soils. The water table is at or near the surface for a large portion of the year. Wetness and flooding are the area's main limitations. Additionally, low strength, subsidence, and the risk of fire limit the organic soils during dry periods. The soils found on the mainland make up 71 percent of the soils found in the entire county.

The Pungo-Belhaven soil unit is found on broad flats and consists of nearly level, very poorly drained soils. These soils have a mucky surface layer with an underlay of loamy material. This unit comprises approximately 51 percent of the county. These soils are used almost exclusively as woodland and wildlife habitat due to several limitations that affect urban and agricultural uses. These limitations include wetness, low strength, flooding, and a high percentage of logs, roots, and stumps in the organic layer.

11 percent of Dare County is comprised of the Hyde-Cape Fear soil unit. These soils are nearly level, very poorly drained soils, with a loamy surface layer and a loamy or clayey subsoil. Hyde-Cape Fear soils are found on broad flats predominantly in the northern central portion of the mainland. Management concerns include wetness, flooding, and low strength.

Ponzer-Roper soils comprise 9 percent of the county and are found on broad flats throughout the central mainland. They are nearly level, very poorly drained soils and have a mucky surface layer with a loamy underlay. These soils are susceptible to wetness and flooding, and are also limited by excessive humus and low strength.

The Dare County mainland marsh areas are lined with a thin strip of soils generalized as the Hobonny-Carteret-Currituck soil unit. This soil unit is also found on Roanoke Island and the Outer

Banks, cumulatively comprising 10 percent of the county. These soils are nearly level, very poorly drained and are primarily utilized as wildlife habitat due to frequent flooding by tides, extreme wetness, and exposure to salt spray. The soils consist of a mucky or sandy surface layer with a similar substratum.

A small portion of the mainland, the Manns Harbor area, is located on the Baymeade-Icaria-Johns soil unit. These soils are more prevalent on Roanoke Island and are discussed in the following section.

Roanoke Island

A large portion of the soil on Roanoke Island is categorized as the Hobonny-Carteret-Currituck soil unit. These nearly level, very poorly drained soils have a sandy or mucky surface and subsurface layers and are found in marsh areas. These areas are utilized almost exclusively as woodland and wildlife habitat due to frequent flooding and extreme wetness.

The developed areas of Roanoke Island are mainly located on the Baymeade-Icaria-Johns soil unit. These soils are nearly level to sloping, with drainage ranging from well drained to very poorly drained. They are found on flats, gently sloping ridges, and depressions with a sandy surface and a loamy subsoil. Collectively, these soils comprise 2 percent of the county's soils. Development and agricultural uses of these soils are limited due to the slope, seepage, the sandy texture, and the flooding of low areas during high-wind tides.

Northern Beaches and Hatteras Island

The Newhan-Duckston-Corolla soils are found along the seaboard side of the Northern Beaches and Hatteras Island and make up 11 percent of the county's soils. Soils within this unit are nearly level to steep and range from excessively drained to poorly drained. They are sandy throughout, making them unsuitable for cropland or woodland uses. These areas are mainly used for urban, recreational and beach activities.

Fripp-Ousley-Osier soils are found on gently sloping or sloping ridges, on flats, and in depressions on the sound side of the Northern Beaches and Hatteras Island. These sandy soils make up 6 percent of the county's soils and range from excessively drained to poorly drained. Management concerns include slope, wetness, seepage, flooding.

The sound side of the Northern Beaches and Hatteras Island is also sporadically lined with a thin strip of marshland soils generalized as the Hobonny-Carteret-Currituck soil unit. This soil unit is also found on Roanoke Island and the Dare County mainland. Cumulatively, it comprises 10 percent of the county. These soils are nearly level, very poorly drained and are primarily utilized as wildlife habitat due to frequent flooding by tides, extreme wetness, and exposure to salt spray. The soils consist of a mucky or sandy surface layer with a similar substratum.

4.4 Water Quality Characteristics

Several Dare County shellfish harvesting areas (SA) have been closed for many years due to poor water quality, specifically high fecal coliform bacteria levels, as determined by the NCDEQ Marine Fisheries Division. These prohibited territories include:

- All waters in the Alligator river and its tributaries
- Waters in the Albemarle Sound – Colington Harbor area

- Waters in the Currituck Sound
- All waters in Shallowbag Bay and its tributaries,
- Waters in the Roanoke sound beginning on the south side of the mouth of Broad Creek, including Mill Creek and its tributaries,
- All those waters in Broad Creek,
- Waters in Roanoke sound near Whalebone,
- All waters near the Oregon Inlet Fishing Center,
- Waters near Ballast Point, including Pirates Cove and other tributaries in the area,
- All waters within Old Nags Head Cove canal system
- Waters near Sand Point,
- Waters near north Shore of Baum Creek on Roanoke Island,
- All waters of Spencer and Callaghan Creeks,
- All waters upstream of mouth of Manns Harbor,
- Waters near South End of Roanoke Island,
- All waters in the canals north of Baumtown Road
- All waters in the Point Peter Canal
- Waters near Lake Worth drainage canal, on west side of Stumpy Point Bay,
- Waters on east side of Stumpy Point Bay near Drain Point,
- All waters in The Slash between Hatteras Ferry Landing Area and Sandy Bay
- Waters in Sandy Bay Area,
- All creeks, canals and tributaries along Hatteras Island between Duncan Point and Joe Saur Creek, to include Joe Saur Creek
- All waters in Sunset Village Marina and surrounding canals
- Waters in Frisco Marina Canals
- Waters in Brooks Point Area,
- Waters in Brigands Bay Canal
- All of Rodanthe Boat Harbor,
- All of Salvo Harbor,
- All of Avon Harbor,
- All waters in Askins Creek,
- All waters in Mill Creek
- Waters in Cape Creek Area
- All waters along Hatteras Island east of Brooks Point in Brigand Bay

- All waters in Hatteras Colony canals
- Waters in Rodanthe Drain area
- All waters in Spencer Creek
- All waters in Port Avon Canal
- and all waters in Pains Bay.

For a complete and up to date description of the closed shell fishing areas, please contact the Marine Fisheries division of the NCDEQ. The main contributors to the impairment of these waters have been identified as urban runoff, failing septic tank systems, and marinas.

Unincorporated Dare County, like many of the coastal areas and barrier islands in North Carolina have septic tank systems, not a municipal sewer system. Many of the coastal areas which still have septic tanks in use have very high fecal coliform counts in the surrounding estuarine waters.

4.5 Land Use

The unincorporated areas of Dare County primarily consist of federal conservation areas. Among these are the Alligator River National Wildlife Refuge, the Pea Island National Wildlife Refuge, and the Cape Hatteras National Seashore.

The unincorporated portions of Dare County that support predominantly residential and commercial properties are the villages of Colington, Rodanthe, Waves, Salvo, Avon, Buxton, Frisco, Hatteras, along with Roanoke Island, and the mainland. These residential and commercial properties mainly consist of impervious surfaces as a result of paved areas (e.g., roads, streets, parking lots, driveways, etc.) and structures (e.g., shopping centers, commercial buildings, houses, etc.). Vegetation, if present, varies and includes maintained lawns, maintained scrub areas along utility easements, or landscaped areas.

4.6 Effects on Water Quality

Stormwater runoff is rainfall or snowmelt that runs off the ground or impervious surfaces (buildings, roads, parking lots, etc.) and ultimately drains to surface waters including streams, ponds, lakes, estuaries, sounds, or the ocean. Most of the Dare County drainage system consists of swales along roads which collect stormwater runoff. There are also several catch basins with piped outfalls to the Sound.

The collection systems, although inadequate, primarily serve to address the water quantity problem but do not address the water quality problem of pollutant removal. Wetlands and vegetated areas perform the natural function of reducing the flow rate of stormwater runoff and allowing the pollutants to settle and filter through soils. This natural pollutant removal system by the environment helps to reduce the impact of man-made pollution on surface waters.

Land use dictates the type of pollutants that enter stormwater runoff and ultimately impact surface waters. First flush is the first portion of runoff from a storm and it usually contains the highest concentrations of pollutants. The land use within the service area affects water quality because of the associated pollutants. Table 4-1 shows the land use activities associated with pollutants.

Table 4-1 Stormwater Pollutants

Pollutant	Land Use Activity
Suspended solids and turbidity	• Plowing agricultural fields/gardens • Land clearing for development without proper sedimentation/erosion controls
Nutrients (chlorophyll, phosphorus, nitrogen)	• Fertilizer (nitrogen) application to lawns, golf courses, and crops
Fecal coliform	• Overuse or failure of septic tanks • Package plant malfunctions • Leaks in sewer lines • Waste from pets, domestic and wild animals
Oil and grease	• Leaky automobiles, industrial areas, illegal dumping
Toxic chemicals	• Automobiles, industrial areas, illegal dumping, pesticide application

4.7 Effects on Water Quantity

Stormwater runoff quantity problems occur in various locations throughout Dare County. These problems include:

- Flooding/ localized drainage problems,
- Soil erosion,
- Freshwater flow increase to estuaries/shellfish harvest areas, and
- Clogged pipes, culverts, and ditches caused by debris from flooded areas.

Development typically causes an increase in the volume and velocity of stormwater runoff that can result in environmental problems. Increased impervious surfaces reduce the opportunity for stormwater runoff to be naturally retained and filtered by vegetation, wetlands, and estuaries. Pipe culverts located under roads and driveways allow a ditch or channel to flow.

Major drainage problems observed on the island, discussed in Chapter 5, are a direct result of inadequate or altered flow paths and conveyances for runoff and increased runoff. Stormwater management will allow the County to effectively design, implement, construct, and manage stormwater controls to prevent environmental problems associated with the increasing amount of stormwater quantity.

4.8 Future Development

As outlined in the 2009 CAMA Dare County Land Use Plan, future development will focus on

residential and commercial development centered around existing village centers. The unincorporated areas of Dare County generally do not have access to a centralized wastewater treatment system and therefore soil suitability for septic tank systems will continue to be a factor in future development.

Table 4-2 illustrates the Dare County population data and the projections of the N.C. Office of State Budget and Management as of 2023. It is significant to note that this data includes all portions of the county, including municipalities. Population growth in these areas, seen in Table 4-3, is considerably higher than the growth of the county as a whole. Further, this indicates a lower countywide growth rate for the remaining unincorporated portions.

In 2010, the U.S. Census determined the year-round population of Dare County to be 33,920. The 2020 U.S. Census determined the year-round population of Dare County to be 36,915. With that data, the N.C. Office of State Budget and Management (OSBM) projected the 2030 population to be 41,583, an increase of 12.3% over 10 years. The OSBM has also projected a population increase of 11% during the period from 2030 through 2040.

Table 4-2 Dare County Population

2010 (Census)	2020 (Census)	2010-2020 % Growth	2030 (Projected)	2020-2030 % Growth (Projected)	2040 (Projected)	2030-2040 % Growth (Projected)
33,920	36,915	8.8%	41,583	12.3%	46,142	11%

Table 4-3 Incorporated Dare County Population Data

Municipality	2010 (Census)	2020 (Census)	% Growth 2010-2020
Duck	369	742	**101%**
Kill Devil Hills	6,683	7,656	**14.6%**
Kitty Hawk	3,272	3,708	**13.3%**
Manteo	1,434	1,602	**11.7%**
Nags Head	2,757	3,146	**14.1%**
Southern Shores	2,714	3,107	**14.5%**

Overall, this growth and development will cause an increase in overall imperviousness in developed areas of Dare County and an increase in number of individuals and structures potentially at risk during flooding events.

Chapter 5 - Drainage Problem Area Recommendations

5.1 Methodology

The project was broken down into five tasks. The initial task of this study was a field study of existing stormwater infrastructure. The second task was public participation. An online survey was developed to solicit input from community members on issues and potential areas of concern pertaining to stormwater and flooding. Additionally, two in-person charettes were held in Manteo and Buxton for interested citizens and meetings were held with stakeholders including representatives from environmental non-profits, NC Department of Transportation, Outer Banks Home Builders Association, and the Outer Banks Association of Realtors. The third task was hazard identification and modeling which included both field assessments and hydrologic and hydraulic modeling. Eight locations were selected for modeling to assess flooding risk and potential solutions. The models were developed using a combination of publicly available state data sets (i.e. LiDAR, SSURGO soils, orthoimagery, building layers). Rainfall depths for the 2-, 10-, and 100-year storms were taken from the NOAA Atlas 14. Storm events were modeled in conjunction with various tidal conditions including normal tides, 1 foot sea level rise, 80 cm sea level rise, and storm surge events.

These models were used to assess infrastructure, specifically buildings, for flooding risk. From these assessments, conceptual stormwater improvements were developed. Conceptual plans and costs were developed for two project areas.

5.1.1 Selection Criteria

During the selection of areas of concern for further modeling as well as the selection of areas for development of proposed recommendations, consideration was given to the source and extents of flooding as well as citizen input and concern addressed, if flooding remediation (such as post storm pumping) has been required in the past, county access/ownership, and long-term viability of solutions with anticipated future sea level rise. For areas of concern that were selected for further investigation, several criteria were evaluated to determine the most appropriate proposed solution for each area. The criteria which were evaluated were:

- Cost to Implement and Maintain
- Regulatory Requirements
- Effectiveness at Solving the Problem
- Acceptability to the County and the Public
- Longevity
- Site Suitability
- Environmental Impact

Cost to Implement and Maintain

The cost to implement and maintain each solution was evaluated and compared. Specific costs for each recommendation were not determined, but relative costs of potential solutions were

compared to determine the most cost-effective solutions.

Regulatory Requirements

Each solution was evaluated to determine if any special regulatory requirements would have to be met for implementation.

Effectiveness at Solving the Problem

Each recommended solution was selected for its effectiveness at solving the flooding problem. The recommended solution may only alleviate the problem in some storm events, not completely solve it, but the other criteria indicated that this solution was the most appropriate.

Acceptability to the County and the Public

Each solution was evaluated as to whether it would be an acceptable solution to the County and to the public.

Longevity

The longevity of each proposed solution was considered.

Site Suitability

Some solutions cannot be constructed in certain areas due to regulatory and/or physical site constraints.

Environmental Impact

Each recommendation was evaluated to determine if any positive or negative environmental impacts would occur due to implementation of the solution.

5.1.2 Field Assessment of Infrastructure

A field assessment was conducted in August of 2022 to identify existing infrastructure and potential areas of concern for further investigation. Field assessment consisted of driving all roadways in unincorporated Dare County and noting the presence of infrastructure, including culverts and collection system structures and pipes. General condition and notes of areas needing maintenance were also recorded.

Throughout the unincorporated County, piped stormwater collection systems were found to be minimal, with the majority of piped systems found in Hatteras Village or associated with parking lot drainage. Piped systems were typically found to be rather small networks with less than five connected inlets or structures. The majority of stormwater drainage in the county occurs through a system of swales and drainage canals. Swales are generally well established along NC-12 but the presence and condition of swales on secondary roads varies greatly. Field maps of inventory collected are provided in Appendix F.

The infrastructure identified in the field was incorporated, as appropriate, in the flood modeling produced in section 5.2.

5.1.3 Public Input

Public input on the update to the stormwater master plan was collected in three ways, in-person public meetings, an online survey, and stakeholder meetings.

There were two in person public meetings held, one in Buxton on Hatteras Island and one in Manteo, to provide opportunities for community members from all parts of the county to attend. There was a total of nine community members in attendance and some themes that arose included concerns about maintenance of swales and potentially blocked culverts, new construction raising lots for septic systems and causing flooding on adjacent properties, tidal and wind driven surge flooding from the sound, and ponding where stormwater infrastructure does not exist. Locations identified as of concern during the public meetings are mapped in Appendix G.

An online survey was offered for individuals who were unable to attend the in person public meetings. The survey received a total of 804 responses. Major areas of concern and key findings of the survey are listed below. Locations identified in the survey are mapped alongside the locations identified in the public meetings and full survey results can also be found in Appendix G.

- Respondents were asked to select the most significant flooding hazard from a list; sound side flooding was the most common with 34% of respondents selecting it as their most significant concern followed by 26% selecting poorly maintained or insufficient drainage infrastructure.
- 62% of respondents indicated that their residence or property has been subjected to flooding.
- When asked to indicate favorability towards different techniques of reducing flood risk improving maintenance, improving the existing storm drainage systems and installing new storm drainage systems were received favorably; elevating structures, modifying land development ordinances, and improving construction standards were received neutrally to positively; and implementing a stormwater utility fee for maintenance and infrastructure funding received the most mixed reactions.
- Common concerns raised in open-ended responses included ditch maintenance, new development, septic systems, and street flooding and ponding.

Stakeholder meetings were held with representatives from environmental non-profits, the Outer Banks Home Builders Association, and the Outer Banks Association of Realtors. A key concern raised in all stakeholder meetings was the importance of education and ongoing maintenance of existing systems. The Association of Realtors emphasized the importance of stormwater solutions on a community not individual basis, particularly with the limited new development left. The environmental non-profits would like to see additional requirements, including for water quality, but understand that would require a dedicated funding source, additional staff, and ordinances to implement. The Home Builders Association discussed the lack of a standard and the differences between jurisdictions throughout the Outer Banks. All stakeholders referenced Nags Head's program as a positive example if Dare County were to adopt stormwater regulations.

5.1.4 Spatially Varying 2D "Rain on Grid" Model

The United States Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) v. 6.3.1 was utilized for the hydrologic and hydraulic model. HEC-RAS was selected for its two-dimensional (2D) spatially varying precipitation, infiltration, runoff, and flow modeling capabilities. The 2D HEC-RAS model utilized seven (7) basic components: A terrain, precipitation data, a Manning's "n" layer, an infiltration layer, boundary conditions, a 2D mesh, and SA/2D connections.

Terrain

The HEC-RAS Terrain utilized in the simulation was a 3ft x 3ft (1-meter) DEM generated from 2019-2020 National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS) Topobathy LiDAR (1-meter resolution). Catch basins and junctions were "stamped" into the DEM to allow for water to enter the piped network system while accounting for structural storage volume within the network. Channels and ditches were "stamped" into the HEC-RAS Terrain in areas where brush and canopy cover obstructed the LiDAR along the channel bottom.

Precipitation

Rainfall data was input as SCS Type III unit rainfall hyetographs for the 2-, 10-, and 100-year, 24-hour storm events. Rainfall depths were obtained from NOAA Atlas 14 (See Appendix H.)

Manning's n Values

The Mannings's Equation is used within the HEC-RAS model to determine the velocity of surface flows over different land cover types. An important variable within the Manning's Equation is the Manning's n-value, a coefficient which represents the roughness or friction applied to the flow of water over a surface. In order to assign appropriate Manning's n-values, the National Land Cover Database (NLCD) was utilized to define varying land cover types.

A spatially varying land cover raster was generated from NLCD for each study area unique land use categories and were used to assign Manning's "n" roughness coefficients and impervious percentages can be seen in Table 5-1.

Table 5-1 Land Cover Characteristics

Classification	Manning's n	Impervious Percentage
Open Water	0.035	100%
Developed, Open Space	0.035	10%
Developed, Low Intensity	0.08	35%
Developed, Medium Intensity	0.12	65%
Developed, High Intensity	0.15	90%
Barren Land Rock-Sand-Clay	0.03	0%
Deciduous Forest	0.1	0%
Evergreen Forest	0.15	0%
Mixed Forest	0.12	0%
Shrub-Scrub	0.07	0%
Grassland-Herbaceous	0.04	0%
Pasture-Hay	0.045	0%
Cultivated Crops	0.05	0%
Woody Wetlands	0.07	50%
Emergent Herbaceous Wetlands	0.05	75%

Infiltration

The HEC-RAS model accounts infiltration of rainfall into in-situ soils by removing the anticipated infiltration volume from the rainfall volume applied to each cell of the HEC-RAS Terrain. The infiltration volume at any given location within the model is a component of land cover and underlying soil types. The infiltration layer was computed within HEC-RAS by intersecting the land cover layer with the SSURGO soils layer. Infiltration was calculated using the Green & Ampt method with Redistribution (GAR). Values for wetting suction front, saturated hydraulic conductivity, initial soil water content, saturated soil water content, residual soil water content, and pore size distribution index were approximated based on the soil textures obtained from the SSURGO soils layer. Parameter approximations were based on values published by Gowdish and Munoz-Carpena in 2009, Rawls and Brakensiek in 1982, and Rawls et al. in 1982. Table 5-2 below summarizes the values utilized within the HEC-RAS model. The land cover layer was utilized to assign impervious percentage to effect direct runoff across the site. Areas of impervious coverage as well as open water were modeled with a saturated hydraulic conductivity of 0.

Table 5-2 HEC-RAS Green & Ampt Infiltration Parameters

Dominant Texture	Wetting Suction Front (in)	Saturated Hydraulic Conductivity (in/hr)	Initial Soil Water Content	Saturated Soil Water Content	Residual Soil Water Content	Pore Size Distribution Index
No Data	0	0	0	0	0	0
Sand	2	4.64	0.033	0.417	0.02	0.694
Loam	3.5	0.26	0.117	0.436	0.027	0.252
Loamy Sand	2.4	1.18	0.055	0.402	0.035	0.553
Other	0	0	0	0	0	0

2D Computational Mesh

The 2D computational mesh, also known as the 2D flow area, is a network of interconnected cells used to represent the two-dimensional flow characteristics of the model area. Each cell and associated cell face of the computational mesh is pre-processed to compute detailed hydraulic property tables based on the underlying terrain. For each cell, the pre-processor computes an elevation vs. volume relationship. For each cell face, which can be thought of as detailed 1D cross sections, the pre-processor computes elevation vs. wetted perimeter, roughness, area, etc. The flow of water between each cell is controlled by these detailed hydraulic property tables which are used in calculating water surface elevation, depth, velocity, etc. This modeling technique is commonly referred to as a "subgrid model" and allows HEC-RAS to determine preferential flow paths in the underlying terrain and wet only a portion of the cell below the computed water surface elevation at that time step.

The "subgrid model" associated with the 2D computational mesh allows for detailed analysis of the model area where accurate overland flow pathways are paramount for model accuracy. In addition, breaklines, which allow for portions of higher cell resolution and specific directional orientation, were utilized to increase model resolution and accuracy. Breaklines were added to ditch centerlines, stream centerlines, stream banks, road crests, and significant topographic features. With this detailed information, the HEC-RAS model was a reasonable representation of the complex flow dynamics of coastal areas.

SA/2D Connections

SA/2D connections allow for storage areas and 2D flow areas to be hydraulically linked in various combinations. These links are represented by several types of hydraulic structures including weirs, gates, culverts, and rating curves. SA/2D connections can also be placed within a 2D flow area to control flow between one cell to another. For example, an SA/2D connection can be used to represent a roadway as an irregular weir, with station and elevation data pulled along the centerline using the specified terrain surface, and a culvert to control flow of water from one side of the road to the other.

SA/2D connections were used to model portions of stormwater infrastructure identified during the field investigation. Road crossing culverts and stormwater network were modeled. Driveway culverts were not modeled in order to reduce processing time due to the large number of SA/2D connections that would be dedicated to driveway culverts which are of lesser concern compared

to storm networks and roadway culverts and their potential impacts when inundated. Where no invert information was known, the upstream and downstream invert were set based on the terrain surface.

Where catch basins and junctions were "stamped" into the surface, SA/2D connections were placed at their midpoint and set with a culvert to represent a stormwater network. Additionally, inlet and outlet loss coefficients were set to 0.5 and 0.1 but tweaked to reduce model instability where necessary.

The HEC-RAS model performed 2D unsteady flow routing utilizing the Shallow Water Equations Eulerian-Lagrangian Method (SWE-ELM). The SWE-ELM was the selected equation set to account for the exceptionally flat terrain across the town, as well as the presence of buildings within the flow paths. The computational time step was varied between 10-second and 30-second in order to maintain numerical accuracy and model stability while avoiding excessive computation time.

Boundary Conditions

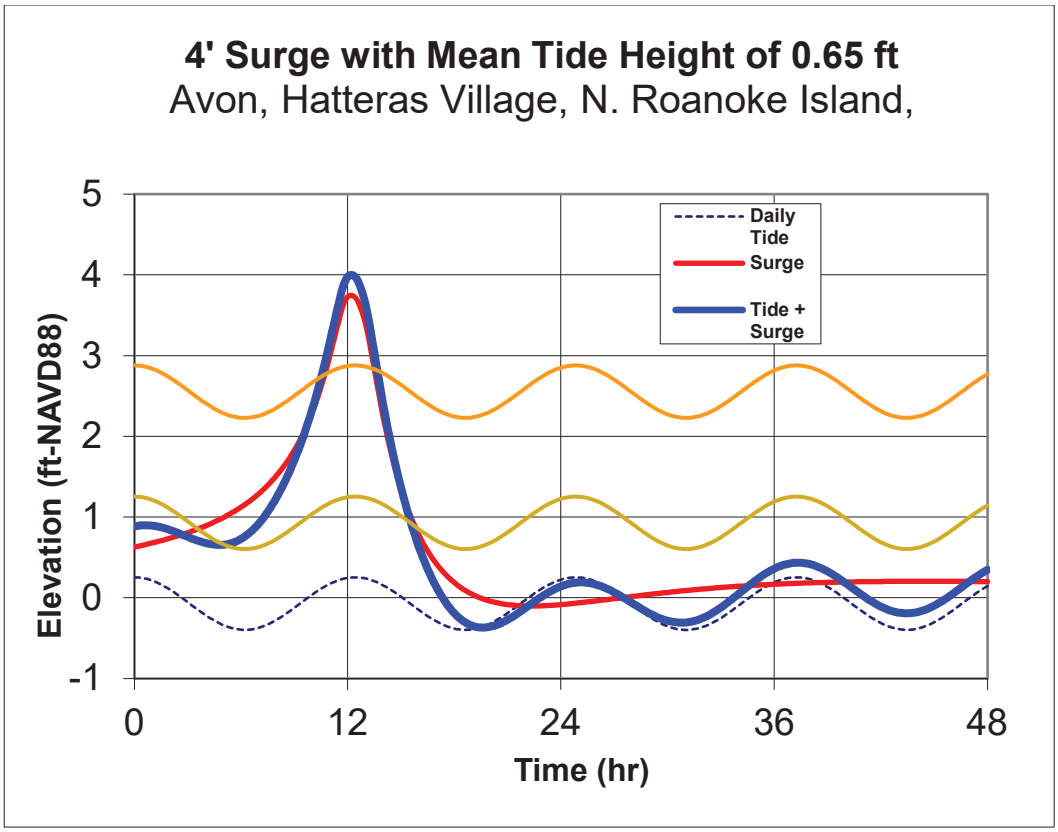
Boundary conditions represent locations in the model where water can flow in or out. HEC-RAS allows a boundary condition to be applied externally (along 2D flow area perimeter), internally (within the 2D flow area), or globally (applied to the entire 2D flow area). There are several boundary condition options that can be applied depending on the type used including flow hydrograph, stage hydrograph, normal depth, rating curve, and precipitation.

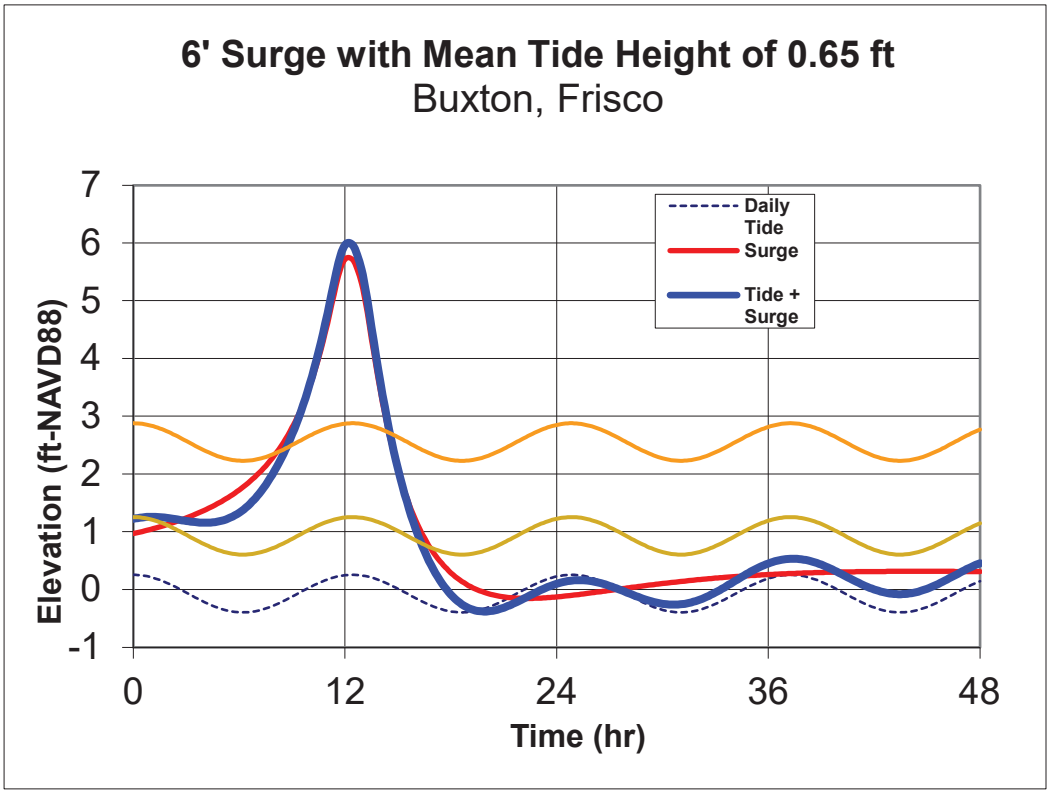
The following boundary conditions were used in the 2D HEC-RAS models:

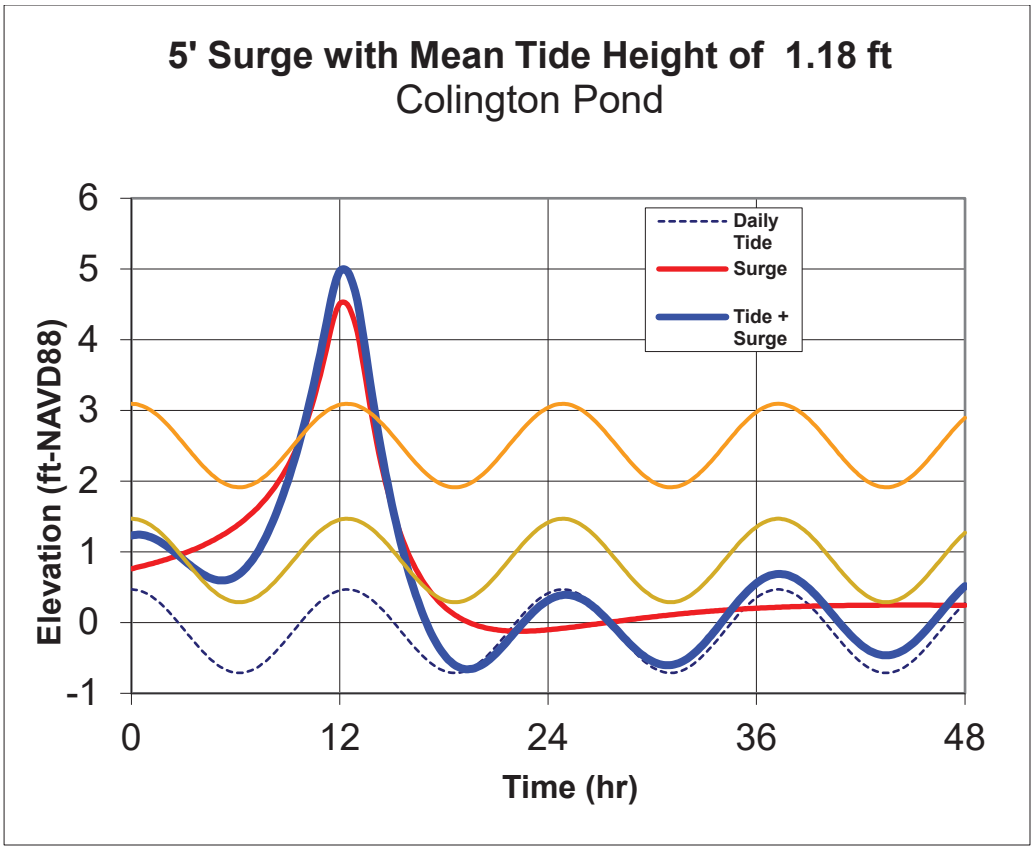
- Upstream Boundary Conditions:
  - Rainfall over model area → Precipitation
- Downstream Boundary Conditions
  - Sound → Stage Hydrograph

Precipitation was applied over the full model areas and the model areas were selected to cover the full drainage area so no additional inflow hydrographs were required for the upstream boundary conditions.

Stage hydrographs were utilized for the downstream boundary conditions along the Sound. Four different stage hydrographs were used to model different scenarios. The first was current tidal conditions. Tidal information from NOAA Tides & Currents Stations at Oregon Inlet and USCG Station Hatteras was used. The tide was approximated with a cosine wave function and shifted to cause the peak of rainfall and peak of tide to coincide. Scenarios to represent 1 foot and 80 cm sea level rise were also modeled, these were approximated by adding 1 ft and 80 cm respectively to the current tide stage hydrograph. The final downstream boundary hydrograph modeled was a storm surge with tide condition. This was approximated with a cosine wave function with a longer wave length to generate only one peak during the model event. The peak surge was set to the flood elevation on the FEMA FIRM panels and shifted to peak at the same time as the precipitation. See the figures below for the stage hydrographs used and Appendix H for tide station information and FIRM panels.


4' Surge with Mean Tide Height of 0.65 ft
Avon, Hatteras Village, N. Roanoke Island,
Elevation (ft-NAVD88)
5
4
3
2
1
0
-1
0
12
24
36
48
Time (hr)
Daily Tide
Surge
Tide + Surge


6' Surge with Mean Tide Height of 0.65 ft
Buxton, Frisco
Elevation (ft-NAVD88)
7
6
5
4
3
2
1
0
-1
0
12
24
36
48
Time (hr)
Daily Tide
Surge
Tide + Surge



Inundation Results

Rasters of maximum flood depth were produced for each model and each scenario to evaluate the inundation impacts. Existing condition flooding depth maps for the modeled areas of North Roanoke Island, Wanchese, Colington Pond, Rodanthe, Avon, Buxton, Frisco, and Hatteras Village can be found in Appendix I. Proposed condition flooding depth maps for the modeled areas of North Roanoke Island, Colington Pond, and Avon can be found in Appendix J.

5.2 Evaluations and Recommendations

Flooding is the primary stormwater problem within Dare County. The following sections provide an explanation of the potential flooding areas of concern in the communities of unincorporated Dare County, and recommendations for improvements. This plan primarily focused on current and near-term stormwater issues at a neighborhood level. Long term impacts and solutions to NC 12 overwash events on Hatteras Island were considered by the NC 12 Task Force. Documents related to their work can be found at https://www.darenc.gov/government/advisory-boards-and-committees/n-c-12-task-force .

5.2.1 Potential Areas of Concern

Mainland

Dare County includes the mainland communities of Manns Harbor, Mashoes, East Lake and Stumpy Point. Stormwater runoff in these areas is conveyed mostly by drainage swales and

channels with driveway and roadway culverts as necessary. Field inspections of stormwater infrastructure completed as part of this Stormwater Master Plan update indicated that the drainage swales were observed to be in varying levels of condition. Several swales were observed to be silted in or contained debris that may impede flow and reduce efficiency. Many of the swales were inundated, an indication of the high-water table present in this area. Attention to continued routine maintenance is recommended.

In the public survey, flooding along 64 in Manns Harbor and one location in Stumpy Point were identified but no other hot spots of flooding concern were identified. Following review of the public survey results, discussions with County staff, and field inspections, the identified flooding concern areas appear to be related to maintenance items (clearing culverts, dredging swales, etc.), significant storm and wind events causing elevated Sound levels, and high water table. No additional assessment was conducted for these areas. Future studies could include a hydraulic assessment of swales in identified problem areas to confirm sizing and conveyance capacity.

North Roanoke Island

The north end of Roanoke Island, outside of Manteo, is part of unincorporated Dare County. In both the public survey and meeting session, several areas immediately north and northwest of the Dare County Regional Airport were identified as flooding hot spots. In the public survey, several roads were identified as having flood related issues including Airport Road, Bradford Lane, Brakewood Road, Candela Drive, Daphne Lane, Dogwood Trail, Holly Ridge Road, Langley Lane, Old County Road, and Roanoke Trail. However, Brakewood Road and Airport Road received the most input by residents. In the public meeting session, residents in attendance identified the same roadways and adjacent neighborhoods as the public survey with Steve Basnight Road as an additional area of flood related issues. In addition, three (3) residents in the Bradford Lane and Brakewood Road neighborhood expressed their concern over rainfall-based flooding, including one resident with excessive flooding impacting her home during large rainfall events.

The field assessment identified limited piped systems, mainly near incorporated Manteo and Airport Road, with most of conveyance in the north end of Roanoke Island provided by drainage ditches and culverts. Sedimentation within drainage ditches and culverts were identified across all areas and was especially evident in the Brakewood-Airport Road area. In addition, the topography of the Brakewood-Airport Road and Steve Basnight Road areas are characterized by a natural depression (low topographic area) with no natural relief besides infiltration. The overall area northwest of the airport drains to the sound via a large drainage canal located on airport property. Infiltration is heavily relied on for drainage but can be limited during periods of heavy rainfall and saturated soil conditions. Based on the topography, it is evident that the natural sinks and low-lying areas without any drainage relief were responsible for many of the flooding concerns in the area.

Wanchese

Wanchese is located on the southern end of Roanoke Island. In the public meeting session, wind tides were identified as a flooding source in Wanchese. In the public survey, several areas across Wanchese were identified as having flooding concerns including Old Wharf Road, Old Schoolhouse Road, and ER Daniels Road. The field assessment identified some traditional stormwater infrastructure (i.e. inlets and pipes) with most conveyance provided by roadside

ditches and culverts that discharge to larger drainage canals towards the sound. While drainage ditches are prevalent along many roadways across Wanchese, a lack of drainage ditches was noted for multiple roadways along certain sections or the entire length of road.

Sedimentation within drainage ditches and culverts were identified across Wanchese. Infiltration is heavily relied on for drainage but can be limited during periods of heavy rainfall and saturated soil conditions. In addition, several residents along Pine Acres Road provided input on historical flooding issues along the road and adjacent properties during field assessment of this area.

Baum Bay Harbor

Baum Bay Harbor is a residential area located on the northern beach area of Dare County, just west of the Wright Brothers National Memorial. Drainage for the majority of this area consists of sheet flow to the southwest towards Baum Bay. In the public survey there were two resident complaints in the area, Colington Creek Dr and Ocean Bay Blvd. Field inspections of stormwater infrastructure indicated that minimal stormwater infrastructure is present in this area. A few drainage swales were observed, most of which were inundated, and based on topographic information they appear to be tidally influenced. Following review of the public survey results, field inspections, and discussions with County staff, no additional assessment was conducted for this area. Future studies could include a hydraulic assessment of swales in identified problem areas to confirm sizing and conveyance capacity.

Colington Road

Colington Road connects Colington to Kill Devil Hills behind the Wright Brothers National Memorial. Colington Road is the single access to Colington and the Colington Harbour neighborhood. In both the public input meetings and survey, Colington Road was a common area of concern for both tidal and rainfall flooding. However, at the time of the field investigation activities and public input collection, improvements to Colington Road were underway by NCDOT. These improvements included raising portions of the roadway, new pavement, expanded shoulders, and improved roadside swales. It is expected that these improvements should improve issues of swale capacity and tidal inundation identified in the public survey. With the active project, further modelling and investigation of the area was not undergone. During the field investigation it was observed that not all roads immediately tributary to Colington Rd. had drainage swales. Establishing swales along these roadways that tie to the newly improved swales along Colington Rd may mitigate localized flooding by providing additional positive drainage.

Colington Pond

Colington Pond, also known as Colony Lake, is a small body of water surrounded by homes and bounded by Kitty Hawk Bay Dr, Colony Ln, and Harbour Rd in the Colington Harbour neighborhood. The pond was identified as a flooding concern during the public input meetings as well as by county staff. In field investigation an outlet could not be located and in discussion with county staff it has been concluded that the outlet has been fully silted in and is nonfunctional as emergency pumping has been required to drain the pond immediately following past major flooding events. In its current condition, the only means for stormwater to drain from the pond is for water elevations within the pond to exceed that of Kitty Hawk Bay Dr., at which time flows cross over the road and discharge into Kitty Hawk Bay via the public access lot across the street.

Due to the several resident complaints concerning flooding in this area and following discussions with County staff, Colington Pond was flagged for additional analysis to assess potential flood mitigation improvements.

Martins Point

Martins Point is a private community located at the east end of Wright Memorial Bridge on a peninsula between the sound and Jean Guite Creek. Lots located around the perimeter of the peninsula appear to drain via sheet flow into either the surrounding sound or creek. Interior lots drain towards the roads or one of three interior ponds.

In the online survey the area around Martins Point Rd and Creek Rd received 11 resident complaints. From field observation it appears that many of the conveyance swales located along the interior roadways have been filled in over time. Homeowner education and increased maintenance is recommended for this area. The outfalls for the interior ponds appear to be directly influenced by tidal activity.

Rodanthe

Rodanthe is the first village located south of Oregon Inlet on Hatteras Island. During field assessment, roadway swales and culverts were observed along NC 12 which serve to collect runoff from the western edge of Rodanthe and direct it to the southwest into the sound. The majority of Rodanthe drains via a channel known as North Drain that runs north to south through the residential areas to the east of NC 12 before crossing under the highway through dual CMP culverts and discharging to the sound just north of S Shore Dr. The channel appears to have been filled between Beulah O'Neal Dr and N Holiday Blvd with no piped alternative flow route apparent during the field investigation.

At the public meeting, the north drain was identified as a flooding hot spot in Rodanthe due to potentially blocked culverts at Sea Sound Rd and Sudie Payne Rd. Fifteen areas of flooding concern were identified throughout Rodanthe in the online survey. However, there was not one clear hot spot but rather each area received 1-3 complaints indicating issues of shallow flooding or standing water throughout the village. Due to the feedback received about flooding concerns in Rodanthe, this area was chosen for additional modeling and assessment.

Waves & Salvo

Waves and Salvo complete the tri-villages immediately south of the Oregon Inlet on Hatteras Island with Waves being located south of Rodanthe and Salvo south of Waves. In the public meetings several areas throughout Waves and Salvos were identified as having swales with insufficient capacity that flooded during rainfall events. The online survey identified 18 potential areas of flooding concern with one clear hot spot located at the Wind Over Waves subdivision. The Wind Over Waves subdivision received 18 resident complaints and 4 non-resident complaints. These complaints were limited to nuisance lot flooding along Otter Way and N Sand Dollar Ct within the Wind Over Waves subdivision. The subdivision is not currently fully built-out as several lots are still vacant. Several roadside swales were observed along the developed lots but an ultimate outfall was not observed. In addition, a retention pond appears to have been installed at the southern end of the development but no outlet was observed during the field inspection. WithersRavenel recommends the County monitor future buildout of this subdivision and its implications on nuisance flooding in the vicinity.

After discussion with County staff, Waves and Salvo Village were not selected for further modeling or investigation.

Avon

Avon is located south of Salvo on Hatteras Island.

Review of topographic information and field inspections indicated that the drainage system in Avon is primarily comprised of roadside swales and driveway cross pipes. There is a stormwater network consisting of curb and gutter, catch basins and pipes within the Hatteras Island Plazas shopping center off of NC 12 just south of Kinnakeet Blvd. Avon is comprised of essentially three (3) drainage areas. The northern portion of Avon (north of Harbor Rd) drains to either NC 12 or one of two parallel south to north channels, all of which ultimately discharge into Mill Creek. The mid portion of Avon (between Harbor Rd and Big Kinnakeet Dr.) drains to NC 12 and/or a north to southwest channel that discharges into the sound just south of Williams Rd. The southern portion of Avon (south of Big Kinnakeet Dr.) drains to the west/southwest. Areas to the west of NC 12 drain via several retention ponds through the low-lying natural areas to the sound while the residential areas to the east of NC 12 drain to roadsides swales along NC 12. These roadside swales flow north to south and ultimately discharge into drainage channel via a culvert under Pheasant Cir. that drains to the sound via Askins Creek.

The public survey identified several areas of concern within Avon including two hot spot locations: Ocean View Drive with 13 resident and 21 non-resident complaints and the Kinnakeet Shores entrance with 11 resident and 15 non-resident complaints.

Review of the complaints and discussion with County staff indicated that the complaints associated with the Kinnakeet Shores entrance were likely related to a low-lying grate inlet on the west side of NC 12 immediately north of Kinnakeet Blvd. Field inspections indicated that this grate is silted in with little to no conveyance capacity at the time of the site visit. In addition, the grate inlet is depressed when compared to the surrounding roadway and intersection causing it to pond a significant depth of water (>1') immediately over the grate following a rain event. Furthermore, the ponding water obscures the significance of the depression around the grate. Since this identified area of flooding appears to be related to maintenance issues associated with a roadway and inlet maintained by NCDOT, no additional assessment was conducted. It is recommended that the County contact NCDOT and request that they investigate a solution to mitigate the above-described issues.

Review of the complaints and discussion with County staff indicated that the complaints associated with Ocean View Dr were related to standing water within Ocean View Dr roadway and adjacent residential lots following rain events. No drainage infrastructure (i.e., roadside swales) are present along Ocean View Dr Topographic information indicates that the centerline of Ocean View Dr is at a slightly higher elevation compared to the adjacent lots on either side of the roadway. While the residential lots on the west side of Ocean View Dr. appear to be sloped to the west, allowing them drain towards the roadside swales along NC 12, the residential lots along the east side of the Ocean View Dr have no means of positive surface drainage, resulting in ponding of runoff within the north bound lane of Ocean View Dr. and the front of the residential lots.

Since Ocean View Dr was identified as an area of flooding that impacts a road and potentially restricts access to residential lots following a storm event, this area was selected as an Area of Concern. Additional assessment and modeling was conducted to assess the feasibility of potential mitigation options.

Buxton

The village of Buxton is located south of Avon. . The field assessment identified some isolated inlets and outfall pipes as well as swales along NC 12. Evidence of frequent ocean over wash in the form of sand build up was present from Old Lighthouse Road towards the dunes.

In the public meeting session, concern of storm surge from the ocean and rainfall flooding near NC Highway 12 and Rocky Rollinson Road were raised. The online survey identified 8 potential areas of concern primarily clustered around the area fronting the ocean. The Buxton motels received the most complaints with 3 resident and 6 non-resident complaints and the area directly south of the motels received 1 - 3 resident complaints about each street. It was found that in this area, any roadside swales that may have once existed were filled in and the only drainage was a swale system on the west side of old lighthouse road with one cross drainage pipe. The majority of runoff in this area must run across the road to drain to the swales and with the flat topography of the area much of it ends up ponding in shallow depressions and being unable to drain. Additional investigation and modeling of the Old Lighthouse Road area was conducted.

Frisco

Frisco is located towards the southern end of Hatteras Island and is situated between Hatteras Village and Buxton. Frisco is more spread out and less concentrated than some of the other villages, the areas with greatest density are Brigands Bay on the sound and the western most part of the village with access to the beach.

In the public input collection process two areas experiencing flooding due to tides or a combination of tides and rainfall were identified during the public meetings. Through the online survey, 15 potential areas of concern were identified in Frisco. There was not one clear hot spot location as all areas received just 1 - 2 complaints.

Through the field assessment, culverts under NC 12, Hatteras Drive, and Runboat Circle were identified and the roadside swales along NC 12 were found to be in generally good condition. As a result of the concentration of residences and flooding areas of concern the western part of Frisco was selected for additional assessment and modeling.

Hatteras Village

Hatteras Village is the southernmost village on Hatteras Island. In the public input meetings several locations of flooding, including locations that have flooded in past hurricane events and areas that have flooding from the dunes, were identified. In the online survey, twelve flooding areas of concern were identified with two hot spot locations at NC12 at the Sea Gull Motel and Eagle Pass Road. In the field investigation, a piped conveyance system was observed in several areas along NC 12, although outfalls for the conveyance system were not always able to be located. According to residents, storm drainage network along NC-12 is tidally influenced. Through the center of Hatteras Village, connecting to the sound on both the east and west sides of town, a waterway known as the Slash, cuts under NC-12 and between NC-12 and Eagle Pass Rd. The Slash and overall low-lying topography makes Hatteras Village especially susceptible to

tidal flooding and future sea level rise. As a result of the concentration of residences and flooding areas of concern, Hatteras Village was selected for additional assessment and modeling.

5.2.2 Selected Areas of Concern

Based on discussions above the following areas were selected for additional analysis, modeling, and/or review of potential mitigation improvements. Table 5-3 summarizes each location, the stormwater problem occurring there and the recommended action to address the problem. Detailed discussion of each area follows.

Table 5-3 Summary of Recommendations

Location	Problem Description	Recommended Action
North Roanoke Island	Ponding	Installation of Storm Drainage Network, Swales, and Culverts
Wanchese	Ponding	Swale Maintenance/Enhancement
Colington Pond	Abandoned/blocked outlet	Installation of Pond Outfall
Rodanthe	Ponding/Altered Drainage Channel	Re-Establish North Drain Connectivity
Avon – Ocean View Drive	Ponding	Installation of Infiltration Trenches and Swales
Buxton – Old Lighthouse Rd	Ponding	Installation of Infiltration Trenches, Culverts and Storm Drainage Network
Frisco	Ponding	Culverts and Swale maintenance/enhancement
Hatteras Village	Ponding	Installation of Detention Swales

North Roanoke Island

The residential areas immediately north and west of the Dare County Regional Airport was modeled from US Route 64 to the outfall southwest of the airport, including Brakewood Road, Airport Road, and Steve Basnight Road. From a review of the existing topography, it was evident that large low areas without clear paths of drainage were responsible for many of the flooding concerns in the area. In the 2-year storm event, the existing conditions model shows flood depths of approximately 0.5-feet to 1.5-feet in several low-lying areas including at the end of Bradford Lane with approximately 0.25-feet to 0.9-feet of flood depth to at least ten (10) residential structures. Bradford Lane does not experience flood impacts but several areas along Brakewood Road experience approximately 0.1-feet to 0.7-feet across all travel lanes. In the area of Steve Basnight Road, flood depths of approximately 0.1-feet to 2.0-feet are experienced at the low point near the end of the cul-de-sac with approximately 0.1-feet to 0.3-feet of flood depth to at least four (4) residential structures. This area also experiences minor ponding of 0.1-feet to 0.2-feet across all travel lanes of Steve Basnight Road near the end of the cul-de-sac. Several other roads and adjacent areas experience minor flooding including Airport Road, Daphene Lane, Dogwood Trail, and Fearing Place. Flooding in the overall area of concern is widespread with Brakewood Road, Bradford Lane, and Steve Basnight Road experiencing the greatest impacts. Many of the drainage ditches appear to have sedimentation and lack positive

drainage in some areas which much of the flooding issues can be attributed to. Flooding issues are exacerbated in the 10 year and 100-year storm events with increased impacts to roadways and property owners.

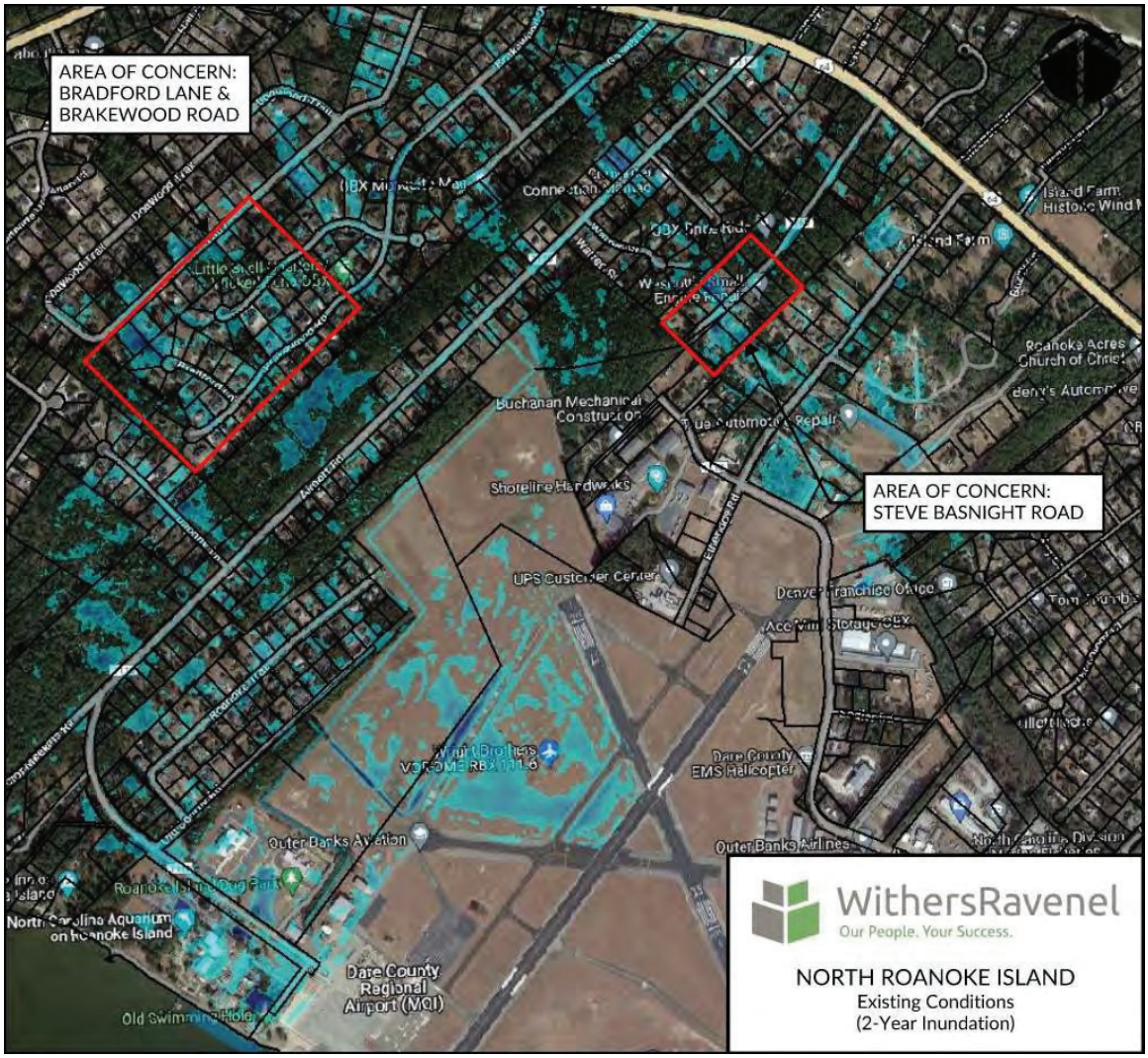


Figure 2 – North Roanoke Island Existing Condition 2 Year Inundation

Based on the existing conditions model, Brakewood Road, Bradford Lane, and Steve Basnight Road were identified as areas with the greatest flooding concern due to their locations in natural depressions without effective means of drainage relief. After review of the model results, public feedback received, and discussions with County staff, these areas were selected for further evaluation of conceptual stormwater improvements to reduce flood impacts.

A Roanoke Island Flooding Analysis completed by others for this overall area in September 2019 proposed a multi-phased approach for reducing flood impacts (see Appendix K for excerpts of the Roanoke Study). The phases consist of upsizing a series of stormwater pipes and culverts at the downstream end of the study area where it discharges into the sound (Phase 1), upsizing and dredging the existing drainage canal located on airport property and extending it upstream to Airport Road to tie into the existing Airport Road drainage network (Phase 2), and a series of

adjacent stormwater improvements in surrounding neighborhoods to convey runoff to the expanded drainage ditch and downstream network (Phase 3). However, the proposed improvements do not consider a proposed development located in the "Evans Tract" which consists of a large undeveloped parcel located between Brakewood Road and Airport Road that would be subdivided into a single-family residential parcels (see Appendix K for Evans Tract Construction Drawings). Phase 3 of their proposed improvement assumes this undeveloped area can be utilized for routing stormwater runoff for temporary detention before discharging downstream to the drainage canal. In addition, the existing drainage network located along Airport Road and adjacent roadways appears to have excessive sedimentation and reduced conveyance capacity which limits the ability to tie-in proposed stormwater improvements without clearing deposited sediment. Therefore, for the purposes of modeling proposed stormwater improvements for Brakewood Road, Bradford Lane, and Steve Basnight Road, only Phases 1 and 2 of the Roanoke Study proposed improvement were incorporated into the model.

The Steve Basnight Road proposed improvement consists of a drainage ditch on private property, culvert, roadside ditch, and associated driveway culverts to collect runoff at the low point adjacent to 155 Steve Basnight Road and convey it downstream. In addition, a proposed 30" HDPE would provide conveyance from the end of the cul-de-sac into airport property and drain via a proposed drainage canal that will tie into the proposed drainage canal associated with Phase 2 of the Roanoke Study improvements. A drainage easement would be required for the drainage ditch located on 155 Steve Basnight Road along the edge of the property.

The Bradford Lane and Brakewood Road, proposed improvements consist of a piped stormwater network with some roadside ditches to collect runoff at the end of Bradford Lane where the low point is located and convey it downstream along Brakewood Road. The proposed network would tie into the proposed Evans Tract stormwater network then continue through Airport Road and tie into the proposed drainage canal associated with Phase 2 of the Roanoke Study improvements. Inlet structures are placed through the proposed trunkline and associated laterals to collect runoff at multiple low points on Bradford Lane, Brakewood Road, and Airport Road. This improvement evaluated 2 proposed alignments (Option A and Option B) to tie-into the stormwater network associated with Evans Tract. Both options would require a drainage easement through a currently undeveloped lot located along Brakewood Road and along the backs of lots of adjacent Evans Tract parcels to tie into the Evans Tract stormwater network. However, Option A ties into the airport drainage canal via existing right-of-way while Option B would require an additional drainage easement through 218 Airport Road along the edge of the property. Proposed concept plans for the described improvements can be found in Appendix L.

In the 2-year storm event, Steve Basnight Road shows a significant improvement from existing conditions with approximately 0.1-feet to 1.0-feet of flooding at the low point. The number of residential structures impacted by flooding at the peak of the storm is reduced from four (4) to one (1) with approximately 0.1-feet of flood depth. Flooding is reduced on Steve Basnight Road with only the travel line edges experiencing minor ponding of approximately 0.1-feet. In addition, residual flooding 6-hours post storm event is almost entirely reduced with some shallow ponding in grassy areas and no impacts to structures or the roadway. In comparison, existing conditions still experience considerable residual flooding due to the lack of conveyance with continued impacts to residential structures and the roadway 6-hours post storm event.

Bradford Lane and Brakewood Road also shows improvement from existing conditions with approximately 0.1-feet to 1.2-feet of flooding in low lying areas. The number of residential structures impacted by flooding at the peak of the storm is at least ten (10) which matches existing conditions; flood depths are approximately 0.1-feet to 0.7-feet which is a slight reduction from existing conditions. Flooding is also reduced on Brakewood Road with only one small area near the end of the cul-de-sac experiencing approximately 0.1-feet to 0.5-feet of flooding with some shallow flooding across portions of both travel lanes. While proposed improvement benefits seem marginal during the peak of the storm, there is considerable improvement 6-hours post storm event as residual flooding is drastically reduced with no flooding of Brakewood Road and only two (2) properties experiencing residential structure flooding. In comparison, existing conditions still experience considerable residual flooding due to the lack of conveyance with continued impacts to residential structures and Brakewood Road 6-hours post storm event.

Proposed concept plans for the described improvements can be found in Appendix L. Based on the above proposed improvements, a budgetary cost opinion was prepared. Total construction costs, including final engineering, permitting, and construction phases services are estimated to be $7.81 million for Option A and $7.78 million for Option B. Budgetary cost opinion breakdowns can be found in Appendix L.

Wanchese

The developed area of Wanchese near the intersection of Baumtown Rd and NC Highway 345 to the southern limits of the island was modeled. Based on public feedback by multiple residents identifying Pine Acres Rd and Old Schoolhouse Rd as areas of concern, model assessment focused on north central Wanchese, specifically in the area bounded by Old Wharf Road, Old Schoolhouse Road, and Mill Landing Road. This area of interest encompasses its own drainage area within Wanchese with the Fire Station along Old Schoolhouse Road located at the headwaters and Mill Landing Road at the downstream end. Based on the existing topography, there are a series of shallow drainage ditches located on several private properties between Old Schoolhouse Road and Mill Landing Road that convey runoff towards Mill Landing Road. Due to their location on private property and thick brush, physical observation was unable to be conducted. Based on the field assessment and publicly available data, there are two (2) culverts located along Mill Landing Road that provide conveyance for this drainage area to the sound.

In the 2-year storm event, the existing conditions model indicates nuisance flooding on private property including some shallow flooding adjacent to structures along Pine Acres Rd (approximately 0.1-feet to 0.75-feet) and Old Schoolhouse Road (approximately 0.1-feet to 0.2 -feet) with shallow ponding of approximately 0.1-feet to 0.3’ along the edge of travel lanes of both roads. In addition, a portion of Old Schoolhouse Road adjacent to the Wanchese Community Building experiences ponding across all travel lanes of approximately 0.1-feet to 0.4-feet in the 2-year storm event. Flooding issues are exacerbated in the 10-year and 100-year storm events with increased impacts to roadways and property owners. Based on the DEM used in the 2D model, many of the ditches in the area of interest appear to have sedimentation and lack positive drainage in some areas which much of the flooding issues for the higher frequency storm events (2 year and 10 year) can be attributed to.

After review of the model results, WithersRavenel recommends that all drainage ditches be cleared of excess sediment and maintained to reduce excess ponding along roadways and adjacent properties and ensure positive drainage. The construction and maintenance of new drainage ditches is also recommended along roadways without a ditch or other stormwater infrastructure to provide a means of conveyance away from roadways and adjacent properties. In addition, WithersRavenel recommends an assessment of feasibility for obtaining drainage easements for the series of shallow drainage ditches located on private property between Old Schoolhouse Road and Mill Landing Road due to their importance in providing downstream conveyance for the Old Schoolhouse Road area, including the Volunteer Fire Department and Wanchese Community Building.

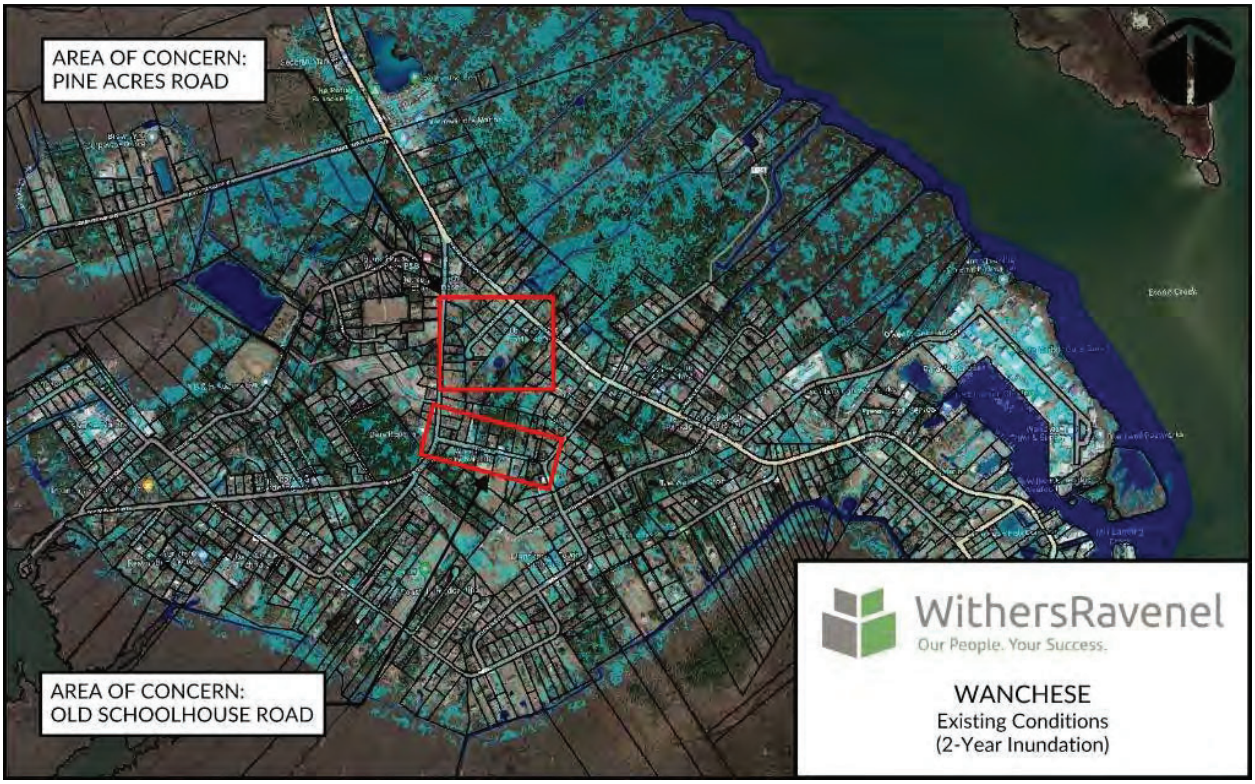


Figure 3 -Wanchese Existing Conditions 2-Year Inundation

Colington Pond

Flooding associated with Colington Pond was modeled from the high points of the pond drainage area to the ultimate discharge location into Kitty Hawk Bay. Flooding of the homes directly adjacent to the pond is demonstrated in the model even during higher frequency storm events (2-year) with flooding further exacerbated in the 10-year and 100-year storm events.

Figure 4 – Colington Pond Existing Conditions 2-Year Inundation

After review of the model results, WithersRavenel recommends that a primary spillway be installed that allows the pond to discharge into the sound without overtopping Kitty Hawk Bay Dr. Under current conditions, the only means of draining the pond is infiltration. During a storm event, water surface levels in the pond increase until Kitty Hawk Bay Dr. overtops. This

overtopping elevation controls flows out of the pond and results in water elevations that impact properties on the upstream side of the pond as show in the figure above.

The proposed primary spillway would consist of a riser structure (i.e., 4'x4' interior dimensioned concrete box) and an 18" outlet barrel. The outlet barrel would cross Kitty Hawk Bay Dr. perpendicularly, run along the right-of-way and then down the west side of the public access property to discharge into Kitty Hawk Bar as shown below:

Figure 5 – Colington Pond Conceptual Layout

Analysis of the proposed improvements indicate that the addition of a primary spillway will reduce flooding on approximately 18 residential lots and reduce the frequency at which Kitty Hawk Bay Dr overtops due to elevated water surface elevations within the pond.

Rodanthe

Flooding in Rodanthe was modeled from the dunes along the eastern edge to the sound and from the NC 12's Jug Handle Bridge south to Camp Hatteras RV Resort and Campground.

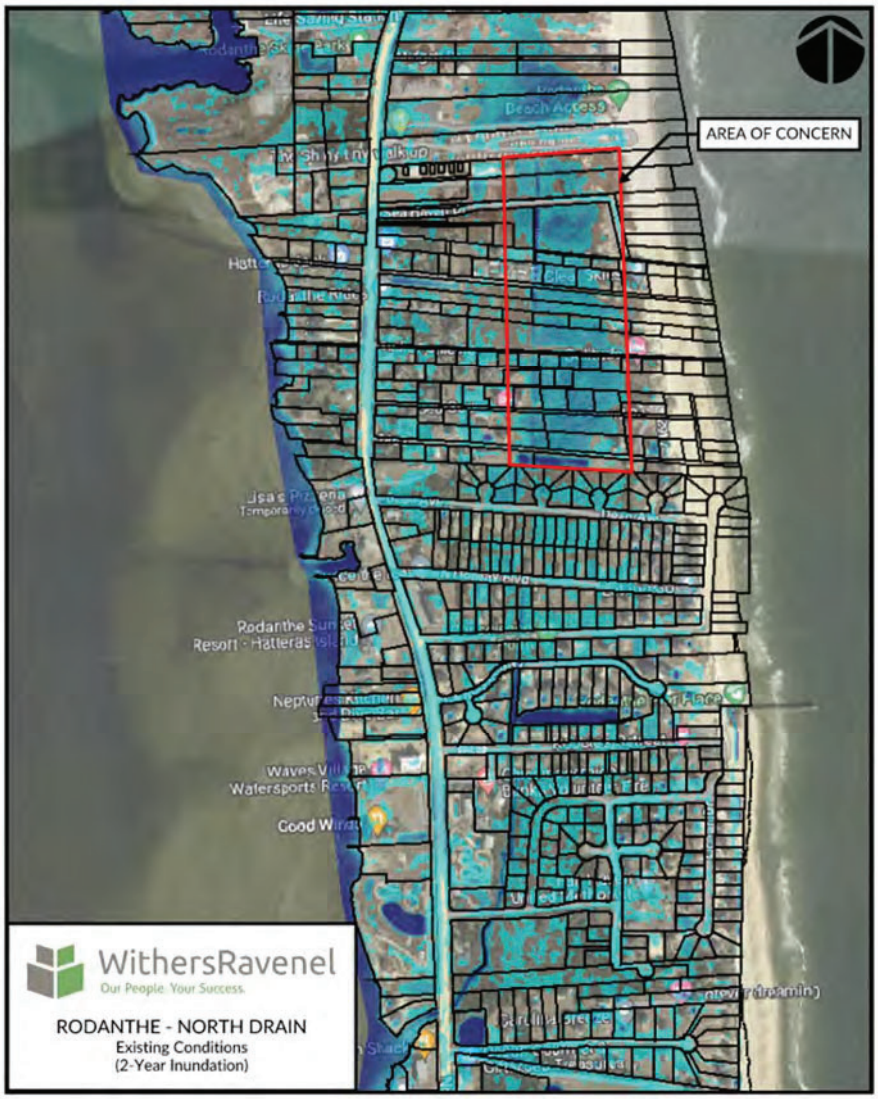


Figure 6 – Rodanthe North Drain Existing Conditions 2-Year Inundation

Review of the model results and public feedback received together with the discussions with County staff indicate that the North Drain is the primary drainage feature of concern within Rodanthe. Model results indicate that ponding is typical in the low-lying areas adjacent to the North Drain channel, especially in the areas upstream of Beulah O'Neal Dr.

As discussed above, it appears that the North Drain channel has been historically filled in the process of creating residential lots along both sides of Dean Ave and the north side of N Holiday Blvd. A retention pond has been installed along the south side of Beulah O'Neal Dr. at the northern end of the filled in portion of the North Drain as a means to provide additional storage. However, this pond, and the associated upstream drainage area have no means to positively drain other than infiltration.

WithersRavenel recommends that the County investigate the feasibility of purchasing property or establishing permanent drainage easements that allow for the northern portion of the North Drain channel to be reconnected hydraulically to the sound and maintained in perpetuity. This would require the installation of a culvert under Dean Ave. In addition, two residential structures are currently present on lots within the historical flow path of the North Drain. The channel can be routed around these developed properties or the North Drain can be piped through these lots as shown below. Regardless, the installation of a culvert under N Holiday Blvd will also be warranted.

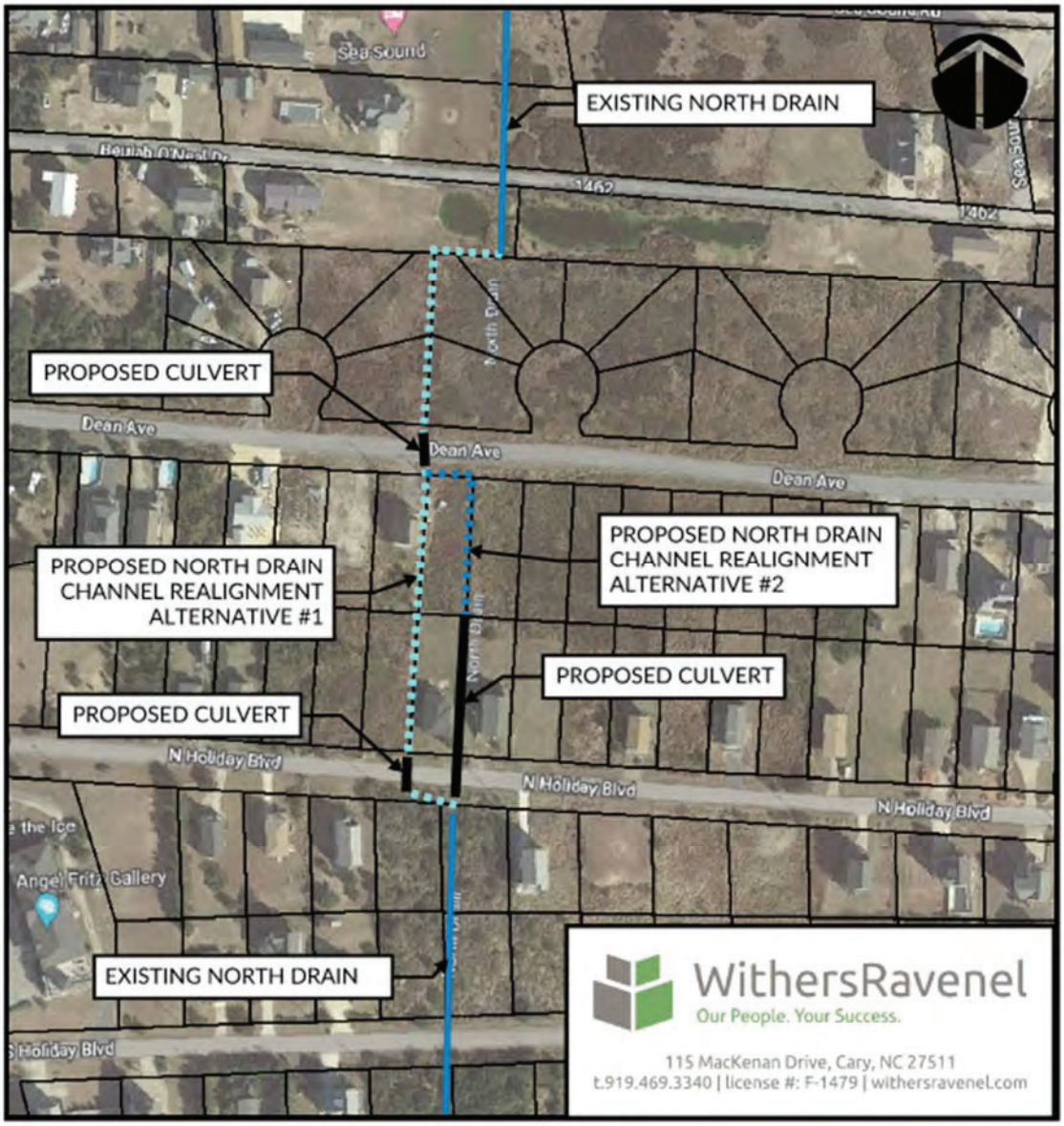


Figure 7 – Rodanthe North Drain Conceptual Layout

Avon

As discussed above, Ocean View Dr. in Avon was selected as an Area of Concern due to identified flooding within the roadway and adjacent residential lots. A detailed flood model was developed for Avon using the methodology discussed in Section 5.2. The model extents ranged from the dunes along east side of the island to the sound along the west and from the intersection of NC12 and Big Kinnakeet Dr in the north to the intersection of NC12 and Park Dr to the south. This area was delineated to ensure the full drainage area associated with Ocean View Dr. was analyzed.

Figure 8 – Avon Existing Conditions 2-Year Inundation

Review of existing conditions model results for all analyzed design storm indicates that shallow flooding (<6”) is present within the north bound lane of Ocean View Dr both during and after the storm events. This flooding extends into nuisance flooding within the adjacent lots to the east with flood depths for all storm events exceeding 1’ in some areas. Inundation map exhibits illustrating peak inundation areas for each design storm event can be found in Appendix I.

WithersRavenel utilized the existing conditions model to assess potential improvements within the Ocean View Dr. right-of-way that would help mitigate the identified flooding. After considering the working area, costs, and the existing downstream infrastructure, WithersRavenel recommends that infiltration swales be installed along the eastern side of Ocean View Dr. Infiltration swales consist of a perforated pipe surrounded by a course media (washed gravel) that is wrapped in geotextile fabric. A minimum of 6" sandy topsoil is placed on top and seeded. Stormwater that pools above the infiltration swale will infiltrate through the course media and into the pipe where it is discharged to a downstream location.

Infiltration swales were chosen over traditional roadside swales for two reasons. First, infiltration swales can be installed deeper than traditional roadside swales without introducing a maintenance hardship or safety hazard adjacent to the roadway. With an infiltration trench there is no drop off adjacent to the roadway that would require maintenance (routine weed whacking and cleanout). Instead, the roadside is essentially in existing conditions allow for a standard grassy shoulder. Second, with Ocean View Dr. being in close proximity to the dunes where ocean wash over is common, there is a concern that traditional swales would easily fill with sediment, requiring routine maintenance to maintain efficiency and flood mitigation benefits. The geotextile fabric around the infiltration trenches should prevent sediment from clogging the underdrain pipes and the expected sandy material from over wash should continue to allow stormwater to infiltrate into the system.

WithersRavenel recommends that infiltration trenches be installed within the right-of-way Ocean View Dr. from the southern cul-de-sac to the north to Yucca St. These infiltration trenches would discharge via pipes under Ocean View Dr. to open roadside swales along Yucca St, Myrtle Dr., and Seaside Dr. that connect to the existing roadside swales along NC 12.

WithersRavenel incorporation of the above proposed improvements into the existing conditions model to assess potential flood mitigation benefits. The results indicate that the proposed infiltration trenches would mitigate ponding within the travel lane of Ocean View Drive for 2-year and 10-year design storm events. While ponding was observed within the travel lane for a 100-year event, it should be noted that the flooding receded quicker following the storm event, as the infiltration trenches provided positive drainage once downstream flooding receded.

After reviewing the proposed improvements with County staff and considering that the entirety of the improvements were located within the right-of-way of a DOT maintained road, the County decided to pursue the implementation of these improvements. WithersRavenel prepared 30% Conceptual Plans illustrating the feasibility of the project. The proposed improvements consist of the following elements:

- ±2,330 LF of Infiltration Trenching consisting of:
  - ±90 LF 12" Perforated HDPE Pipe
  - ±640 LF 15" Perforated HDPE Pipe
  - ±1,600 LF 18" Perforated HDPE Pipe
- 20 Concrete Manholes
- ±730 LF of Roadside Swales
- 39 Driveway/Roadway Repairs

Proposed concept plans for the described improvements can be found in Appendix M. Based on the above proposed improvements, a budgetary cost opinion was prepared. Total construction costs, including final engineering, permitting, and construction phases services are estimated to be $1.7 million. Budgetary cost opinion breakdowns can be found in Appendix M.

Buxton

Flooding in Buxton was modeled from the dunes to Old Lighthouse Rd in the west and the sound to Schooner Es Newman Drive in the south. In the 2-year storm event, the existing conditions model indicates flood depths of approximately 0.1-feet to 0.7-feet along NC Highway 12 between Lighthouse Road and Old Lighthouse Road along the westbound travel lanes with the entirety of the roadway impacted between Angelo's Pizza and Diamond Shoals Restaurant. In addition, shallow flood depths of up to 0.3-feet are experienced across sections of Diamond Shoals Drive and Old Lighthouse Road. Nuisance flooding to private property is identified throughout the model area with significant flood depth of 0.5-feet to 1.0 feet to Ocean Drive, Cottage Avenue, North Tower Circle, and South Tower Circle including adjacent properties and structures. The existing topography corroborates the model results in this area as it's situated in a natural low point bordered by the dunes to the east and Old Schoolhouse Road to the west which are high points in comparison.

WithersRavenel recommends two independent solutions for the two areas of flooding concern. In the area of flooding along NC-12, installation of a small piped stormwater network could serve to quickly collect and remove runoff from the roadway. In order to implement this solution easement acquisition to discharge behind Angelo's Pizza and Diamond Shoals Restaurant would be needed. For the area of flooding along Old Lighthouse Road, and its side streets, an infiltration swale installed along the east side of Old Lighthouse Road is recommended. Due to the frequent ocean overwash and historical issues of traditional swales filling with sediment as well as the limited available space in the right of way, the infiltration swale design is recommended over a traditional swale. The infiltration swale will discharge to the existing ditches on the western side of Old Lighthouse Road. As part of Phase III of the Resilient Coastal Communities Program (RCCP) design plans for Old Lighthouse Road were prepared by WithersRavenel under a separate project.

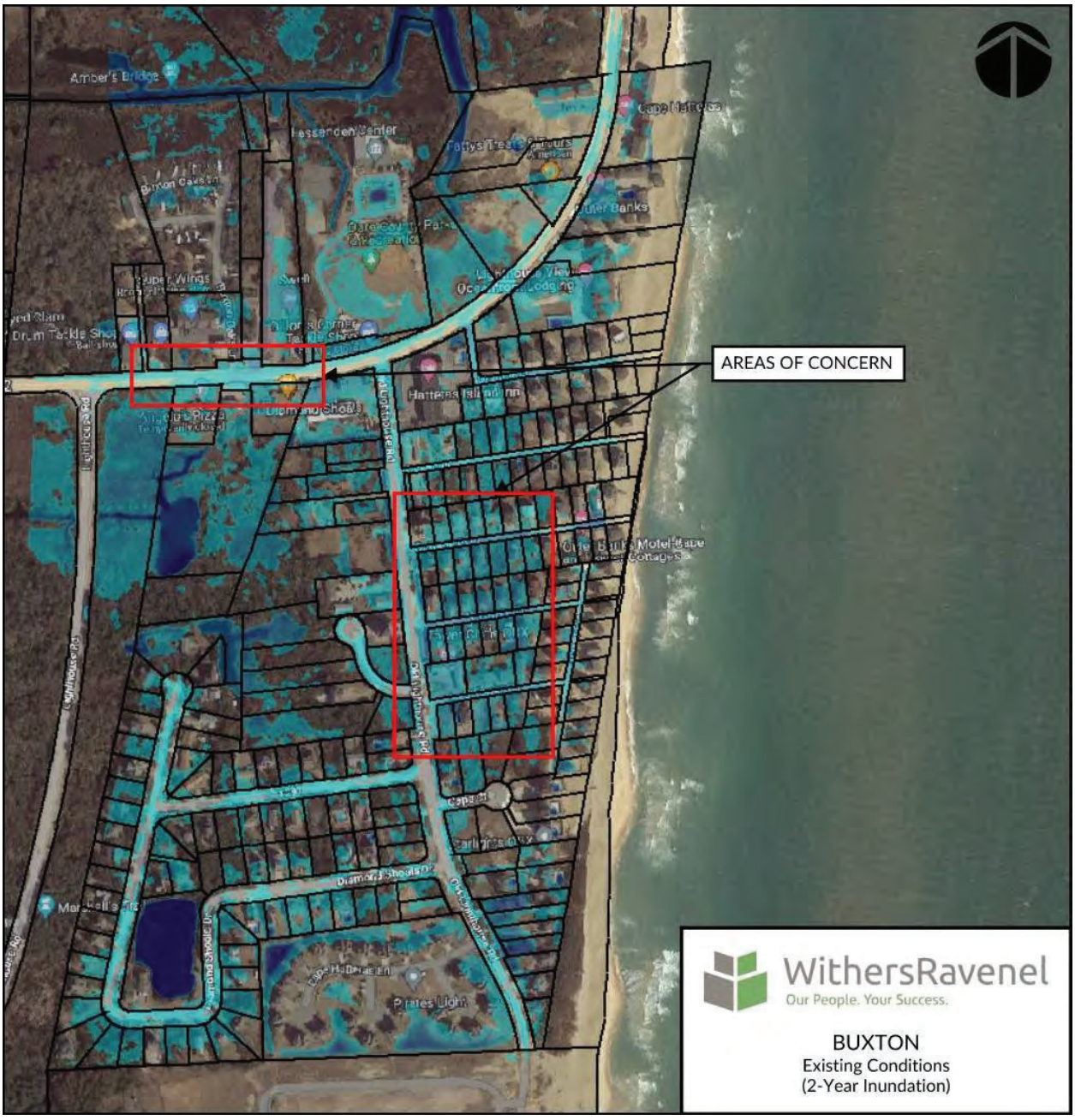


Figure 9 – Buxton Existing Conditions 2-Year Inundation

Frisco

Flooding in Frisco was modeled for the area between Sandpiper Drive (west) and Park Road (east) from the dunes (south) to the sound (north). The existing conditions model indicated varying impacts to almost all side streets of NC Highway 12 in the modeled area. Shallow flooding of approximately 0.1-feet to 0.4-feet are experienced by Runboat Circle, Tides Edge Court, Cape Hatteras Pier Drive, Sand Piper Drive, Surf on Sound Drive, and Osprey Way inundating all travel lanes. Significant flood depths, which would limit access to and from these side streets, include Ships Timbers Road, Cape Hatteras Drive, Hatterask Road, Shoresurf Lane, Tent Drive, and Marlin Court which experience approximately 0.1-feet to 1.1-feet of flooding. In comparison, based on model results and existing topography, NC Highway 12 sits slightly higher than its adjacent areas and experiences shallow flooding of approximately 0.1-feet to 0.2-feet impacting portions of travel lanes with a few area of inundation across all travel lanes. Private properties and associated residential structures along all previously described roadways also experience overland flooding of various depths between 0.1-feet to 1.0-feet.

Frisco is characterized by low topography relative to mean sea level with an elevated groundwater table subject to tidal fluctuations which limits the feasibility of different mitigation measures. Based on the model results, WithersRavenel recommends upsizing culverts and enlarging swales along NC Highway 12 to limit flooding of the primary roadway while installation and maintenance of swales along the other roads could improve the incidental flooding throughout the adjacent neighborhoods.

Figure 10 – Frisco Existing Conditions 2-Year Inundation

Hatteras Village

Flooding in the vicinity of Hatteras Village was modeled from the Hatteras Landing on the west side to the intersection of C Deering Ridge Rd and NC 12 on the east side and from the dunes to the south to the sound along the north side. Review of the model results indicated that roadway flooding is present along several roadways within the village with significant flooding (>6 inches or both travel lanes inundated) observed along NC 12, Kohler Rd., and Eagle Pass Rd which results in limited access to both residential and commercial properties following a storm event.

Figure 11 – Hatteras Village Existing Conditions 2-Year Inundation

Unfortunately, the low topographic nature of Hatteras Village in combination with an elevated groundwater table subject to tidal fluctuations makes implementing mitigation improvements difficult. In the vicinity of Kohler Rd., WithersRavenel recommends the installation of shallow grassy swales along Kohler Rd. These swales should connect to new swales along Altona Ln and

Stowe Landing Rd on to M V Australia Ln where they can discharge into the harbor. Similarly, grassy swales can be installed along Peerless Ln to also ultimately discharge into the harbor. Grassed swales should help reduce the ponding problem by eliminating standing water in the roadway and providing additional surface area for infiltration along with positive drainage to the sound. It should be noted that the shallow grass swales are only expected to reduce ponding depths during more common, higher frequency storm events (2-year or less); however, the swales are expected to help reduce the dissipation time of observed residual ponding for larger storm events.

The vegetation (grasses) in the swales also removes pollutants, through filtration and nutrient uptake, from the stormwater runoff. The size of drainage swales and driveway culverts, along with the amount of grading necessary will have to be determined through simple hydraulic and hydrologic (H & H) studies of the area. A detailed survey is also necessary prior to completion of the H&H model and design efforts.

Topographic information indicates that Eagle Pass Rd is already superelevated with the majority of the roadway sloped to the north to drain into the Slash. Care should be taken when undertaking any roadway maintenance to ensure positive drainage across the roadway from the sidewalk and adjacent properties along the southern side of the roadway. A grassy swale can be installed along the northern side of Eagle Pass Rd with intermittent cross channels that allow for discharge into the Slash to facilitate drainage along the roadway.

As discussed above, significant ponding is also present along NC 12 in Hatteras. Ponding is several inches deep and extends into the travel lanes on many occasions. These ponding conditions cause a safety hazard for pedestrians and motorists, along with the potential for property damage to cars. As informed by NCDOT, planned work on the bridge over Slash Creek will include improvements to the stormwater drainage in the area. WithersRavenel recommends the County monitor the impacts of the proposed NCDOT project and that the County work with NCDOT to ensure existing stormwater infrastructure remains maintained and functional by routinely cleaning out debris and sediment.

5.3 Water Quality

Although water quality was not the main focus of this study, the preservation and improvement of surface water quality in Dare County is of high importance. Water quality is critical to the shellfishing industry as well as public health and recreation and the resulting tourism industry. Improvement in the quality of the stormwater runoff may make it possible to see openings in previously closed shellfishing waters. Green infrastructure practices that encourage the infiltration of stormwater runoff as opposed to piping and discharging as quickly as possible allow for natural filtering and treatment of pollutants in stormwater. Infiltration swales and rain gardens are some of the simplest applications of this concept and could be implemented throughout much of Dare County. Maintenance and proper design of septic systems is also of utmost importance in preserving water quality in unincorporated Dare.

Chapter 6 - Stormwater Management Program Recommendations

The recommendations presented throughout this report are summarized in this Chapter. Some of the recommendations could be implemented as Capital Improvement Program (CIP) projects. Recommendations for minor repair and maintenance could be made part of the County's operating budget. Recommended policy changes may or may not have budget implications.

6.1 Policy

Dare County does not currently have a stormwater management ordinance. An ordinance could be implemented, however; with current conditions and level of existing developed lands, the effect would likely be limited without high level of engagement by residents to install retrofits on their properties. A public education campaign on Low Impact Development and public engagement into implementing best management practices would yield both water quality and quantity benefits to the community.

6.2 Capital Improvements Projects

Inadequate system capacity is the biggest water quality and quantity problem requiring capital improvements. Table 6-1 describes the capital improvement actions that have been recommended with an order of magnitude cost estimate for planning purposes. The costs are preliminary as they are based on several factors such as unknown site conditions, available survey data which could result in adjustment to size, material and length of changes that are yet to be determined. As the County is not responsible for maintaining roads and therefore does not have ownership of the Right of Way, the County will need to coordinate the placement of many of these improvements with NCDOT.

A methodical approach to the recommended improvements is needed, funding should be planned for in advance and as funding is available projects should be addressed in order of priority. Avon and North Roanoke Island have concept plans and cost breakdowns but each project will require survey and design to be shovel ready.

Table 6-1 Capital Improvement Projects

Location	Project Description	Order of Magnitude Cost
North Roanoke Island	Installation of Storm Drainage Network, Swales, and Culverts	$6M to $8M
Wanchese	Swale Maintenance/Enhancement	$500K to $1M
Colington Pond	Installation of Pond Outfall	$250K to $500K
Rodanthe	Re-Establish North Drain Connectivity	$500K to 1M
Avon – Ocean View Drive	Installation of Infiltration Trenches and Swales	$1.5M to $2M
Buxton – Old Lighthouse Rd	Installation of Infiltration Trenches, Culverts and Storm Drainage Network	$500K to $1M
Frisco	Culverts and Swale maintenance/enhancement	$500K to $1M
Hatteras Village	Installation of Detention Swales	$250K to $500K

6.3 Operations and Maintenance Program

During the field inspection of the system several inlets were covered with dirt and debris and many of the roadside swales and driveway culverts were blocked and/or filled in. Most of the inlets and pipe systems are in need of maintenance and pumping to remove sand buildup. Many swales and canals could benefit from dredging or mowing and maintenance to restore their conveyance capacity. Since some swales are on private property or private roads, homeowner education of the importance of maintaining these drainage features is important. Roadside swales, storm drain inlets, pipes, and structures should be periodically inspected, cleaned of debris and mowed. Additionally, all should be regularly cleaned, as needed.

To have a successful stormwater management program, an operation and maintenance program is vital. Although much of the drainage infrastructure throughout the county is either the responsibility of NCDOT or private, partnership to ensure maintenance of stormwater structures will help everyone in the long term. The County could opt for obtaining drainage easements for maintaining main stormwater infrastructure over the long term. An asset inventory of the stormwater system is important to develop a maintenance program. It is also recommended that the County investigate purchasing or leasing a vacuum system for cleaning out storm drainpipes and the infiltration systems.

6.4 Funding

The amount necessary to fund these projects can come from several sources. The costs estimated for the action items are preliminary, order-of-magnitude amounts.

Taxes

The County could raise property taxes to fund part or all of the program. The public usually does not respond well to this option. A dedicated millage would require a referendum, which may be difficult to sell to the public. A dedicated millage would mean that the County could depend on a certain amount year to year being committed to a planned program of O & M and replacement and improvements.

Stormwater Utility

An independent tax authority, or the creation of a stormwater utility could be established to collect stormwater fees. A service rate study would need to be performed to critically evaluate the charges and fees, and to distribute the costs of the stormwater management program proportionately among the users. The costs of the stormwater management program include: administration including overhead, customer billing, customer complaint response, ditch and pipe cleaning, illicit discharge investigation, site plan review, public education, and capital improvement program.

Many localities divide the total costs by the amount of impervious area in their service area to calculate a unit cost. An equivalent residential unit (ERU), which is the average amount of impervious area for a single family residence, is used as the billing unit. Non-residential property owners are billed according to the number of ERUs equivalent to the total impervious area on their property.

Utility Credits

A utility credit is a reduction in the stormwater utility fee for a property. It is given because of a drainage system improvement located on the property which causes a reduction in pollutants and/or a reduction in the peak flows and volumes leaving the property. It can be used as an incentive for voluntary construction of small stormwater control measures. The reasons and benefits of a utility credit program need to be established before it is implemented. Is the credit program perceived as necessary for public acceptance of the utility charges? Will it be perceived as enough of an incentive for voluntary implementation of SCMs and riparian buffers.

The implementation of a SCM or buffer used to receive credit will reduce some of the cost to the County for construction of a similar facility for a water quantity/quality benefit. However, some portion of the utility charge should be retained for those properties with credits in order to receive revenue for on-going program needs such as administration, system operation and maintenance, and inspection of on-site facilities. The loss of long-term revenue due to the credit program should not unfairly cause a burden to other customers without credits by making them pay more than their share of costs.

Grants and Loans

There are several sources that the County can apply to for grants and low interest loans. Due to the location of the County, and its sensitive environment, the County should have a good chance at receiving a variety of grants. Some of these programs include:

- NC DEQ Division of Water Infrastructure (DWI) Clean Water State Revolving Fund (SRF) Loan
- NC DEQ Division of Water Infrastructure (DWI) Local Assistance for Stormwater Infrastructure Investments Program (LASII) Construction Grants
- FEMA Building Resilient Infrastructure and Communities (BRIC) Program
- FEMA Hazard Mitigation Grant Program
- Golden Leaf Foundation Grants

These possible sources of additional funding will need to be evaluated by the County to establish policy on additional funding methods.

6.5 Public Involvement

It is recommended that the County implement a comprehensive public education/public involvement program. The education programs and/or outreach activities should inform individuals and households about the impacts stormwater discharges have on water bodies and identify the steps that must be taken to reduce stormwater pollution. It is anticipated that public understanding will foster endorsement of the stormwater management program.

Activities that could be implemented include quarterly stormwater newsletters which update citizens on activities being undertaken through the County stormwater management program and gives tips for residents to reduce stormwater runoff on their property, and drawing/coloring contests for school children with information about the do's and don'ts of stormwater management. The County may want to hold periodic stormwater seminars possibly in conjunction

with other, well-attended County activities. The County is encouraged to contact the NCDEQ for information regarding state educational programs in which the County may be able to become involved.

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